

Foreword

This document is intended to present the Users of the Eastern and Western Ranges with a common set of requirements that will help minimize safety risks and maximize Range User objectives.

Developing this latest edition of the Range Safety Requirements required a vigorous effort on the part of the staff of both Wings, and significant contribution by the Range User community. This revision considers and reflects the following:

- 1) Existing statutes, regulations, and codes.*
- 2) Current industry standards and practices.*
- 3) Technological developments.*
- 4) Lessons learned from our 40 years on the cutting edge of Space Launch.*

We seek to strengthen our partnership with the Range Users, jointly developing a cooperative atmosphere to effect timely and mutually satisfactory solutions to all issues pertaining to Safety.

Range Users are encouraged to contact the Safety Staffs at each Wing during the earliest stages of conceptual development and planning. Only by a concerted, dedicated, and diligent effort on the part of both parties will we achieve our mutual objective.

We look forward to working with our Range Users in assuring our nation's continuing access to Space!

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1 CHAPTER 1

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GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

30 SW/SEGP - 30th Space Wing, Operations Safety

30 SW/SEO - 30th Space Wing, Mission Flight Control

30 SW/SEY - 30th Space Wing, Flight Analysis

45 SW/SEO - 45th Space Wing, Mission Flight Control and Analysis

45 SW/SEOE - 45th Space Wing, Expendable Launch Vehicle Operations Support and Analysis

45 SW/SEOO - 45th Space Wing, Mission Flight Control

45 SW/SEOS - 45th Space Wing, Space Transportation System Operations Support and Analysis

45 and 30 LG - 45th and 30th Logistics Group

45 and 30 MDG - 45th and 30th Medical Group

45 and 30 OG - 45th and 30th Operations Group

45 and 30 SPTG - 45th and 30th Support Group

45 and 30 SW/SE - 45th and 30th Space Wing, Office of the Chief of Safety; *see also Office of the Chief of Safety*

45 and 30 SW/SEG - 45th and 30th Space Wing, Ground Safety

45 and 30 SW/SES - 45th and 30th Space Wing, Systems Safety

approval - Range Safety approval is the final approval necessary for data packages such as the Preliminary Flight Data Package, the Final Flight Data Package, the Missile System Prelaunch Safety Package, the Range Safety System Report, the Ground Operations Plan, and the Facility Safety Data Package. In addition, Range Safety approval is required for hazardous and safety critical procedures prior to the procedure being performed; however, Range Safety approval does not constitute final approval for hazardous and safety critical procedures since Range Users normally have additional approval requirements prior to the procedure being performed.

AF - Air Force

AFETR - Air Force Eastern Test Range

AFI - Air Force Instruction

BDA - Blast Danger Area

Blast Danger Area - a hazardous clear area; clearance prior to establishment of a major explosive hazard such as vehicle fuel/oxidizer load and pressurization; the area subject to fragment and direct overpressure resulting from the explosion of the booster/payload

CAL-OSHA - California Occupational Safety and Health Act

CCAS - Cape Canaveral Air Station

cDR - Conceptual Design Review

CDR - Critical Design Review; Command Destruct Receiver

CFR - Code of Federal Regulations

COLA - Collision Avoidance

collective risk - the total risk to an exposed population; the expected (average, mean) number of individuals who will be casualties

commercial user - a non-federal government organization that provides launch operations services

Control Area Clears - a hazardous clear area; clearance of defined areas to protect personnel from hazardous operations

control authority - a single commercial user on-site director and/or manager, a full time government tenant director and/or commander, or United States Air Force squadron/detachment commander responsible for the implementation of launch complex safety requirements

deviation - a designation used when a design non-compliance is known to exist prior to hardware production or an operational noncompliance is known to exist prior to beginning operations at CCAS and Vandenberg Air Force Base

DDESB - Department of Defense Explosive Safety Board

DEP - Directed Energy Plan

DoD - Department of Defense

DoDD - Department of Defense Directive

DOT - Department of Transportation

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

ECP - Engineering Change Proposal

ER - Eastern Range

ERR - Eastern Range Regulation

ESMCR - Eastern Space and Missile Center Regulation

errant launch vehicle - a launch vehicle that, during flight, violates established flight safety criteria and/or operates erratically in a manner inconsistent with its intended flight performance. Continued flight of an errant launch vehicle may grossly deviate from planned flight, with the possibility of increasing public risk to unacceptable limits.

explosive warhead launch approval - the mandatory prior written approval given by the Eastern or Western Range Commanders to Range Users who launch launch vehicles carrying explosive warheads

explosive quantity distance site plans - a formal plan for explosives facilities and areas required in accordance with AFM 91-201 and DoD 6055.9-STD detailing explosives quantity operating and storage limits and restrictions and resultant distance clearance requirements

FAA/AST - Federal Aviation Administration/Associate Administrator for Commercial Space Transportation

FCA - Flight Caution Area

FDR - Final Design Review

FFDP - Final Flight Data Package

FFPA - Final Flight Plan Approval

Flight Caution Area - a Hazardous Launch Area; the controlled surface area and airspace outside the Flight Hazard Area (FHA) where individual risk from a launch vehicle malfunction during the early phase of flight exceeds 1×10^{-6} . When activated, only personnel essential to the launch operation (mission-essential) with adequate breathing protection are permitted in this area; *see also Flight Hazard Area, mission-essential personnel*

FHA - Flight Hazard Area

Flight Hazard Area - a Hazardous Launch Area; the controlled surface area and airspace about the launch pad and flight azimuth where individual risk from a malfunction during the early phase of

flight exceeds 1×10^{-5} . Because the risk of serious injury or death from blast overpressure or debris is so significant, only mission-essential personnel in approved blast-hardened structures with adequate breathing protection are permitted in this area during launch.

FSDP - Facility Safety Data Package

FTS - Flight Termination System

GOP - Ground Operations Plan

GPS - Global Positioning System

h - hour, hours

Hazardous Clear Areas - Safety Clearance Zones for ground processing that are defined in the Operations Safety Plans for each operating facility; include BDA, Control Area Clears, and Toxic Hazard Corridor

Hazardous Launch Area Clearance - required clearances; concurrence from the Chief of Safety must be obtained for all personnel required or requesting to be in a Hazardous Launch Area during a launch operation; mission-essential personnel may be permitted within the Impact Limit Lines and the FCA, but only within the FHA if located in approved blast-hardened structures with adequate breathing apparatus; Wing-essential personnel located at required work areas and non-essential personnel may be permitted inside the impact limit lines with Wing Commander approval; *see also FCA, FHA, impact limit lines, mission-essential personnel*

Hazardous Launch Areas - Safety Clearance Zones during launch operations, including the FCA, FHA, Vessel Exclusion Area, and impact limit lines

HCA - Hazardous Clear Areas

HLA - Hazardous Launch Areas

HPWT - High Performance Work Team

ILL - impact limit line

imminent danger - any condition, operation, or situation that occurs on the Range where a danger exists that could reasonably be expected to cause death or serious physical harm, immediately or before the imminence of such danger can be eliminated through control procedures; these situations also include health hazards where it is

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

reasonably expected that exposure to a toxic substance or other hazard will occur that will cause harm to such a degree as to shorten life or cause a substantial reduction in physical or mental efficiency even though the resulting harm may not manifest itself immediately

impact limit line - a Hazardous Launch Area; the boundary within which trajectory constraints and FTSs are used to contain an errant launch vehicle and vehicle debris. Mission-essential and Wing-essential personnel are permitted within the ILLs; with Wing Commander approval, non-essential personnel may be permitted within this area. However, the collective risk will not exceed acceptable standards for non-essential personnel; *see also mission-essential personnel, non-essential personnel*

individual risk - the risk to a randomly exposed individual; the probability that the individual will be a casualty

ISP - Intended Support Plan

KMR - Kwajalein Missile Range

KSC - Kennedy Space Center

launch area safety - safety requirements involving risks limited to personnel and/or property on CCAS and may be extended to KSC or VAFB; involves multiple commercial users, government tenants, or United State Air Force squadron commanders

launch area - the facility, in this case, CCAS and KSC or Vandenberg Air Force Base, where launch vehicles and payloads are launched; includes any supporting sites on the Eastern or Western Range; also known as launch head

launch complex - a defined area that supports launch vehicle or payload operations or storage; includes launch pads and/or associated facilities

launch complex safety - safety requirements involving risk that is limited to personnel and/or property located within the well defined confines of a launch complex, facility, or group of facilities; for example, within the fence line; involves risk only to those personnel and/or property under the control of the control authority for the launch complex, facility, or group of facilities

launch head - *see launch area*

launch vehicle - a vehicle that carries and/or delivers a payload to a desired location; this is a generic term that applies to all vehicles that may be launched from the Eastern and Western Ranges, including but not limited to airplanes; all types of space launch vehicles, manned space vehicles, missiles, and rockets and their stages; probes; aerostats and balloons; drones; remotely piloted vehicles; projectiles, torpedoes and air-dropped bodies

lead time - the time between the beginning of a process or project and the appearance of its results

LDCG - Launch Disaster Control Group; ER and WR teams responsible for responding to launch emergencies

LRR - Launch Readiness Review

MIC - meets intent certification; a noncompliance designation used to indicate that an equivalent level of safety is maintained despite not meeting the exact requirements stated in this Regulation

MIL-SPEC - military specification

MIL-STD - military standard

mission-essential personnel - those persons necessary to successfully and safely complete a hazardous or launch operation and whose absence would jeopardize the completion of the operation; includes persons required to perform emergency actions according to authorized directives, persons specifically authorized by the Wing Commander to perform scheduled activities, and person in training; the number of mission-essential personnel allowed within Safety Clearance Zones or Hazardous Launch Areas is determined by the Wing Commander and the Range User with Range Safety concurrence

MSPSP - Missile System Prelaunch Safety Package

NASA - National Aeronautics and Space Administration

NASC - National Aeronautics and Space Council

NAWC - Naval Air Warfare Center

NSC - National Security Council

noncompliance - a noticeable or marked departure from Regulation standards or procedures; includes

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

deviations, meets intent certifications, and waivers

non-essential personnel - those persons not deemed mission-essential or Wing-essential; includes the general public, visitors, the media, and any persons who can be excluded from Safety Clearance Zones with no effect on the operation or parallel operations

O&SHA - Operating and Support Hazard Analysis

OSHA - Occupational Safety and Health Act

Office of the Chief of Safety - the Range office headed by the Chief of Safety; this office ensures that the Range Safety Program meets Range and Range User needs and does not impose undue or overly restrictive requirements on a program

OCST - Office of Commercial Space Transportation, DOT

PAFB - Patrick Air Force Base located in Florida

PMRF - Pacific Missile Range Facility

payload - the object(s) within a payload fairing carried or delivered by a launch vehicle to a desired location or orbit; a generic term that applies to all payloads that may be delivered to or from the Eastern or Western Ranges; includes but is not limited to satellites, other spacecraft, experimental packages, bomb loads, warheads, reentry vehicles, dummy loads, cargo, and any motors attached to them in the payload fairing

PD - presidential directive

PDR - Preliminary Design Review

PFDP - Preliminary Flight Data Package

PHA - Preliminary Hazard Analysis

PL - public law

program - the coordinated group of tasks associated with the concept, design, manufacture, preparation, checkout, and launch of a launch vehicle and/or payload to or from, or otherwise supported by the Eastern or Western Ranges and the associated ground support equipment and facilities

PTR - Program Trouble Report

public safety - safety involving risks to the general public of the United States or foreign countries and/or their property

radioactive material launch approval - approval granted by Range Safety to Range Users intending to launch radioactive materials

Range Commander - Commander of the Eastern and Western Range in accordance with DoDD 3200.11; sometimes called *Range Director*, when interfacing with commercial Range Users.

NOTE: Currently, the 45 SW and 30 SW Commanders are also the Range Commanders and Range Directors

Range Safety Launch Commit Criteria - hazardous or safety critical parameters, including, but not limited to, those associated with the launch vehicle, payload, ground support equipment, Range Safety System, hazardous area clearance requirements, and meteorological conditions that must be within defined limits to ensure that public, launch area, and launch complex safety can be maintained during a launch operation

Range Safety Program - a program implemented to ensure that launch and flight of launch vehicles and payloads present no greater risk to the general public than that imposed by the overflight of conventional aircraft; such a program also includes launch complex and launch area safety and protection of national resources

Range Safety System - the system consisting of the airborne and ground flight termination systems, airborne and ground tracking system, and the airborne and ground telemetry data transmission systems

Range Users - clients of the Cape Canaveral Air Station and Vandenberg Air Force Base, such as the Department of Defense, non-Department of Defense US government agencies, civilian commercial companies, and foreign government agencies that use Eastern or Western Range facilities and test equipment; conduct prelaunch, launch, and impact operations; or require on-orbit support

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

Ranges - in this document, *Ranges* refers to the Eastern Range at CCAS, KSC, and PAFB, and the Western Range at Vandenberg Air Force Base

risk - a measure that takes into consideration both the probability of occurrence and the consequence of a hazard to a population or installation. Risk is measured in the same units as the consequence such as number of injuries, fatalities, or dollar loss. For Range Safety, risk is expressed as casualty expectation or shown in a risk profile; *see also collective risk and individual risk.*

risk analysis - a study of potential risk

risk-cost benefit concept - the concept used to determine the granting of waivers, deviations, or meets intent certifications to Eastern and Western Range 127-1 requirements by comparing the costs, risks, and benefits of the mission. If the application of an EWR 127-1 requirement results in a significant reduction of risk at an acceptable level of cost, it may be judged by Range Safety to be sufficient to impose a requirement; however, if the benefit is insignificant and/or the cost is high, the requirement may be deviated from, waived, or determined to meet the intent, all with consideration to public safety. The risk of concern may be the mean or average risk, or it may be a risk corresponding to a high consequence at a low probability (a catastrophic risk). The assurance of a very low probability may be required for a very high consequence even if a high cost may be entailed.

RSBBS - Range Safety Bulletin Board System

RSLCC - Range Safety Launch Commit Criteria

RSSR - Airborne Range Safety System Report

RTS - Range Tracking System

safety holds - the holdfire capability, emergency voice procedures, or light indication system of each launch system used to prevent launches in the event of loss of Range Safety critical systems or violations of mandatory Range Safety launch commit criteria

Safety Clearance Zones - restricted areas designated for day-to-day prelaunch processing and launch operations to protect the public, launch area, and launch complex personnel; these zones are established for each launch vehicle and payload at specific processing facilities, including

launch complexes; includes HCA and HLA

safety margins (destruct) - margins used to avoid overly restrictive flight termination limits; normally based on launch vehicle three-sigma performance characteristics

SCN - Specification Change Notice

SHA - System Hazard Analysis

space safety professional - a safety professional who has been trained and formally certified to meet the criteria outlined in the Launch Complex Safety Training and Certification Program Document

SPR - Software Problem Report

SSHA - Subsystem Hazard Analysis

SSPP - System Safety Program Plan

STR - Software Trouble Report

STS - Space Transportation System

SWI - space wing instruction

TDTS - Telemetry Data Transmitting System

THC - Toxic Hazard Corridor

TIM - Technical Interchange Meeting

Toxic Hazard Corridor - a Hazardous Clear Area; clearance of a sector in which toxic material may reach predetermined concentration levels

TPS - Telemetry Processing Station

US - United States

USAF - United States Air Force

USC - United States Code

VEA - Vessel Exclusion Area

Vessel Exclusion Area - a combination of the sea surface area and airspace measured from the launch point and extending downrange along the intended flight azimuth; the size of the VEA is based on hazard containment or a combination of acceptable impact probability and personnel risk

WCOOA - West Coast Offshore Operating Area

waiver - a designation used when, through an error in the manufacturing process or for other reasons, a hardware noncompliance is discovered after hardware production, or an operational noncompliance

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

is discovered after operations have begun at the Eastern or Western Range

Wing Commander - *see Range Commander*

WSMCR Western Space and Missile Center Regulation

VAFB - Vandenberg Air Force Base; located in California

WR - Western Range

WRR - Western Range Regulation

REFERENCED DOCUMENTS

29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals*

40 CFR 355, *Emergency Planning and Notification*

40 CFR 68, *Risk Management Program*

45 SWI 99-101, 45th Space Wing Mission Program Documents

AFI 91-204, *Safety Investigations and Reports*

AFI 91-110, *Nuclear Safety Review and Launch Approval for Space or Missile Use of Radioactive Material and Nuclear Systems*

AFI 99-101, *Developmental Test and Evaluation*

AFI 99-102, *Operational Test and Evaluation*

AFI 99-113, *Space Systems Test and Evaluation Process Direction and Methodology for Space Systems Testing*

AFMAN 91-201, *Explosive Safety Standards*

AFMAN 99-110, *Airframe Propulsion-Avionics Test and Evaluation Process*

CERCLA, *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*

Department of Defense Directive 3200.11, *Major Range and Test Facility Base*

Department of Defense Directive 3230.3, *DoD Support for Commercial Space Launch Activities*

DoD 6055.9-STD, *DoD Ammunition and Explosives Safety Standards*

DOT OCST 14 CFR, Chapter III, "Commercial Space Transportation; Licensing Process for Commercial Space Launch Activities"

Executive Order 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements"

MIL-STD-498, *Software Development and Documentation*

National Aeronautics and Space Council, *Nuclear Safety Review and Approval Procedures for Minor Radioactive Sources in Space Operations*

Presidential Directive/National Security Council 25, *Scientific or Technological Experiments with Possible Large-Scale Adverse Environmental Effects and Launch of Nuclear Systems into Space*

Public Law 10, 10 USC Section 172, *Ammunition Storage Board*

Public Law 91-596, 29 USC 651-678, *Occupational Health and Safety Act*

Public Law 60, 81st Congress, 1st Session, *Guided Missiles Joint Long Range Proving Ground*

Public Law 98-575, 49 USC 2601-2623, *The Commercial Space Launch Act of 1984, As Amended*

Public Law 99-499, 42 USC 11001-11050, *Superfund Amendments and Reauthorization Act (SARA), Title III: Emergency Planning and Community Right-to-Know Act (EPCRA)*

CHAPTER 1

EASTERN AND WESTERN RANGE SAFETY POLICIES AND PROCESSES

1.1 INTRODUCTION

1.1.1 Purpose of the Chapter

Chapter 1 describes the Range Safety Program; defines responsibilities and authorities; and delineates policies, processes, and approvals for all activities from design concept through test, check-out, assembly, and launch of launch vehicles and payloads to orbital insertion or impact from or onto the Eastern Range (ER) or Western Range (WR). The following major topics are addressed:

- 1.2 Range Safety Program
- 1.3 Responsibilities and Authorities
- 1.4 Range Safety Policy
- 1.5 Safety Authorizations, Compliances, and Documentation
- 1.6 Range Safety and Range User Interface Process
- 1.7 Range Safety "Concept to Launch" Process
- 1.8 Changes to Approved Generic Systems
- 1.9 Changes to the Document
- 1.10 Investigating and Reporting Mishaps and Incidents
- 1.11 Range Safety Range User Handbook
- 1.12 Range Safety Bulletin Board System

1.1.2 Applicability

The policies, requirements, processes, procedures, and approvals defined in this Chapter and the other chapters in this document are applicable to all organizations, agencies, companies, and programs conducting or supporting operations on the ER and WR. **NOTE:** When used in this document, the terms *Range* or *Ranges* refer to both the Eastern

Range and the Western Range.

1.1.2.1 The Eastern and Western Ranges

1.1.2.1.1 The Eastern Range.

a. The ER is the launch head at Cape Canaveral Air Station (CCAS); owned or leased facilities on downrange sites such as Antigua and Ascension; and in the context of launch operations, the Atlantic Ocean, including all surrounding land, sea, and air space within the reach of any launch vehicle extending eastward into the Indian and Pacific Oceans. Figure 1-1 shows the typical launch sector for launches from the ER; Figure 1-2 shows owned or leased facilities on sites downrange from the ER.

b. Range management activities are concentrated at Patrick Air Force Base (PAFB), Florida.

c. Launch vehicle and payload prelaunch and launch activities are concentrated at CCAS, Kennedy Space Center (KSC), and miscellaneous outlying support locations.

d. Launch activities conducted by ER personnel operating outside the geographical limits described above may occur under Department of Defense (DoD) or United States Air Force (USAF) direction or under the auspices of agreements made by those agencies. In such cases, the term *Eastern Range* or *ER* is expanded to include these situations and apply, as required, for the specific mission, launch, launch area, and impact area.

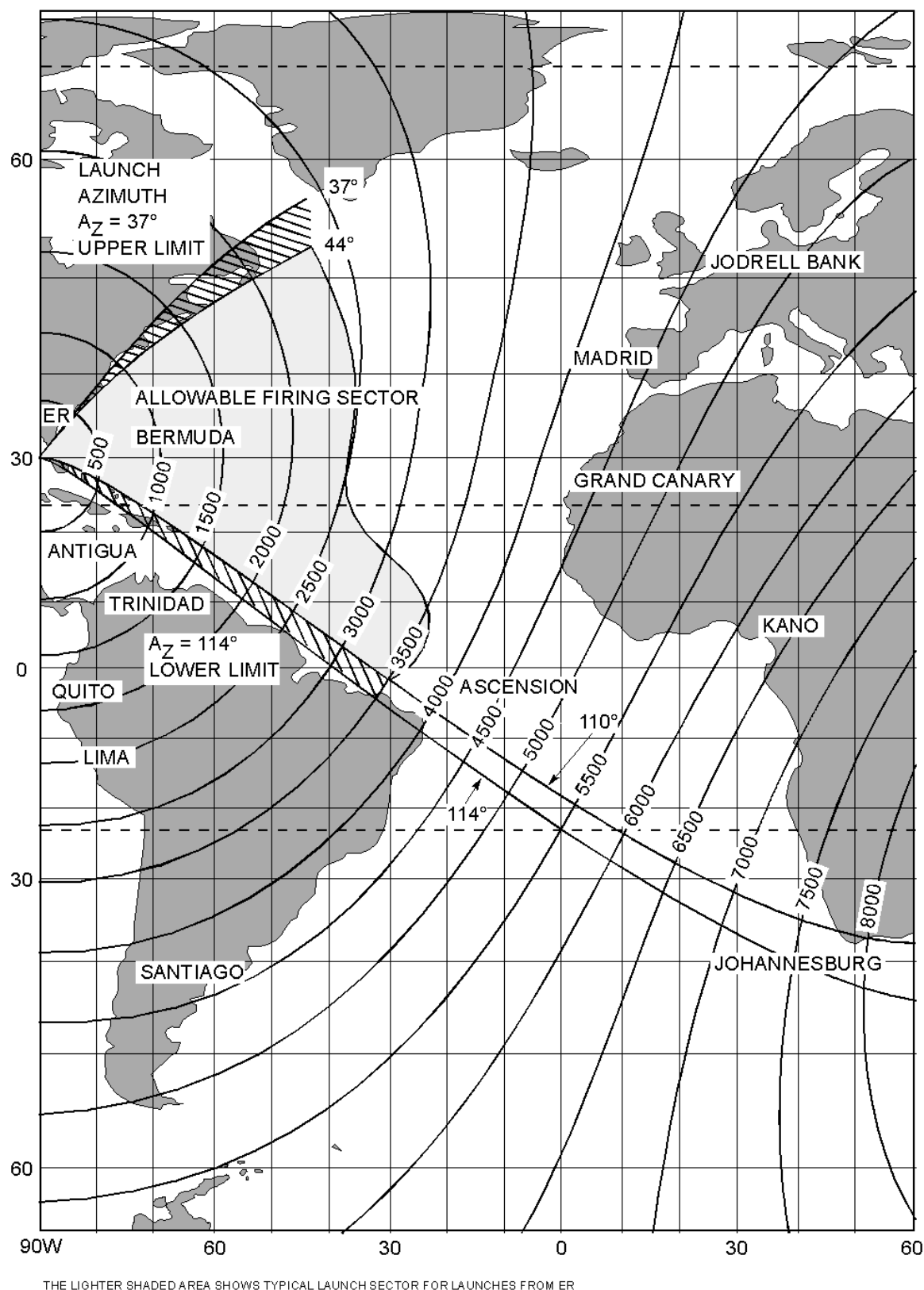


Figure 1-1
Typical Launch Sector for Launches From the Eastern Range

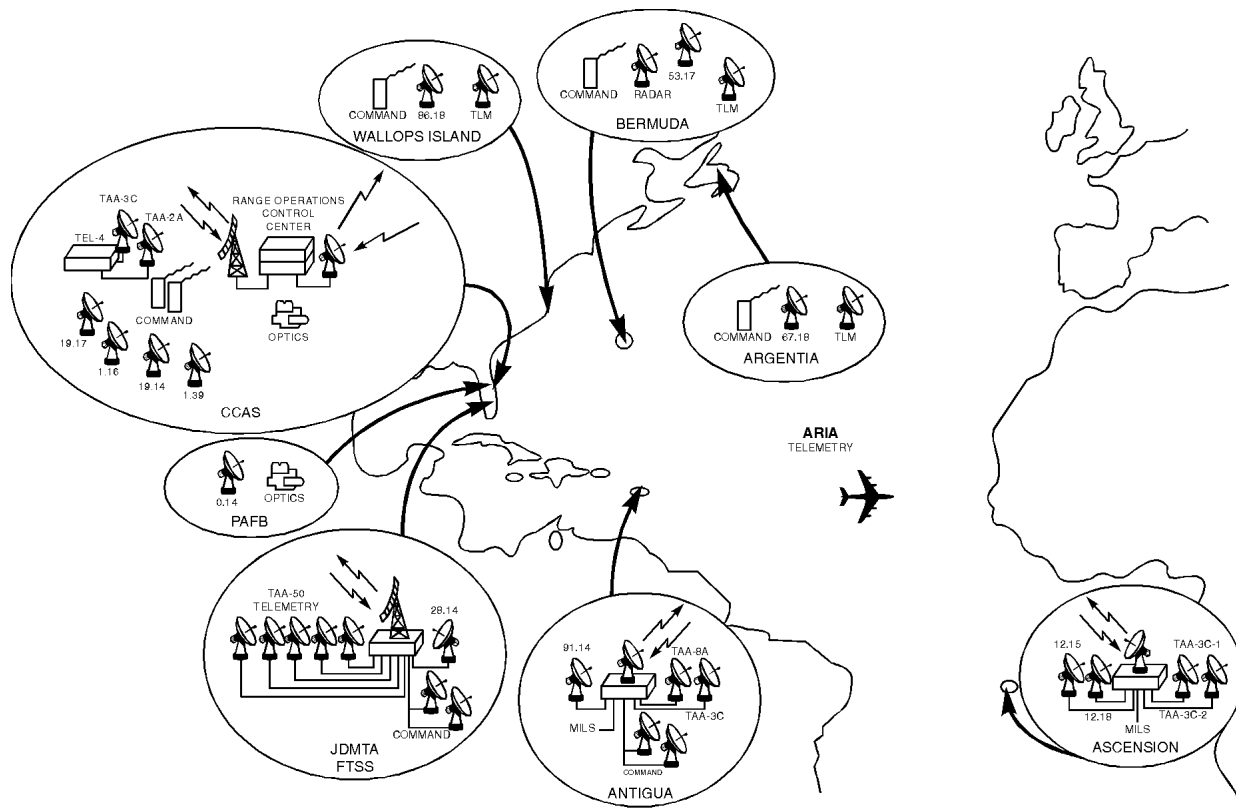


Figure 1-2
Owned or Leased Facilities on Sites Downrange from the Eastern Range

1.1.2.1.2 The Western Range.

a. The WR is the launch head at Vandenberg Air Force Base (VAFB) and extends along the West Coast of the continental United States (US) westward through the Pacific and Indian Oceans. Figure 1-3 shows the typical launch sector for launches from the WR; Figure 1-4 shows owned or leased facilities on sites uprange along the Pacific Coast, including US Navy facilities at Point Mugu, and downrange from the WR.

b. Range management activities as well as launch and prelaunch processing activities are concentrated at VAFB in California.

c. Launch activities conducted by WR personnel operating outside the geographical limits described above may occur under DoD or USAF direction or under the auspices of agreements made by those agencies. In such cases, the term *Western Range* or *WR* is expanded to include these situations and apply, as required, to the specific mission, launch, launch area, and impact area.

1.1.2.1.3 Eastern and Western Range Differences.

The ER and WR have some differences in their Range Safety requirements. These differences are caused by geographical differences that change risk levels for launch operations, organizational variations, and different Range User requirements such as those associated with manned space flights at the ER and ballistic launches into the Kwajalein Atoll and aircraft tests at the WR. At present, where a requirement differs, the Range User may standardize to the more stringent requirement or meet the requirements of each Range, whichever option is technically or economically more desirable. Specific ER and WR differences are noted throughout this document.

1.1.2.2 Range Users

Range Users include the DoD, non-DoD US government agencies, civilian commercial companies, and foreign government agencies that use ER and WR facilities and test equipment; conduct prelaunch,

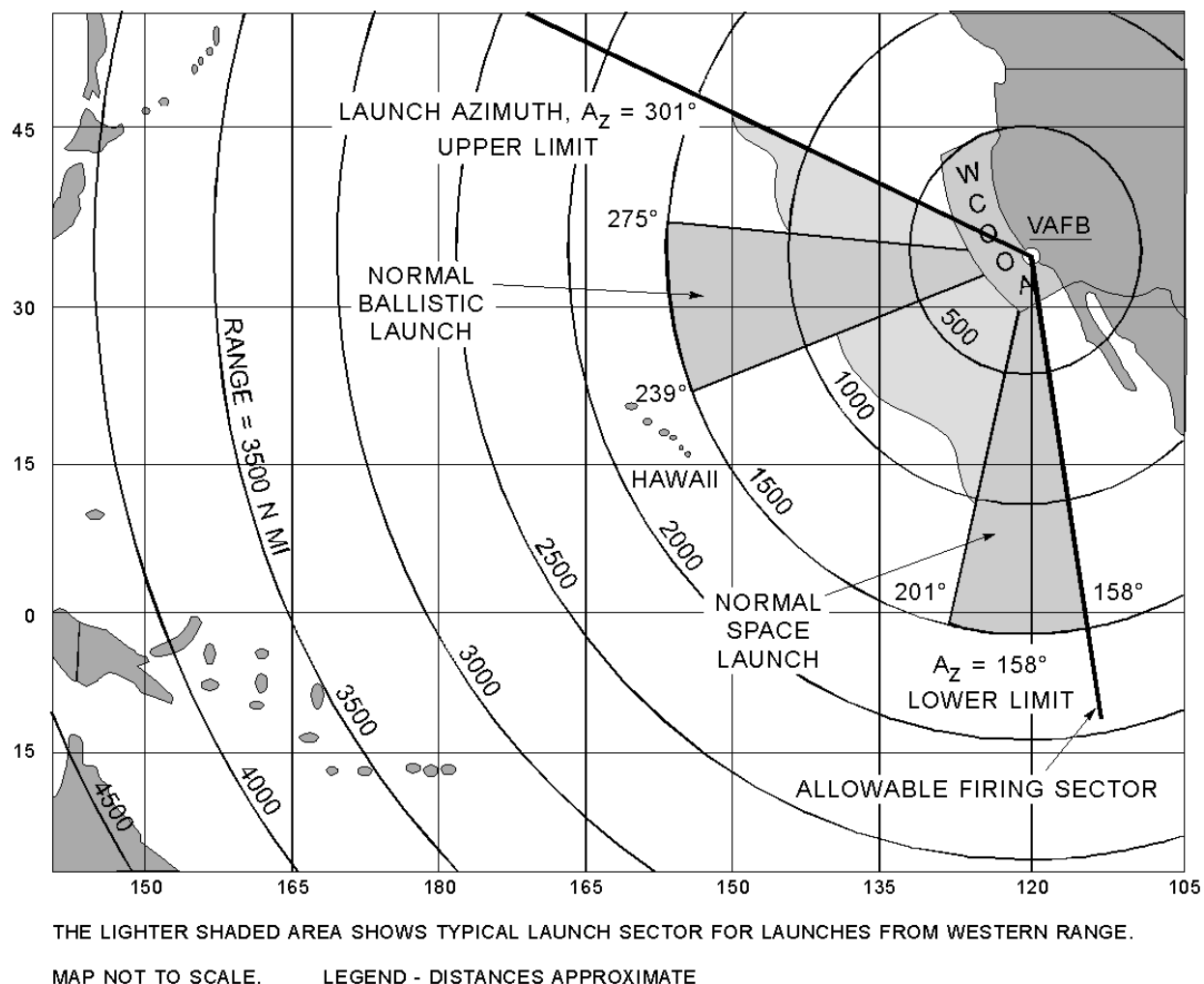


Figure 1-3
Typical Launch Sector For Launches From the Western Range

launch operations, and impact; or require on-orbit or other related support.

a. Commercial users intending to provide launch services from one of the Ranges shall be sponsored and have a license from the Department of Transportation (DOT) or have a DoD sponsorship and be accepted by the DoD to use the ER or WR.

b. Foreign government organizations or companies shall be sponsored by an appropriate US government organization or be a customer of a commercial Range User.

1.2 RANGE SAFETY PROGRAM

The national range system, established by Public Law 60, was originally sited based on two primary concerns: location and public safety. Thus, Range Safety, in the context of national range activities, is rooted in PL 60.

To provide for the public safety, the Ranges, using a Range Safety Program, shall ensure that the launch and flight of launch vehicles and payloads present no greater risk to the general public than that imposed by the overflight of conventional aircraft. In addition to public protection, safety on a national range includes launch area safety, launch complex safety, and the protection of national resources.

Range Safety is intrinsic to the range mission of providing Range Users the facilities, instrumentation, and infrastructure to support launch vehicles and payloads during prelaunch and launch operations. Significant hazards and risks are inherent to launch vehicle and payload tests and operations; therefore, all reasonable precautions shall be taken to minimize these risks with respect to life, health,

shot torpedoes on submarines. The document has been developed as a baseline document for the following reasons:

a. Past experience and input from Range Users regarding concerns about referenced documents, particularly military standards and military specifications, causing a tiering effect with the result that designers have difficulty understanding which specific requirements apply to a given design

b. Standardized design and safety requirements for many aerospace hazardous systems that do not exist except in this document

c. The need for a set of standards that, through experience, ensures a prudent level of public safety protection is provided during prelaunch and launch operations

d. The need for a set of minimum criteria and requirements to ensure launch area safety since commercial users are not required to directly use military standards or military specifications in the design of their hazardous systems except for flight termination systems required by the Ranges. Therefore, to ensure each Range User is protected from the activities of others, this baseline document provides a set of minimum criteria and requirements to ensure launch area safety.

e. Wherever possible, military standards (MIL-STDs) and military specifications (MIL-SPECs) will be replaced with equivalent commercial standards. Anywhere a MIL-STD or MIL-SPEC is referenced in this document, an equivalent commercial standard may be used. However, both 45 SW/SE and 30 SW/SE shall recognize and approve the equivalency of the commercial standard prior to its use. As commercial standards and specifications are developed and approved, this document will be updated to list and/or incorporate them.

1.2.4 Applicability of the 1997 Edition of EWR 127-1

This edition of EWR 127-1 is applicable to all new programs with Program Introduction submittals dated after 31 October 1997. **NOTE:** Programs that have begun significant design prior to this date and with Program Introductions occurring at a later date may submit a program milestone schedule (cDR, PDR, CDR, PI, document submittals, and other items) and request Range Safety concurrence that the edition/revision of 127-1 at the time of design commencement is acceptable. However, all Range Users are encouraged to perform Pro-

gram Introductions at the earliest possible time in the program.

1.2.4.1 Status of Previously Approved Programs

Existing program approval and compliance agreements on Range User flight hardware systems and subsystems and ground support equipment, facilities, operations, and procedures, including all deviations, waivers, and meets intent certifications, approved prior to 31 October 1997 shall be honored and do not have to meet the requirements in this document unless it is determined by the Chief of Safety or the Range User that one or more of the situations listed in *a* through *g* below exist. **NOTE:** The exceptions also apply to programs that are approved in accordance with this document, when application of previously non-enforced requirements of this document are contemplated.

a. Existing programs make major modifications or include the use of currently approved components, systems, or subsystems in new applications. *EXCEPTION: Previously approved existing components, systems, or subsystems that do not increase the risks, do not degrade safety, or can survive new environments or the new environments are equivalent to or lower than the originally approved qualification levels shall be honored and do not have to meet new requirements as long as data and analyses submitted to and approved by Range Safety show that the criteria have been met.*

b. The Range User has determined that it is economically and technically feasible and desirable to incorporate new requirements into the system.

c. The system has been or will be modified to the extent that it is considered a new program or that existing safety approvals no longer apply. **NOTE:** Risk and hazard analyses in accordance with Appendix 1B and developed jointly by Range Safety and the Range User shall be used by Range Safety to determine applicability of the safety approvals.

d. A previously unforeseen or newly discovered safety hazard exists that is deemed by either Range Safety or by the Range User to be significant enough to warrant the change.

e. The system does not meet the requirements existing when the system was originally accepted. **NOTE:** This category includes systems that were previously approved, but when obtaining the approval, noncompliances to the original requirement were not identified.

f. A system or procedure is modified and a new requirement reveals that a significant risk exists.

g. Mishap and incident investigations and reports may dictate compliance with this edition of the document.

1.2.4.2 Implementation of Required Changes

All program hardware and operational changes required by the imposition of a new Range Safety requirement shall be implemented in a manner and on a schedule that minimizes the impact on the program and that is agreed to by both the Range User and Range Safety.

1.3 RESPONSIBILITIES AND AUTHORITIES

PL 10, PL 60, PL 98-575, and PD/NSC 25, as implemented by DoDDs 3200.11 and 3230.3, define public, international, launch area, and launch complex safety requirements and establish the responsibility for safety on the Range.

1.3.1 Commanders, 45th Space Wing and 30th Space Wing

a. Final authority and responsibility for safety at the ER and WR rests with the Space Wing Commanders (Range Commanders). The Range Commander or a designated representative is responsible for carrying out the Range Safety Program described in this document.

b. The Wing Commanders shall implement, handle noncompliances, and/or disposition the requirements of this document as it applies to Range User programs on their Range.

c. Where feasible, the Wing Commanders shall coordinate all actions between the Ranges to ensure that consistent and standard Range Safety requirements and approvals are levied on all Range Users.

1.3.2 Chiefs of Safety, 45th Space Wing and 30th Space Wing

The Chiefs of Safety, the designated representatives of the Wing Commanders/Range Commanders, are responsible for establishing, complying with, implementing, and directing the Range

Safety Program. The Chiefs of Safety responsibilities include the following:

a. Enforcing public safety requirements; defining launch area safety and launch complex safety requirements for mission flight control and other Range Safety launch support operations

b. Reviewing and coordinating changes with the Range User and providing Range Safety approval for operational procedures along with oversight for all prelaunch operations at the launch complex and launch vehicle or payload processing facilities for public safety and launch area safety concerns

c. Reviewing, providing Range Safety approval, and auditing operations at a launch complex and associated support facilities for launch complex safety concerns in accordance with a jointly accepted Launch Complex Safety Training and Certification program. **NOTE:** If the Range User control authority decides not to implement the plan then Range Safety will assume complete safety responsibility per subparagraph *b* above.

1.3.3 Commanders, 45th Operations Group and 30th Operations Group

The Commanders, 45th Operations Group (45 OG) and 30th Operations Group (30 OG), are responsible for:

a. Complying with, implementing, and enforcing the Range Safety Program

b. Reviewing and accepting all prelaunch and launch operations procedures at CCAS and VAFB for Air Force Programs, including hazardous and safety critical procedures that may affect public safety or launch area safety, after insuring they have been approved by Range Safety

c. As a control authority, in accordance with the Launch Complex Safety Training and Certification Plan, reviewing and approving prelaunch and launch operations procedures for Air Force programs that are limited to launch complex safety concerns

d. Providing 45 SW/SE and 30 SW/SE with the instrumentation, computers, communications, command transmitter systems, weather support, and Range Safety display systems necessary to carry out prelaunch and flight safety functions. Range Safety shall provide the Operations Groups with mandatory support requirements, and the Operations Groups shall ensure that these requirements are met.

1.3.4 Commander, 45th Logistics Group

The Commander, 45th Logistics Group (45 LG) and 30th Logistics Group (30 LG), are responsible for complying with, implementing, and directing the Range Safety Program and ensuring that all required instrumentation, computers, communications, command systems, and display systems necessary for Range Safety to carry out its functions perform to the prescribed level of reliability and meet specified design requirements.

1.3.5 Commanders, 45th Support Group and 30th Support Group

The Commanders, 45th Support Group (45 SPTG) and 30th Support Group (30 SPTG), are responsible for complying with, implementing, and directing the Range Safety Program and determining, coordinating, and enforcing fire safety, environmental engineering, and explosive ordnance disposal requirements. The Fire Department, Environmental Engineering, and Explosive Ordnance Disposal are responsible for establishing and implementing their programs in coordination with the Office of the Chief of Safety.

1.3.6 Commanders, 45th Medical Group and 30th Medical Group

The Commanders, 45th Medical Group (45 MDG) and 30th Medical Group (30 MDG), are responsible for complying with, implementing, and directing the Range Safety Program and determining, coordinating, and enforcing medical, biological, and radiological health requirements. Radiation Protection Officers and Bioenvironmental Engineering are responsible for establishing and implementing their programs in coordination with the Office of the Chief of Safety.

1.3.7 Offices of the Chiefs of Safety, 45th Space Wing and 30th Space Wing

The Offices of the Chiefs of Safety, 45th Space Wing (45 SW/SE) and 30th Space Wing (30 SW/SE) ensure that the Range Safety Program complies with public law and DoD directives as noted in the **Purpose of the Requirement** section of this Chapter, meets the needs of the Ranges and Range Users, and does not impose undue or overly restrictive requirements on Range User programs. **NOTE:** Unless otherwise noted, the use of the term *Range Safety* in this Chapter refers to 45 SW/SE and 30 SW/SE. The Safety Offices provide operational, engineering, scientific, and mathe-

matical expertise to accomplish flight analysis, system safety, mission flight control, and Air Force ground safety. Figures 1-5a and b provide charts representative of both of the Eastern and Western Range Safety Organizations. The responsibilities of these sections are slightly different and are described below:

1.3.7.1 Air Force Ground Safety, 45th Space Wing and 30th Space Wing and Operations Safety, 30th Space Wing

1.3.7.1.1 Air Force Ground Safety, 45th Space Wing and 30th Space Wing. Air Force Ground Safety, 45th Space Wing (45 SW/SEG) and 30th Space Wing (30 SW/SEG), are responsible for developing and implementing a ground and industrial safety program for Air Force personnel and Air Force resources.

1.3.7.1.2 Operations Safety, 30th Space Wing. Operations Safety, 30th Space Wing (30 SW/SEGP) is responsible for the following. **NOTE:** 30 SW/SEGP is similar to the ER Operations Safety, a government contractor.

- a. Reviewing, coordinating, and approving procedures for prelaunch processing
- b. Monitoring selected activities at the launch head
- c. Providing prelaunch and countdown Launch Disaster Control Groups
- d. Defining Safety Clearance Zones and providing advice for the control of access to Safety Clearance Zones within the confines of the launch head
- e. Providing emergency response support and/or assistance in the event of failures and mishaps during ground operations
- f. Advising the on-site commander on disaster preparedness and responsiveness

1.3.7.2 Mission Flight Control, 45th Space Wing and 30th Space Wing

Mission Flight Control, 45th Space Wing (45 SW/SEOO) and 30th Space Wing (30 SW/SEO) are responsible for protecting the general public, the launch area, and US and foreign land masses from errant launch vehicle flight. In conjunction with Operations Support and Analysis (30 SW/SEY and 45 SW/SEOE and SEOS) and Systems Safety (SES), Mission Flight Control uses flight safety analysis and systems safety engineering products to develop and implement real-time mission rules and flight termination criteria to control errant launch vehicle flight from launch to

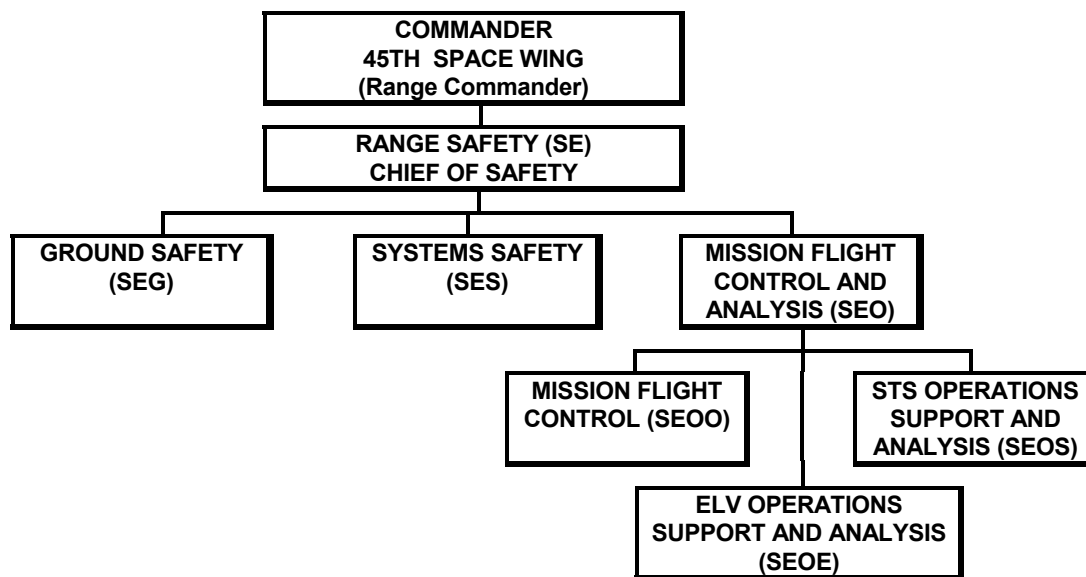


Figure 1-5a
Eastern Range Safety Organization

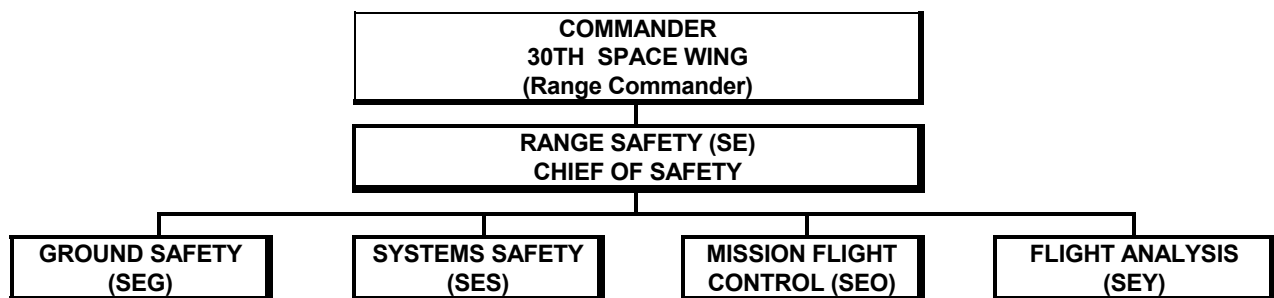


Figure 1-5b
Western Range Safety Organization

impact of vehicles with suborbital trajectories or to orbital insertion for space launch vehicles.

1.3.7.3 Systems Safety, 45th Space Wing and 30th Space Wing

Systems Safety, 45th Space Wing (45 SW/SES) and 30th Space Wing (30 SW/SES) are responsible for ensuring that public, launch area and launch complex safety and resource protection are adequately provided by and for all programs using the Ranges. Responsibilities include:

- a. Developing safety critical design and operating criteria and requirements
- b. Reviewing and approving design, test, and documentation for airborne range safety systems.
- c. Developing, enforcing, reviewing and approving engineering design, test, and documentation for hazardous launch vehicle, payload, ground support

equipment, and facility systems

d. Reviewing, approving, monitoring, and classifying (as public launch area or launch complex safety) hazardous and safety critical operations

e. Providing safety engineering and developing processes and procedures to mitigate risks involved in prelaunch and launch operations for both the general public and launch area

f. At the ER, overseeing Operations Safety and ensuring they meet contract requirements

g. Operations Safety, a government contractor for 45 SW/SES is responsible for reviewing for, monitoring for, and enforcing compliance through Range Safety and/or the appropriate launch complex control authority, with this document and other Range Safety requirements by all personnel operating as Range Users or Support Agencies on the ER, primarily during hazardous and safety

critical operations. The operations and responsibilities of this organization are similar to those performed by 30 SW/SEGP on the WR.

1.3.7.4 Operations Support and Analysis, 45th Space Wing, and Flight Analysis, 30th Space Wing

Operations Support and Analysis, 45th Space Wing (45 SW/SEOE and SEOS) and Flight Analysis, 30th Space Wing (30 SW/SEY) are responsible for developing criteria for the control of errant vehicle flight to provide public safety. Responsibilities include:

- a. Approving all launch vehicle and payload flight plans
- b. Determining the need for flight termination systems
- c. Establishing mission rules in conjunction with 45 SW/SEO and 30 SW/SEO and Range Users
- d. Determining criteria for flight termination action
- e. Assessing risks to protect the general public, launch area, and launch complex personnel and property
- f. Identifying and evaluating risk reduction actions such as evacuation, sheltering, and safety holds for suitable meteorological conditions
- g. Developing mathematical models to increase the effectiveness of errant vehicle control while minimizing restrictions on launch vehicle flight
- h. In conjunction with Mission Flight Control, ensuring that Mission Flight Control Officers are trained to perform errant launch vehicle control
- i. Determining collision avoidance (COLA) requirements for mannable objects

1.3.7.5 Relationship with Range Users

Each of the Safety Office sections is responsible for initiating, establishing, and implementing Range User interface processes to ensure that the requirements of this document are met and, if desired, tailored to meet individual Range User program requirements. The interface process is described in the **Range Safety and Range User Interface Processes** section of this Chapter.

1.3.8 Range Users and Supporting Agencies

Range Users and supporting agencies are responsible for the following:

- a. Providing safe systems, equipment, facilities, and materials in accordance with this document
- b. Conducting their operations in a safe manner

that complies with and implements those portions of the Range Safety Program that are applicable to their programs

c. Obtaining review and approval for the following documents:

1. Tailored versions of EWR 127-1, as desired, System Safety Program Plans (SSPP), noncompliance requests, and Launch Complex Safety Training and Certification Plans (See Appendixes 1A, 1B, and 1C of this Chapter.)

2. Preliminary and Final Flight Data Packages (PFDP and FFDP), Aircraft and Ship Intended Support Plans (ISPs), and Directed Energy Plans (DEPs) (See Chapter 2.)

3. Missile System Prelaunch Safety Package (MSPSP) (See Chapter 3 and Appendix 3A.)

4. Airborne Range Safety System Report (RSSR) (See Chapter 4 and Appendix 4A.)

5. Facility Safety Data Packages (FSDP) as required for all critical facilities and launch complexes (See Chapter 5 and Appendix 5A.) and explosive quantity distance site plans

6. Ground Operations Plans (GOP) and Hazardous and Safety Critical Procedures (See Chapter 6 and Appendixes 6A and 6B.)

- d. Submitting data for flight control operations, obtaining a Range Safety Launch Operations Approval Letter or verbal approval at the Launch Readiness Review, and participating in safety critical operations (See Chapter 7.)

- e. As applicable, ensuring compliance with the National Aeronautics and Space Council document *Nuclear Safety Review and Approval Procedure for Minor Radioactive Sources in Space Operations*

- f. As applicable, ensuring compliance with Presidential Directive/NSC 25 as outlined in DoDD 3200.11 and AFI 91-110

- g. As applicable, ensuring that the requirements of PL 98-575 and DOT Office of Commercial Space Transportation (OCST) 14 CFR, Chapter III are met

h. Performing risk analyses and implementing contingency plans to protect the general public in the event of a threat from de-orbiting launch vehicles. **NOTE:** DOT commercial licenses normally address these analyses for commercial programs.

i. Coordinating their safety programs with Range Safety to ensure the activities of both organizations meet national policy goals and provide for public and launch site safety and resource protection while minimizing impact on mission requirements

j. Providing for crew safety in manned space launch systems and coordinating crew safety policy, procedures, and activities with the Office of the Chief of Safety

k. Verifying compliance with this document. **NOTE:** The use of subcontractors does not relieve the Range User of responsibility. The Range User shall provide adequate contractual direction and monitor subcontractor performance to verify compliance.

l. As applicable, when involved in joint projects, interfacing and integrating with other Range Users or associated contractors in their safety programs

1.4 RANGE SAFETY POLICY

a. It is the policy of the Ranges to ensure that the risk to the public, to personnel at the launch area, and to national resources is minimized to the greatest degree possible. This policy shall be implemented by employing risk management in three categories of safety: Public Safety, Launch Area Safety, and Launch Complex Safety.

b. The Range User shall endeavor to maintain the lowest risk possible, consistent with mission requirements, and in consonance with ER and WR launch risk guidance. **NOTE:** Individual hazardous activities may exceed guidance based on national need after implementation of available cost-effective mitigation. The **Launch Area Safety** section of this Chapter includes formulations for evaluating cost-effectiveness.

c. The Wing Commanders may vary from this criteria for particular programs or missions based on geography, weather, and national need; however, the basic standard is no more than that voluntarily accepted by the general public in normal day-to-day activities.

d. Launch risk guidance has been established based on a standard of a collective risk level of not more than 30 casualties in 1 million (30×10^{-6}) for the general public and not more than 300 casual-

ties in 1 million (300×10^{-6}) for essential launch area personnel. The basic standard for the general public is not more than the risk voluntarily accepted in normal day-to-day activities. Further information on acceptable risk criteria may be found in Appendix 1D.

e. Imminent danger situations are subject to the following:

1. Immediate action shall be taken by the supervisor or individual responsible for the immediate area to correct the situation, apply interim control measures, stop the operation, and evacuate all personnel.

2. Any operation, condition, or procedure that presents imminent danger shall be brought to the immediate attention of the supervisor or individual responsible for the immediate area.

3. All imminent danger situations shall be reported to Range Safety not later than 1 h from the time the situation is identified.

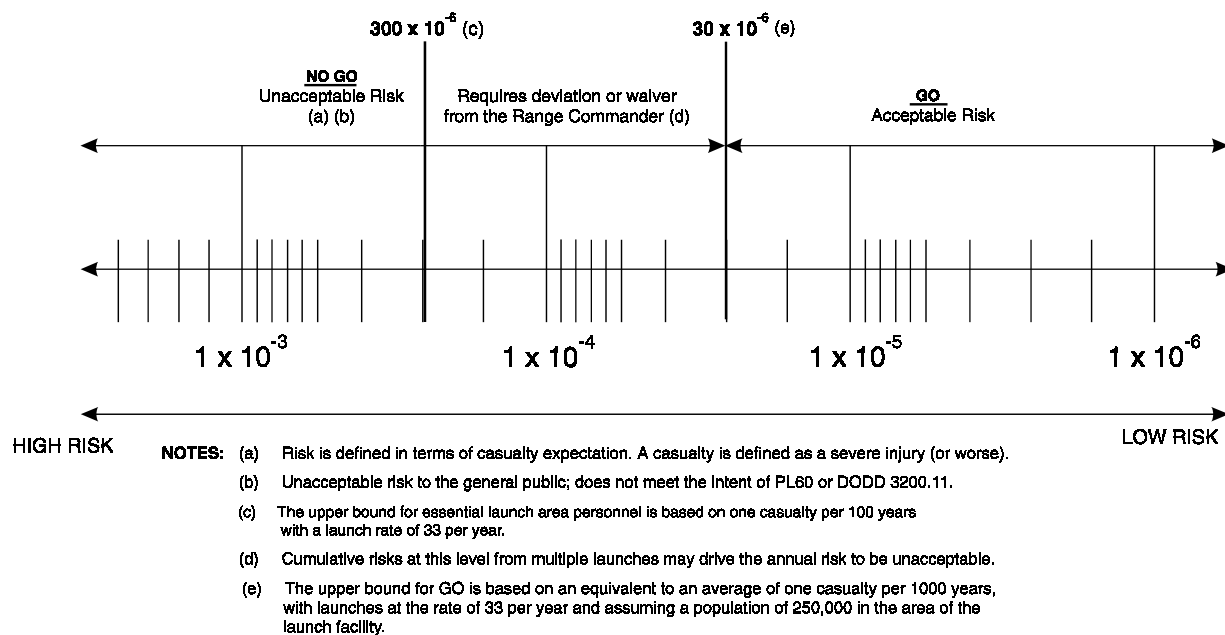
4. Personnel may decline to perform assigned tasks because of a reasonable belief that, under the circumstances, the task presents imminent danger, coupled with a reasonable belief that there is insufficient time through normal reporting for abatement procedures to correct the situation.

1.4.1 Public Safety

The Ranges shall strive to ensure that the risk to the general public and foreign countries from Range operations meets the criteria established in PL 60, Legislative History. Figure 1-6 shows the risk management criteria guidance to be used for determining acceptable risk for individual launches. The figure of 30×10^{-6} shall be used by both Ranges as a level defining "acceptable launch risk without high management (Range Commander) review." Based on national need and the approval of the Range Commander/Wing Commanders, launches may be permitted using a predicted risk above 30×10^{-6} .

1.4.1.1 Prelaunch and Launch Operations

a. Range Safety shall review, approve, and through Operations Safety, monitor, and impose safety holds when necessary, on all prelaunch and launch operations conducted on the Ranges to ensure that the hazards associated with propellants, ordnance, radioactive material, and other hazardous systems do not expose the general public to risks greater than those considered acceptable by public law and state documents, such as PL 99-499, 29



("From a Safety Standpoint they [missiles] will be no more dangerous than conventional airplanes flying overhead." Legislative History, 81st Congress, pg. 1235)

Figure 1-6
Acceptable Public Exposure Launch Operation Risk Guidance

CFR 1910.119, 40 CFR 355, 40 CFR 68, Executive Order 12856, and CAL-OSHA.

b. Range Safety shall conduct and oversee launch vehicle, payload, mission flight control, and Range Safety launch support operations to ensure that risks to the general public and foreign countries and their property do not exceed acceptable limits consistent with mission and national needs.

c. Range Safety shall ensure that each Range User provides each launch system with a capability that allows Range Safety to initiate a hold-fire that prevents launch in the event of loss of Range Safety critical systems or violation of mandatory Range Safety launch commit criteria (Appendix 7A).

1. Safety holds shall be initiated to prevent the start of a launch operation or to stop a launch operation that is already underway if it violates public, launch area, or launch complex safety or launch commit criteria.

2. Safety holds may be called if Range Safety launch commit criteria are violated or if adequate safety cannot be ensured or verified when personnel or resources are jeopardized.

3. Safety holds may be initiated by the Mission Flight Control Officers, Operations Safety Manager, Range Control Officers, Range Operations Commander (WR), Aerospace Control Offi-

cer (WR), Range User, or any responsible supervisor in charge of a launch operation.

1.4.1.2 Range Safety Critical Systems

Range Safety critical systems include all airborne and ground subsystems of the Range Safety System. The Range Safety System consists of airborne and ground flight termination systems (FTSs), airborne and ground Range Tracking Systems (RTSs), and the Telemetry Data Transmitting System (TDTS).

a. All Range Safety critical systems shall be designed to ensure that no single point of failure, including software, will deny the capability to monitor and terminate or result in the inadvertent termination of a launch vehicle or payload, as applicable.

b. The reliability requirements of the Range Safety System are as follows:

1. The overall airborne and ground FTS reliability goal is 0.9981 at the 95 percent confidence level.

(a) The airborne FTS reliability goal shall be a minimum of 0.999 at the 95 percent level. This goal shall be met by combining the design approach and testing requirements of Chapter 4 of this document.

(b) The ground FTS shall have a reliability of 0.999 at the 95 percent confidence level for a 4 h

duration, as required.

2. The overall airborne and ground Range Tracking System (RTS) reliability is a function of the following requirements:

(a) The airborne RTS reliability shall be 0.995 at the 95 percent confidence level for transporter systems and 0.999 at the 95 percent confidence level for global positioning systems. These goals shall be met by combining the design approach and testing requirements of Chapter 4 of this document.

(b) The ground RTS reliability shall be 0.999 at the 95 percent confidence level for a 1 h duration, as required.

3. There are no reliability requirements for the TDTS.

c. When possible, Range Safety critical systems shall be designed to allow single failures in hardware and software and still provide overall system redundancy.

d. Other systems determined to be Range Safety critical shall have a design reliability of 0.999 at the 95 percent confidence level.

1.4.1.3 Control of Errant Vehicle Flight

a. Range Safety shall verify that all launch vehicles launched from or onto the Ranges have a positive, range-approved method of controlling errant vehicle flight to meet the objective of minimizing risks to the general public and foreign countries. **NOTE:** Normally, control systems on launch vehicles using the Ranges shall consist of an airborne Range Safety System that shall meet all the requirements of Chapters 2, 4, and 7 of this document. A thrust termination system may be considered as an alternative to a Range Safety System; however, quantification of risks must be determined, and the requirements in Chapter 2 shall be met. The alternative thrust termination concept and design shall be approved by the Range Commander.

b. Range Safety shall establish flight termination criteria and Range Safety mission flight rules to ensure that operations do not exceed acceptable public safety limits.

c. Range Safety shall establish and control Hazardous Launch Areas and procedures to protect the public on land, on the sea, and in the air for each launch and launch vehicle using the Ranges and to ensure the following criteria are met:

1. No intact launch vehicle, scheduled debris, or payload, or launch vehicle and payload subsystems shall be allowed to intentionally impact on land ex-

cept in the launch area inside the impact limit lines.

2. Flight paths and trajectories shall be designed so that normal impact dispersion areas do not encompass land.

3. Safety margins shall be used to avoid overly restrictive flight termination (destruct) limits.

d. Range Safety may allow errant launch vehicles to fly to obtain maximum data until they would present an unacceptable risk to the public or until Range Safety can no longer control the launch vehicle.

1.4.2 Launch Area Safety

The Ranges shall ensure that all personnel located on CCAS or VAFB or on any supporting site within the ER or WR are provided protection from the hazards associated with Range operations.

a. Table 1-1 shows nominal launch area and launch complex hazard consequence and probability categories correlated to different levels of acceptability for prelaunch hazards not associated with launch or Range Safety launch commit criteria. Numbers provided in Table 1-1 are guides only and are not necessarily hard limits.

b. Range Safety shall provide errant launch vehicle control protection for the launch area, including CCAS, KSC, and VAFB.

c. Range Safety shall conduct risk studies and analyses to determine the risk levels, define acceptable risk levels, and develop exposure criteria.

d. Range Safety shall establish design criteria and controls, procedures, and processes to minimize personnel risks and ensure acceptable launch area/complex risk levels are not exceeded.



e. Range Safety shall evaluate all launch vehicle, payload, ground support, and facility systems used on the Ranges to test, checkout, assemble, handle, support, or launch launch vehicles or payloads with regard to their hazard potential and ensure they are designed to minimize risks to personnel and fall within acceptable exposure levels.

f. Range Safety shall ensure that all hazardous operations affecting launch area safety are identified and conducted using Range Safety approved formal written procedures. Through Operations Safety, Range Safety shall ensure launch area safety is provided in accordance with this document and approved Operations Safety Plans.

g. Range Safety shall define the threat envelope of all hazardous operations affecting launch area safety and establish Safety Clearance Zones to protect personnel and resources. **NOTE:** A minimum

Table 1-1
Acceptability Guidelines for Prelaunch Launch Area/Launch Complex Hazard Consequences and Probability Categories

HAZARD SEVERITY		POTENTIAL CONSEQUENCES				PROBABILITY*				
Category	Personnel Illness/Injury	Equipment Loss(\$)	Unit Downtime	Data Compromise		A	B	C	D	E
I Catastrophic	May cause death.	> 1,000,000	> 4 months	Data is never recoverable or primary program objectives are lost.						
II Critical	May cause severe injury or severe occupational illness.	200,000 to 1,000,000	2 weeks to 4 months	May cause repeat of test program.						
III Marginal	May cause minor injury or minor occupational illness.	10,000 to 200,000	1 Day to 2 Weeks	May cause repeat of test period.						
IV Negligible	Will not result in injury or occupational illness.	< 10,000	< 1 Day	May cause repeat of data point, or data may require minor manipulation or computer rerun.						

RISK PRIORITY:  Unacceptable  Waiver or deviation required  Operation permissible

*Probability refers to the probability that the potential consequence will occur in the life cycle of the system (test/activity/operation). Use the following list to determine the appropriate Risk Level.

DESCRIPTION**	THRESHOLD LEVEL	PROBABILITY VALUE	SPECIFIC INDIVIDUAL ITEM	FLEET OR INVENTORY***
A Frequent	8×10^{-2}	3×10^{-1}	Likely to occur repeatedly	Continuously experienced
B Reasonably probable	8×10^{-3}	3×10^{-2}	Likely to occur several times	Will occur frequently
C Occasional	8×10^{-4}	3×10^{-3}	Likely to occur sometime	Will occur several times
D Remote	8×10^{-5}	3×10^{-4}	Unlikely to occur, but possible	Unlikely, but can reasonably be expected to occur
E Extremely Improbable		3×10^{-5}	The probability of occurrence cannot be distinguished from zero.	Unlikely to occur, but possible

** Definitions of descriptive words may have to be modified based on quantity involved.

*** The size of the fleet or inventory and system life cycle should be defined.

number of personnel shall be exposed to the minimum hazard level consistent with efficient task accomplishment.

h. Range Safety shall ensure all personnel performing hazardous operations that may impact launch area safety are provided adequate training to ensure proper conduct of their jobs and tasks by

reviewing Range User training plans.

i. Launch Area Resource Protection

1. The Ranges shall ensure that launch area physical resources are provided an acceptable degree of protection based on federal law and national standards.

2. Procedures and policies that are applied for public and launch area safety shall be used to reduce risks to launch area physical resources to acceptable levels.

3. Siting, design, and use of physical resources shall consider potential hazards and threat envelopes to ensure that damage exposure is limited to acceptable levels as defined by federal law and national consensus standards.

1.4.3 Launch Complex Safety

The single commercial user, full-time government tenant organization or USAF squadron/detachment commander, as the control authority has the responsibility for launch complex safety and will exercise the function in accordance with the Launch Complex Safety Training and Certification requirements. The control authority has the option of delegating this responsibility to the Chiefs of Safety. **NOTE:** The control authority for safety as defined in this document includes areas within a complete launch complex (or missile silo) and adjacent facilities used by each agency for launch vehicle and/or payload processing. In all cases, the Chiefs of Safety shall review and approve all hazardous operating procedures and any other procedures that Range Safety may review to insure such operations do not pose or create a hazardous condition.

1.4.3.1 General Requirements

a. Regardless of whether the control authority or Range Safety takes responsibility for launch complex safety, the following general requirements apply:

1. Range Safety shall provide errant launch vehicle control protection for the launch area, including CCAS, KSC, and VAFB and all launch complex locations therein.

2. Range Safety shall conduct risk studies and analyses to determine and define launch complex acceptable risk levels and develop exposure criteria.

3. Range Safety shall establish design criteria and controls, procedures, and processes to minimize launch area and launch complex personnel risks and ensure acceptable risk levels are not exceeded.

4. Range Safety shall evaluate all launch vehicles, payloads, ground support, and facility systems used on the Ranges to test, checkout, assemble, handle, support, or launch vehicles or payloads with regard to their hazard potential and ensure they are designed, tested, and maintained to minimize risks to launch complex personnel and fall within acceptable exposure levels.

b. If the control authority assumes responsibility for launch complex safety, the following general requirements apply:

1. As requested, Range Safety shall provide technical advice, requirements interpretation, and safety guidance to the control authority for launch

complex safety issues.

2. Range Safety shall audit launch complex hazardous and safety critical procedures to ensure compliance with this document.

1.4.3.2 Launch Complex Safety Responsibility

The organization responsible for launch complex safety, either Range Safety or the launch complex control authority (AF Squadron Commanders for AF programs), is subject to the following requirements:

a. Hazardous Operations

1. If requested by the control authority, Range Safety shall ensure that all hazardous operations affecting launch complex safety are conducted using Range Safety approved formal written procedures. Through Operations Safety, Range Safety shall ensure launch complex safety is provided in accordance with this document and approved Operations Safety Plans.

2. If assuming responsibility, the control authority shall ensure that all hazardous operations affecting launch complex safety are conducted using formal written procedures approved by a space safety professional. In accordance with Launch Complex Safety Training and Certification Requirements, the control authority shall ensure launch complex safety is provided in accordance with this document and approved Operations Safety Plans.

b. Either the control authority or Range Safety, if requested, shall define the threat envelope of all hazardous operations affecting launch complex safety and establish Safety Clearance Zones to protect launch complex personnel and resources. **NOTE:** A minimum number of personnel shall be exposed to the minimum hazard level consistent with efficient task accomplishment.

c. Either the control authority or Range Safety, if requested, shall ensure all personnel performing hazardous operations that may impact launch complex safety are adequately trained to perform their jobs and tasks.

d. Either the control authority or Range Safety, if requested, shall ensure that adequate personal protective equipment is provided as defined by this document and approved Operations Safety Plans.

e. The areas and facilities for which the control authority has responsibility for launch complex safety are available from the Range Safety Offices.

f. Launch Complex Resource Protection

1. The Ranges and control authorities shall ensure that launch complex physical resources are provided an acceptable degree of protection based on federal law and national consensus standards.

2. Procedures and policies that are applied for public, launch area, and launch complex safety shall be used to reduce risks to launch complex physical resources to acceptable levels.

3. Siting, design, and use of physical resources shall consider potential hazards and threat envelopes to ensure that damage exposure is limited to acceptable levels as defined by federal law and national consensus standards.

4. Launch complex resource protection issues shall be coordinated between Range Safety and the affected Range Users.

(a) USAF squadron or detachment Commanders shall be responsible for implementing resource protection requirements for all DoD flight hardware, ground support equipment, and facilities within their assigned areas.

(b) US Navy, NASA, and other government tenant organizations shall be responsible for all tenant-occupied facilities and tenant-owned equipment.

(c) The CCAS Commander shall be responsible for implementing of resource protection requirements for an area on CCAS not assigned to a specific USAF squadron or detachment commander or other Range User.

(d) Commercial Range Users shall be responsible for commercially owned, leased, or licensed physical resources

1.4.3.3 Launch Complex Safety Training and Certification Requirements

The control authority shall implement a Launch Complex Safety Training and Certification Plan in accordance with the Launch Complex Safety Training and Certification Requirements available from the Range Safety Offices. This process includes the following steps:

a. Range Safety and the control authority jointly tailor the subject document.

b. The control authority submits a plan to comply with the subject document.

c. Range Safety reviews and approves the plan.

d. The complex control authority safety plan shall include qualification and certification documentation of personnel performing the safety function for review and approval by the Chiefs of Safety.

e. Range Safety shall audit launch complex safety procedures and processes as necessary.

1.5 SAFETY AUTHORIZATIONS, COMPLIANCES, AND DOCUMENTATION

1.5.1 Purpose of Obtaining Safety Approvals

a. To operate, use, and launch launch vehicles and payloads from or onto the Ranges, specific mandatory safety approvals shall be obtained to show compliance with and meet the requirements of the Ranges.

b. Commercial users providing launch services shall have a license approved by the Federal Aviation Administration/Associate Administrator for Commercial Space Transportation (FAA/AST) in accordance with 14 CFR Chapter III and meet the requirements of PL 98-575.

1.5.2 Authorizations

a. Programs launching from only the ER or WR shall obtain authorizations from the appropriate 45 SW or 30 SW authority.

b. Programs launching from both the ER and WR shall obtain authorizations for common requirements from appropriate 45 SW and 30 SW authorities.

c. Unique requirements shall require authorizations from the appropriate 45 SW or 30 SW authority.

d. In general, if a program is approved at the ER or WR, it will be approved at the other without further review with the exception of ER or WR specific requirements identified in this document, design or operational changes to the program due to the change of processing location (a new GOP and hazardous procedures are normally always required), and the exceptions identified in items a through g of the **Status of Previously Approved Programs** section of this Chapter.

1.5.2.1 Safety Approvals Authorized by the Wing Commanders

The following safety approvals shall be authorized by the Wing Commanders:

a. Tailored versions of EWR 127-1 affecting public safety

b. Range Safety mission flight rules, including termination (errant vehicle control) criteria for all launch vehicles

c. Range Safety launch commit criteria for all launch vehicles

- d. The launch of launch vehicles containing explosive warheads
- e. The launch of nuclear payloads
- f. Noncompliances affecting public safety

1.5.2.2 Safety Approvals Authorized by the Chief of Safety or a Designated Representative

The following safety approvals shall be authorized by the Chief of Safety or a designated representative:

- a. Tailored versions of EWR 127-1 not affecting public safety
- b. Noncompliances not affecting public safety
- c. System Safety Program Plan
- d. Launch Complex Safety Training and Certification Plan
- e. Preliminary and Final Flight Data Packages
- f. Aircraft and Ship Intended Support Plans
- g. Directed Energy Plans
- h. Missile System Prelaunch Safety Package
- i. Airborne Range Safety System Report
- j. Hazardous and Safety Critical Procedures
- k. Facilities Safety Data Package
- l. Range Safety Launch Operations Approval Letter
- m. Final Range Safety Approval for Launch
- n. Range Safety instrumentation, tracking, data, and display requirements for all launch vehicles
- o. Range Safety Operations Requirements

1.5.2.3 Launch Complex Safety Approvals Authorized by Control Authorities

Control authorities may approve hazardous and safety critical procedures associated with launch complex safety in accordance with Launch Complex Safety Training and Certification Requirements.

1.5.2.4 Safety Approvals Authorized by the DoD Explosive Safety Board

Explosive site plans require the signature of a member of the DoD Explosive Safety Board (DDESB).

1.5.3 Radioactive Material Launches

All Range Users shall notify Range Safety of any intended launch of radioactive materials during the concept phase of the program.

1.5.3.1 National Aeronautics and Space Council Compliance

As applicable, all Range Users shall certify compliance with the National Aeronautics and Space

Council (NASC) document, *Nuclear Safety Review and Approval Procedures for Minor Radioactive sources in Space Operations*, dated 16 June 1970. Range Users may use their own agency equivalent document if it meets the requirements of the NASC document. Detailed information and procedures are in Chapter 3.

1.5.3.2 Presidential Directive/National Security Council 25 Compliance

As applicable, all Range Users contemplating launch of a major radioactive source shall comply with PD/NSC 25 as outlined in DoDD 3200.11 and AFI 91-110. Detailed information and procedures are in Chapters 2 and 3.

1.5.3.3 Radioactive Material Launch Approval

All Range Users shall certify and show proof to Range Safety that they have obtained launch approval for radioactive materials. Detailed information and procedures are in Chapters 2 and 3.

1.5.4 Documentation and Activity Requirements

Chapters 2 through 7 of this document have **Documentation Requirements** sections. These sections describe the documents that shall be submitted and the processes that shall be used to obtain the necessary approvals to launch from the Ranges. In addition, appendixes in Chapters 2, 3, 4, 5, and 6 provide detailed document content requirements that shall be met for some, but not all required documents. All other documentation noted in the specific chapters shall also be approved as indicated in the respective chapters. **NOTE 1:** While developing the documentation requirements, Range Users are encouraged to work closely with Range Safety to facilitate the approval process. **NOTE 2:** The Range User Handbook provides additional helpful information regarding documentation requirements.

1.5.4.1 Tailored EWR 127-1, System Safety Program Plan, Noncompliance Requests, and Launch Complex Safety Training and Certification Plan

- a. If desired, a Range User and Range Safety jointly tailored EWR 127-1 may be developed. (See Appendix 1A for further information.)
- b. A Systems Safety Program Plan (SSPP) shall be approved within 45 days of any program cDR. (See Appendix 1B for further information.)
- c. Noncompliance requests shall be submitted

for all identified noncompliances to this document. (See Appendix 1C for further information.)

d. If a control authority desires to assume launch complex safety responsibility, a Launch Complex Safety Training and Certification Plan shall be approved prior to assumption of this responsibility.

1.5.4.2 Flight Data Packages, Intended Support Plans, and Directed Energy Plans

a. The PFDP and FFDP shall be approved prior to support final Launch Readiness Reviews (LRRs).

b. ISPs shall be approved prior to the LRR.

c. DEPs shall be approved prior to the LRR.

d. PFDP, FFDP, ISP, and DEP content requirements may be found in Chapter 2.

1.5.4.3 Missile System Prelaunch Safety Package

a. The MSPSP including design documentation, initial test plans and test reports, and recertification requirements for all hazardous and safety critical launch vehicle and payload systems, ground support equipment, facilities, their interfaces, and operations shall be approved prior to hardware arrival and/or use at the Ranges. **NOTE:** The National Aeronautics and Space Administration (NASA) is responsible for providing review and approval for potential hazardous systems and activities on KSC, except for launch vehicle flight safety, which is the responsibility of the ER.

b. Content and submittal requirements for the MSPSP can be found in Chapter 3 and Appendix 3A.

1.5.4.4 Airborne Range Safety System Report

a. The airborne RSSR, including all design documentation and test plans and test reports for the FTS, RTS, and TDTS shall be approved prior to launch.

b. Content and submittal requirements can be found in Chapter 4 and Appendix 4A.

1.5.4.5 Ground Operations Plan and Hazardous and Safety Critical Procedures

a. The GOP shall be approved prior to the start of operations at the Ranges.

b. Content and submittal requirements for the GOP can be found in Chapter 6 and Appendix 6A.

c. Hazardous and safety critical procedures shall be approved by Range Safety prior to their use at the Ranges.

d. Content and submittal requirements for Haz-

ardous and Safety Critical Procedures may be found in Chapter 6 and Appendix 6B.

1.5.4.6 Facilities Safety Data Package

a. The FSDP shall be approved prior to facility use.

b. Content and submittal requirements for the FSDP may be found in Chapter 5 and Appendix 5A.

1.5.4.7 Launch Operations Approval

a. WR. A Range Safety Launch Operations Approval Letter to launch from or onto the WR shall be provided to the Range User no later than the scheduled LRR conducted prior to a planned launch operation. Receipt of this letter depends on the Range User having obtained the previously required approvals described in this Chapter.

b. ER. Launch Operations Approval Letters are not normally used on the ER. Wing Safety's GO at the LRR constitutes approval to launch and is contingent upon the Range User having obtained the required approvals identified in this Chapter. However, a Range Safety Launch Operations Approval Letter can be provided, if requested.

c. Lack of Launch Operations Approval may result in the launch being withdrawn from the Range schedule.

1.5.4.8 Final Range Safety Approval to Launch

a. Holdfire checks, Range Safety System checks, and other safety critical checks shall be performed satisfactorily; environmental conditions shall be met; and all Range Safety launch commit criteria shall be "green" prior to final approval to launch.

b. Given that holdfire checks, Range Safety System checks, other safety critical checks, and

environmental conditions are satisfactory and all Range Safety launch commit criteria are “green,” Range Safety shall provide a final approval to launch as follows: At the ER, the Chief of Safety provides approval by relaying the MFCO, “CLEAR TO LAUNCH.” At the WR, the MFCO issues a GREEN to go electronically and a verbal call “Safety is sending a green.”

1.6 RANGE SAFETY AND RANGE USER INTERFACE PROCESS

The complexity of present space programs and the inevitable cost of changes in hardware and impact on time schedules can be reduced by joint Range Safety and Range User planning. The goal of the interface process is to provide final Range Safety approvals for launch as early as possible. Range Users are strongly encouraged to solicit Range Safety participation in the development of Requests for Proposals, source selection processes, and development of contract documents such as Statements of Work and Contract Data Requirements Lists.

It is not the intent of this document or the interface process to stifle ingenuity, new technology, state-of-the-art development, or unique solutions to safety problems. Instead, the interface process ensures that both Range Safety and Range Users understand the requirements of this document and reach mutual agreement on compliance methods early in the program.

1.6.1 Range Safety Funding

Range Users and supporting agencies are responsible for full funding of activities associated with Range Safety support early in and throughout the program in accordance with funding requirements of DoDD 3200.11, AFR 80-29, AFI 99-110 at the ER and WR and 45 SWI 99-101 at the ER with the follow-on funding for each fiscal year to be received at the start of each fiscal year. Programs intending to perform launch operations at both the ER and WR shall fund both Ranges.

At the ER, Range Safety will provide cost estimates in accordance with 45 SWI 99-101 to help Range Users estimate funding requirements.

1.6.2 Initial Range Safety and Range User Technical Interchange Meeting

Range Users shall contact Range Safety to arrange an initial Technical Interchange Meeting (TIM) during the concept phase of a program. The pur-

pose of this meeting is to present program concepts regarding flight plans; launch complex selection; launch vehicle, payload, and ground support equipment; range safety system; and facility design, operations, and launch complex safety responsibility to determine if there are any major safety concerns that could impact the program.

This TIM may occur at anytime but should be no later than the formal Program Introduction in accordance with the Universal Documentation System and, at the ER, 45 SWI 99-101. The cost of the initial interface meetings will not be charged to the Range User as long as the workload associated with this activity is insignificant in scope.

1.6.3 Tailoring Process

If desired by the Range User, Range Safety and the Range User shall jointly develop a tailored edition of this document for the program. The purpose of tailoring the document is to ensure that only applicable or alternative Range User requested equivalent requirements are levied upon the program and that Range Safety requirements are levied in the most efficient manner possible.

a. Requirements in this document are subject to tailoring within limits, including detailed design, operating, and documentation submission requirements. Details of the tailoring process can be found in Appendix 1A.

b. Tailoring, if desired, should begin at the earliest opportunity and finish no later than the critical design review.

1.6.4 Other Range Safety and Range User Technical Interchange Meetings and Reviews

Range Users and Range Safety shall jointly agree to arrange the following TIMs and reviews as necessary:

a. Flight Safety TIMs (PFDP-, FFDP-related, Chapter 2)

b. As required, combined or independent safety reviews in association with the Concept Design Review (cDR), Preliminary Design Review (PDR), and Critical Design Review (CDR) for launch vehicle, payload, and associated ground support equipment design (MSPSP-related, Chapter 3), airborne Range Safety System and associated ground support equipment design (RSSR-related, Chapter 4), critical facility design (FSDP-related, Chapter 5), and ground operations plans (GOP-related, Chapter 6)

1. cDRs shall provide design and operations detail to at least the system level.

2. PDRs shall provide design and operations detail to at least the subsystem and box level.

3. CDRs shall provide design and operating detail to the component and piece part level.

c. Hazardous and Safety Critical Procedures TIMs (Chapter 6)

d. Other TIMs, reviews, and meetings as necessary

1.6.5 Noncompliance With the Requirements

Range Users are responsible for identifying all noncompliances with this document to Range Safety for resolution. The three types of noncompliances are meets intent certifications (MICs), deviations, and waivers. Details and requirements for submitting noncompliance requests can be found in Appendix 1C.

1.6.5.1 Meets Intent Certification

MICs are used when Range Users do not meet exact EWR 127-1 requirements but do meet the intent of the requirements. Rationale for equivalent safety shall be provided. **NOTE:** MICs are normally incorporated during the tailoring process.

1.6.5.2 Deviations and Waivers

Deviations and waivers to the requirements of this document are used when the mission objectives of the Range User cannot otherwise be achieved. **NOTE 1:** Many previously approved waivers would be classified as deviations based on the definition below. **NOTE 2:** Programs using earlier editions of the document will continue to hold waiver approvals; new documentation is not required.

1.6.5.2.1 Deviations. Deviations are used when a design noncompliance is known to exist prior to hardware production or an operational noncompliance is known to exist prior to beginning opera-

tions at the Ranges.

1.6.5.2.2 Waivers. Waivers are used when, through an error in the manufacturing process or for other reasons, a hardware noncompliance is discovered after hardware production, or an operational noncompliance is discovered after operations have begun at the Ranges.

1.6.5.2.3 Deviation and Waiver Policy.

a. It is the policy of the Ranges to avoid the use of deviations and waivers except in extremely rare situations, and they are granted only under unique and compelling circumstances. Range Safety and the Range User shall jointly endeavor to ensure that all requirements of this document are met as early in the design process as possible to limit the number of required deviations and waivers to an absolute minimum.

b. Individually, the Range Commanders have the authority to change, deviate from, or waive any requirement in this document for a specific program or mission operating at the respective launch area. Each Range Commander has the authority to accept risks that exceed those defined in Table 1-1 for a specific mission based on national or mission need.

1. Rationale for national need or mission requirements shall be explained.

2. Acceptable risk mitigation and "get well" plans shall be provided since they are an integral part of the basis for approval.

c. When granted, deviations and waivers are normally given for a defined period of time or a given number of missions until a design or operational change can be implemented.

1.6.6 System Safety Program Requirements

Range Users shall develop and maintain a System Safety Program in accordance with Appendix 1B of this Chapter. An SSPP shall be submitted to Range Safety for review and approval.

1.7 RANGE SAFETY CONCEPT TO LAUNCH PROCESS

The overall Range Safety process from "concept to launch" for new launch vehicles is shown in Figure 1-7. This process is tailorable to apply to payloads, ground support equipment, critical facilities, and/or hazardous and safety critical operations. The top row of boxes represents the subprocesses for establishing the program concept and applicable Range Safety requirements per this Chapter. The second

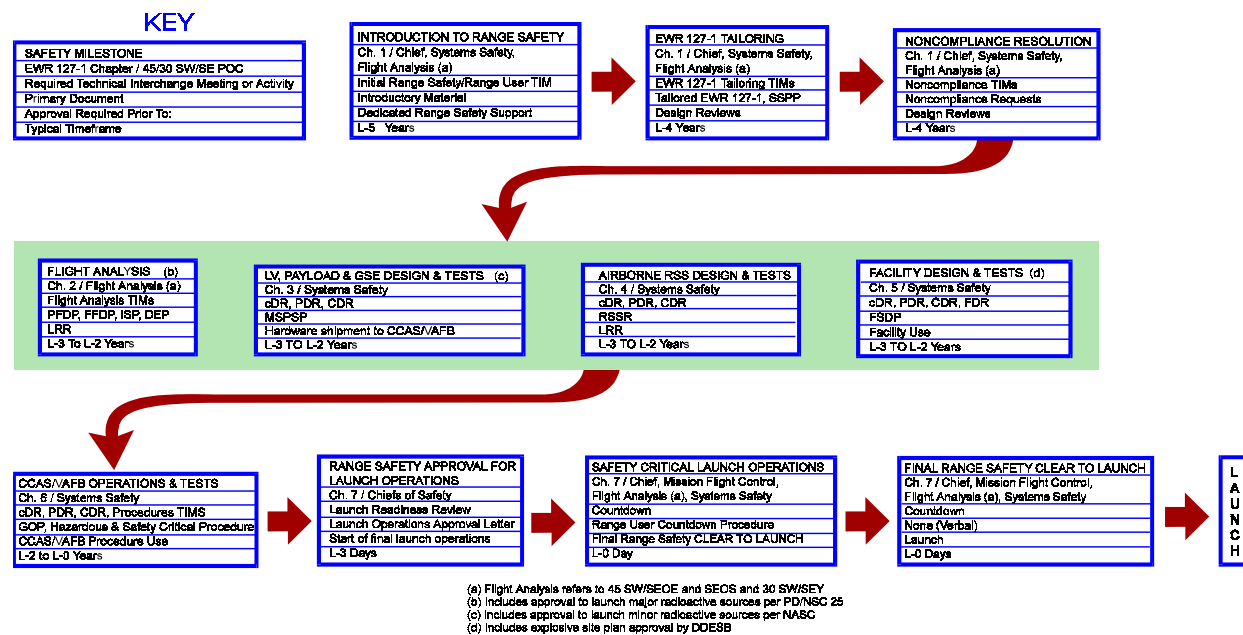


Figure 1-7
Range Safety "Concept to Launch" Process

row of boxes represents the subprocesses for analysis, design and test for the program per Chapters 2-5 of this document. The third row of boxes represents the subprocesses for operations and launch at the Ranges per Chapters 6 and 7 of this document. Details of the steps of this process can be found in this Chapter and Chapters 2 through 7 of this document as indicated. In addition, the Range User Handbook describes this process in greater detail. **NOTE:** Appendix 1F contains a detailed tailored version of this process specifically developed for generic payloads and payload buses.

1.7.1 Range Safety Milestones

Range Safety milestones are those events that shall occur for Range Safety to approve a program during the "concept to launch" cycle. The contents of the document, 45 SW/SE and 30 SW/SE responsibilities and authorities, required meetings and activities, documentation, and approvals, have been addressed earlier in this Chapter.

1.7.2 Time Frames and Schedules

Time frames and event schedules vary depending upon the complexity of the program. Figure 1-7 time frames provide a general schedule of events as guidance for new, major launch vehicle pro-

grams. For smaller vehicles and payloads, these time frames can be compressed to a year or less. Time frame requirements for Range Safety and the Range Users throughout the document are baselines for all programs; however, they may be altered during the tailoring process.

1.8 CHANGES TO APPROVED GENERIC SYSTEMS

a. Once baseline or generic launch systems, including launch vehicles, payloads, ground support equipment, RSSs, and critical facilities have been approved, only those systems and subsystems that change shall be submitted to Range Safety for review and approval. **NOTE 1:** The approval process remains the same as described above and is subject to the requirements in the **Situations Requiring Reevaluation of Previously Approved Programs** section of this Chapter. **NOTE 2:** Ap-

pendix 1F provides a tailored process for the approval of generic payloads.

b. Documentation shall be marked or labeled as "Mission Unique," "Upgrade," "Change," or "Other" to the previously approved system and shall be prepared in such a manner to allow easy reference to previously approved submittals.

1.9 CHANGES TO EWR 127-1

This document shall normally be updated at least once every four years; however, it may be updated once a year. If circumstances warrant, revisions may be made on a chapter-by-chapter basis within these time constraints.

a. Permanent changes to EWR 127-1 shall be performed in accordance with the requirements in Appendix 1E.

b. Changes requiring immediate attention, such as those based on a previously unknown risk or safety compromise, shall be made as necessary and distributed as EWR 127-1 Change Notices.

c. Change Notices shall be coordinated between the ER and WR, and all affected Range Users shall be notified.

1.10 INVESTIGATING AND REPORTING MISHAPS AND INCIDENTS

1.10.1 Mishaps and Incidents Involving Air Force Personnel and Resources

In accordance with AFI 91-204, the Ranges shall investigate and report all mishaps involving Air Force personnel and resources.

1.10.2 Non-Air Force Personnel and Resources

a. The ER and the WR will not report or investigate non-Air Force mishaps under AFI 91-204 aus-

pices. However, Range Safety may assist and participate in non-Air Force mishap investigations that affect or could affect operations on the Range, public safety, launch area safety, launch complex safety, or resource protection.

b. Range Safety shall be provided with the investigation results of any mishaps or incidents occurring on the Ranges.

c. Regardless of the Range User, the Range Commander may conduct formal investigations into any mishap and incident that affects or could affect public, launch area safety, or launch complex safety.

1.11 RANGE SAFETY RANGE USER HANDBOOK

A Range Safety Range User Handbook is available to all Range Users. This handbook provides informational tools to help Range Users achieve the Range Safety "concept to launch" process in the most efficient manner possible. Contact the Range Safety Office to obtain a copy or download the handbook from the Range Safety web site.

1.12 RANGE SAFETY WEB SITE

The Range Safety web site is a tool for notifying the Range User community of issues pertaining to Safety, including changes to EWR 127-1, and for distributing the various editions of 127-1. The 1997 and subsequent editions will be distributed primarily via the web site. The address (subject to change) is as follows:

<http://www.patrick.af.mil/45sw/rangesafety/45swse.htm>

Accessing through the 45th Space Wing Home Page (<http://www.patrick.af.mil/>) requires clicking on "Wing Staff," then selecting "Range Safety" (subject to change). Questions and comments can be sent via e-mail to ewr1271@patrick.af.mil.

APPENDIX 1A**1.2 1.2 THE EWR 127-1 TAILORING PROCESS****1A.1 INTRODUCTION****1A.1.1 Purpose**

Tailoring provides a means for formulating a specific edition of the document incorporating only those requirements that apply to a particular Range User program. A tailored version of the document is denoted as EWR 127-1 [T]. Programs that launch from only the ER or WR shall be tailored by the appropriate 45 SW/SE or 30 SW/SE section. Programs that intend to launch from both Ranges shall be tailored by a combined 45 SW/SE and 30 SW/SE team.

1A.1.2 Content

This Appendix describes the rationale for tailoring, the tailoring process, and the requirements for documenting tailored editions of the document.

1A.1.3 Applicability

The tailoring process is applicable to all programs (boosters, solid rocket motors, upper stages, payloads, associated ground support equipment and facilities). The tailoring process is optional for new programs, and existing programs where Range Safety and the Range User agree this process would be effective.

1A.1.4 Formation of a High Performance Work Team

A high performance work team (HPWT) shall be formed to perform tailoring during Technical Interchange Meetings (TIMs). HPWT Membership shall include Range User and Range Safety personnel who have specific tailoring authority.

1A.1.5 Tailoring Rationale

Tailoring shall be accomplished based on the following rationale:

1A.1.5.1 Deletion of a Requirement

a. When a requirement is not applicable to a Range User Program, the requirement shall be deleted.

b. The original paragraph number and headings shall remain, but the non-applicable text shall be removed and replaced with the abbreviation *N/A*.

1A.1.5.2 Change to a Requirement.

a. MICs may be provided by the High Performance Work Team through the change process; however, the High Performance Work Team cannot provide deviation or waivers.

b. A change is allowed to tailor the requirement to a particular system as long as the intent of the requirement is met and the equivalent level of safety is maintained.

c. The change shall be written in the place of the original requirement.

d. The existing numbering system shall remain the same to the maximum extent possible.

e. Additional paragraphs may be added; however, using the remaining unaffected paragraph numbers is not allowed.

f. All changes shall be highlighted in bold.

1A.1.5.3 Addition to a Requirement

a. An addition to a requirement is allowed when there are no existing requirements addressing new technology, when unforeseen hazards are discovered, when federal or industry standards change, and for similar reasons.

b. An addition shall be added with new paragraph numbers in the section for which it is appropriate or in a new section if no other section applies.

c. All additions shall be highlighted by underline.

1A.1.5.4 Range User Information Only

a. Requirements having only an indirect effect on the Range User but which are still required of the program as a whole shall remain in the tailored document as information only. Examples of such requirements include Operations Safety responsibilities, other Range Contractor responsibilities, and Range User facilities manager responsibilities.

b. All "Range User Information Only" requirements shall be highlighted with an asterisk prior to the affected paragraph number.

1A.1.5.5 Deviations and Waivers

Deviations and waivers are not rationale for the deletion of requirements. The requirements shall

APPENDIX 1A

1.1 1.1 THE EWR 127-1 TAILORING PROCESS

remain in the EWR 127-1 [T] and the deviation and waiver process shall be used for the disposition of the requirement.

1A.1.5.6 Risk-Cost Benefit Analysis

a. Technical issues regarding such items as applicable requirements, policy, criteria, or data may be evaluated on a risk-cost benefit basis to determine if the risk is acceptable to deviate from or waive the requirements.

b. A risk-cost benefit analysis, based on the criteria defined in Figure 1-6 and Table 1-1 of this Chapter shall be submitted to Range Safety.

c. Based on risk-cost benefit analysis data, Range Safety and the Range User shall reach agreement on the disposition of the requirement in question.

d. If the application of an EWR 127-1 requirement results in significant reduction of risk at a significant cost benefit, it may be judged by Range Safety to be sufficient to impose the requirement; however, if the benefit is insignificant and/or the cost is high, the requirement may be deviated from, waived, or determined to meet the intent, all with consideration for public safety.

1A.1.6 Scheduling Technical Interchange Meetings

a. TIMs are required for Range Users to present their systems to Range Safety and to participate in the active tailoring of the document.

b. TIMs shall be scheduled as early in the program as possible when program definition is sufficient to make the meetings worthwhile and structured so that technical tailoring is completed before contractual tailoring (word smithing) is started.

c. EWR 127-1 [T] TIM data shall be provided to Range Safety at least 30 days prior to scheduled TIMs.

1A.2 TAILORING PROCESS

1A.2.1 Preparation of an Optional Draft Edition of EWR 127-1

a. If desired, the Range User and/or Range Safety may produce an optional draft edition of EWR 127-1 Tailored [T] based on conceptual data and meetings.

b. The purpose of a draft EWR 127-1 [T] is to eliminate all non-applicable requirements, leaving only applicable requirements from which detailed tailoring can be performed.

c. The draft EWR 127-1 [T] shall be delivered as

soon as possible and is negotiable.

1A.2.2 Generation of Tailoring Requests

a. EWR 127-1 [T] Tailoring Requests shall be used to document proposed EWR 127-1 [T] deletions, changes, and additions.

b. Tailoring Requests should be completed prior to scheduled TIMs and submitted to Range Safety for review or they may be completed during TIMs. **NOTE:** An example is in the Range User Range Safety Handbook.

c. The forms for submitting Tailoring Requests may be found in the Range User Handbook.

d. A matrix-type format, containing the same information as the Tailoring Request form, may be used as an alternative if mutually agreeable to the Range User and Range Safety.

1A.2.2.1 Completing Tailoring Requests

a. The original EWR 127-1 paragraph number, original (or summarized, if sufficiently detailed) text, tailored paragraph number, proposed text, and the rationale for the change shall be included.

b. Deletions of requirements that are non-applicable and need no formal explanation may all be listed on one or more Tailoring Request forms.

c. Tailoring Requests dealing with similar or related requirements and rationale may all be combined on the same Tailoring Request form.

1A.2.2.2 Disposition of Tailoring Requests

a. If necessary, Range Safety will comment on the proposed change and dispose of it as "approved as written," "approved with provided comments," or "disapproved."

b. When agreement is reached and a Tailoring Request approved, Range Safety and Range User representatives shall sign and date the form.

1A.2.3 Publication of EWR 127-1 [T]

1A.2.3.1 Final Publication

a. The goal for final publication of an EWR 127-1 [T] is as soon as possible, but should be no later than 30 days after the PDR.

b. In some cases, it may be necessary to complete the EWR 127-1 [T] as part of the contracting process or at some other point prior to the PDR. In these cases, Range Safety will work with the Range User to establish and meet a completion date for EWR 127-1 [T] publication.

APPENDIX 1A**1.3 1.3 THE EWR 127-1 TAILORING PROCESS****1A.2.3.2 Identification of EWR 127-1 [T]**

a. Each EWR 127-1 [T] shall be given a unique title and each header of each page of the EWR 127-1 [T] shall indicate the edition is a tailored edition of EWR 127-1.

b. Even page headers shall incorporate the title of the program, the edition number, and the date (EWR 127-1 Tailored for XXX Program, Edition X, Date).

c. Odd page headers shall incorporate the title of the chapter and the chapter number (Eastern and Western Range Policies and Processes, Chapter 1 [T]).

1A.2.3.3 Effectivity of EWR 127-1 [T]

a. Each EWR 127-1 [T] shall contain a preface paragraph detailing its effectivity.

b. At a minimum, the types of vehicles, the time period, and the number of vehicles to which the EWR 127-1 [T] applies shall be addressed.

1A.2.3.4 Assumptions

a. Each EWR 127-1 [T] shall contain a preface paragraph detailing the critical assumptions that were made in writing the tailored edition.

b. The nature of the assumptions shall be such that a change may invalidate the EWR 127-1 [T] or require a change or update. An example of such a critical assumption is that the design of any hazardous system does not change from that presented prior to publication of the EWR 127-1 [T].

1A.2.3.5 Management Summaries

a. Since management will be unable to review all complete editions of EWR 127-1 [T], management summaries shall be prepared to specifically identify EWR 127-1 [T] deletions, changes, and additions.

b. The management summary shall consist of all signed EWR 127-1 [T] Tailoring Requests and a list of all HPWT members.

c. A copy of the management summary and the final EWR 127-1 [T] ready for signature shall be provided to the Range Commander and the Chief of Safety for their signature.

1A.2.4 Approvals

a. Each significant addition, change, or deletion shall be signed off by the Range Safety Program manager and the appropriate Range User representative on the Tailoring Request form.

b. Tailored chapters affecting public safety (normally Chapters 1, 2, 4, and 7) shall be approved and signed by the Chief of Safety or a designated representative and the appropriate Range User representative on the Preface page of the EWR 127-1 [T].

c. Tailored chapters not affecting public safety (normally Chapters 3, 5, and 6) shall be approved and signed by the appropriate Range Safety section chief or a designated representative and the appropriate Range User representative.

d. Each complete, final EWR 127-1 [T] affecting public safety shall be approved and signed by the Wing Commander or a designated representative and the appropriate Range User representative.

1A.2.5 Revisions to EWR 127-1 [T]

a. Any revision to the document shall be evaluated against each program EWR 127-1 [T] to determine applicability.

b. Any revisions to EWR 127-1 [T] shall be made in accordance with the EWR 127-1 change process.

APPENDIX 1B

SYSTEM SAFETY PROGRAM REQUIREMENTS

1B.1 GENERAL SYSTEM SAFETY PROGRAM REQUIREMENTS

1B.1.1 System Safety Program

The Range User shall establish and maintain a system safety program to support efficient and effective achievement of overall system safety objectives.

1B.1.1.1 Management System

The Range User shall establish a safety management system to implement provisions of this document. A Range User program manager shall be responsible for the following:

- a.* Establishing, controlling, incorporating, directing, and implementing the system safety program policies
- b.* Ensuring that mishap risk is identified and eliminated or controlled within established program risk acceptability parameters.
- c.* Establishing internal reporting systems and procedures for investigation and disposition of system related mishaps and safety incidents, including potentially hazardous conditions not yet involved in a mishap or incident and reporting such matters to Range Safety
- d.* Reviewing and approving safety analyses, reports, and documentation submitted to Range Safety to establish knowledge and acceptance of residual risks.

1B.1.1.2 Key System Safety Personnel

The Range User shall establish and maintain a key system safety position for each program. The individual in this position shall be directly responsible to the Range User program manager for safety matters. At a minimum, Range User safety personnel shall be responsible for the following:

- a.* Reviewing and approving safety analyses, reports, and documentation submitted to Range Safety.
- b.* Reviewing and approving all hazardous and safety critical test plans and procedures conducted at the Ranges and verifying that all safety requirements are incorporated.

1B.1.1.3 Compliance

Compliance with all contractually imposed requirements of this document is mandatory. When a requested system safety program plan is approved by Range Safety, it provides a basis of understanding between the Range User and Range

Safety as to how the system safety program will be accomplished. Any noncompliance must be requested by the Range User and approved by Range Safety.

1B.1.1.4 Conflicting Requirements

When conflicting requirements or deficiencies are identified in system safety program requirements or with other program requirements, the Range User shall submit notification, with proposed solutions or alternatives and supporting rationale, to Range Safety for resolution.

1B.1.1.5 System Safety Precedence

The order of precedence for satisfying system safety requirements and resolving identified hazards shall be as follows:

- a.* Design for minimum risk. From the first, design to eliminate hazards. If an identified hazard cannot be eliminated, reduce the associated risk to an acceptable level, as defined by Range Safety, through design selection.
- b.* Incorporate safety devices. If identified hazards cannot be eliminated or their associated risk adequately reduced through design selection, that risk shall be reduced to a level acceptable to Range Safety through the use of fixed, automatic, or other protective safety design features or devices. Provisions shall be made for periodic functional checks of safety devices when applicable.
- c.* Provide warning devices. When neither design nor safety devices can effectively eliminate identified hazards or adequately reduce associated risk, devices shall be used to detect the condition and to produce an adequate warning signal to alert personnel of the hazard. Warning signals and their application shall be designed to minimize the probability of incorrect personnel reaction to the signals and shall be standardized within like types of systems.
- d.* Develop procedures and training. Where it is impractical to eliminate hazards through design selection or adequately reduce the associated risk with safety and warning devices, procedures and training shall be used. However, without a specific deviation or waiver from Range Safety, no warning, caution, or other form of written advisory shall be used as the only risk reduction method for Category I or II hazards (per Chapter 1 Table 1-1). Procedures may include the use of personal protective equipment. Precautionary notations shall be standardized as specified by Range Safety. Tasks

APPENDIX 1B**1.4 1.4 SYSTEM SAFETY PROGRAM REQUIREMENTS**

and activities judged to be safety critical by Range Safety require certification of personnel proficiency.

1B.1.1.6 Risk Assessment

Decisions regarding resolution of identified hazards shall be based on assessment of the risk involved. To aid the achievement of the objectives of system safety, hazards shall be characterized as to hazard severity categories and hazard probability levels, when possible. Since the priority for system safety is eliminating hazards by design, a risk assessment procedure considering only hazard severity, will generally suffice during the early design phase to minimize risk. When hazards are not eliminated during the early design phase, a risk assessment procedure based upon the hazard probability, hazard severity, as well as risk impact, shall be used to establish priorities for corrective action and resolution of identified hazards.

1B.1.2 Task 1: Establish a System Safety Program

The purpose of this task is to establish the foundation for a system safety program. The requirements for Task 1 are as follows:

- a.* Establish and execute a system safety program that meets the tailored requirements of this document.
- b.* Develop a planned approach for safety task accomplishment, provide qualified people to accomplish the tasks, establish the authority for implementing the safety tasks through all levels of management, and allocate appropriate resources, both manning and funding, to ensure the safety tasks are completed.
- c.* Establish a system safety organization or function and lines of communication within the program organization and with associated organizations (government and contractor).
- d.* Establish interfaces between system safety and other functional elements of the program, as well as between other safety disciplines such as nuclear, range, explosive, chemical, and biological.
- e.* Designate the organizational unit responsible for executing each safety task.
- f.* Establish the authority for resolution of identified hazards.
- g.* Define system safety program milestones and relate these to major program milestones, program element responsibility, and required inputs and

outputs.

- h.* Establish an incident alert and notification, investigation and reporting process, to include notification of Range Safety.

1B.1.3 Task 2: Develop a System Safety Program Plan

The purpose of this task is to develop a System Safety Program Plan (SSPP). The SSPP shall describe in detail tasks and activities of system safety management and system safety engineering required to identify, evaluate, and eliminate and control hazards, or reduce the associated risk to a level acceptable to Range Safety throughout the system life cycle. The approved plan provides a formal basis of understanding between the Range User and Range Safety on how the SSPP will be conducted to meet the requirements of EWR 127-1, including general and specific provisions. The approved plan shall account for all contractually required tasks and responsibilities on an item-by-item basis. The Range User shall submit a draft SSPP to Range Safety for review and approval within 45 days of contract award and a final at least 45 days prior to any program cDR. The SSPP shall include the following information:

1B.1.3.1 System Safety Organization

The System Safety Organization section shall describe the following:

- a.* The system safety organization or function within the organization of the total program using charts to show the organizational and functional relationships and lines of communication
- b.* The organizational relationship between other functional elements having responsibility for tasks with system safety impacts and the system safety management and engineering organization
- c.* Review and approval authority of applicable tasks by system safety
- d.* The responsibility and authority of system safety personnel, other Range User organizational elements involved in the system safety effort, contractors, and system safety groups
- e.* A description of the methods by which safety personnel may raise issues of concern directly to the program manager or the program manager's supervisor within the organization
- f.* Identification of the organizational unit responsible for executing each task
- g.* Identification of the authority in regard to resolution of all identified hazards

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h. The staffing of the system safety organization for the duration of the program to include personnel loading and a summary of the qualifications of key system safety personnel assigned to the effort, including those who possess coordination and approval authority for Range User prepared documentation

i. The process by which Range User management decisions will be made, including such decisions as timely notification of unacceptable risks, necessary action, incidents, or malfunctions, waivers to safety requirements, program deviations

j. Details of how resolution and action relative to system safety will be accomplished at the program management level possessing resolution authority

1B.1.3.2 System Safety Program Milestones

The SSPP shall:

a. Define system safety program milestones and relate these to major program milestones, program element responsibility, and required inputs and outputs

b. Provide a program schedule of safety tasks, including start and completion dates, reports, and reviews

c. Identify subsystem, component, software safety activities as well as integrated system level activities such as design analyses, tests, and demonstrations applicable to the system safety program but specified in other engineering studies and development efforts to preclude duplication

1B.1.3.3 System Safety Data

The SSPP shall:

a. Identify deliverable data by title, number, and means of delivery such as hard copy, electronic

b. Identify non-deliverable system safety data and describe the procedures for accessibility by Range Safety and retention of data of historical value

1B.1.3.4 System Safety Interfaces

The SSPP shall identify, in detail:

a. The interface between system safety and all other applicable safety disciplines such as: nuclear safety, Range Safety, explosive and ordnance safety, chemical and biological safety, laser safety, and any others

b. The interface between system safety, systems engineering, and all other support disciplines such as maintainability, quality control, reliability,

software development, human factors engineering, medical support (health hazard assessments), and any others

c. The interface between system safety and all system integration and test disciplines

1B.1.4 Task 3: Establish System Safety Program Reviews and Audits

The purpose of this task is to establish a system safety program review and audit program as specified by Range Safety. This task is also used to acquire support for special requirements such as certifications and test and flight readiness reviews. The following tasks shall be performed:

a. Conduct, document, and make documentation available to Range Safety upon request the following reviews and audits:

1. The Range User system safety program

2. Associate contractor system safety programs

3. Support contractor system safety programs

4. Subcontractor system safety programs

b. Provide the support for the following:

1. Safety reviews and audits performed by representatives of Range Safety

2. Presentations to government certifying activities such as phase safety reviews, munitions safety boards, nuclear safety boards, or flight safety review boards to the extent specified by this document. **NOTE:** These may also include special reviews such as flight and article readiness reviews or pre-construction briefings.

3. Safety reviews shall be held in association with program cDR, PDR, and CDRs. Generally, the safety reviews shall address the following:

a) Program systems and operations overview

b) Presentation of Range Safety required documentation

c) EWR 127-1 Noncompliances

d) Open safety issues

1B.1.5 Task 4: Track Hazards and Risk Resolution

The purpose of this task is to establish a single closed-loop hazard tracking system by development of a method or procedure to document and track hazards and their controls, providing an audit trail of hazard resolutions. A centralized file, computer database, or document called a *Hazard Log* shall be maintained and made available to Range Safety upon request. At a minimum, the Hazard Log shall contain the following information:

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- a.* Description of each hazard, including an associated hazard risk index
- b.* Status of each hazard and control
- c.* Traceability of resolution on each Hazard Log item from the time the hazard was identified to the time the risk associated with the hazard was reduced to a level acceptable to Range Safety
- d.* Identification of residual risk
- e.* Action persons and organizational element
- f.* The recommended controls to reduce the hazard to a level of risk acceptable to Range Safety
- g.* The signature of Range Safety accepting the risk effecting closure of the Hazard Log item

1B.2 HAZARD ANALYSIS AND RISK RESOLUTION

NOTE: The Range User shall perform all of the required Preliminary Hazard Analyses (PHAs), Subsystem Hazard Analyses (SSHAs), System Hazard Analyses (SHAs), Operating and Support Hazard Analyses (O&SHAs) and Safety Assessments per Tasks 1 through 8 that follow; however, the Range User shall submit to Range Safety only those Hazard Analyses and Safety Assessments as specifically required per the Data Requirements sections of Chapters 3, 4, 5, and 6 of this document.

1B.2.1 Task 1: Perform and Document A Preliminary Hazard Analysis

The purpose of this task is to perform and document a Preliminary Hazard Analysis (PHA) to identify safety critical areas, to provide an initial assessment of hazards, and to identify requisite hazard controls and follow-on actions. The Range User shall perform and document a PHA to obtain an initial risk assessment of a concept or system. Based on the best available data, including mishap data from similar systems and other lessons learned, hazards associated with the proposed design or function shall be evaluated for hazard severity, hazard probability, and operational constraint. Safety provisions and alternatives needed to eliminate hazards or reduce their associated risk to a level acceptable to Range Safety shall be included. At a minimum, the PHA shall consider the following for identification and evaluation of hazards:

- a.* Hazardous components such as fuels, propellants, lasers, explosives, toxic substances, hazardous construction materials, pressure systems, and other energy sources

- b.* Safety related interface considerations among various elements of the system such as material compatibility, electromagnetic interference, inadvertent activation, fire and explosive initiation and propagation, and hardware and software controls. **NOTE:** This shall include consideration of the potential contribution by software, including software developed by other contractors and sources, to subsystem and system mishaps.

- c.* Safety design criteria to control safety-critical software commands and responses such as inadvertent command, failure to command, untimely command or responses, inappropriate magnitude, or designated undesired events shall be identified and appropriate action taken to incorporate them in the software and related hardware specifications.

- d.* Environmental constraints including the operating environments such as drop, shock, vibration, extreme temperatures, humidity, noise, exposure to toxic substances, health hazards, fire, electrostatic discharge, lightning, electromagnetic environmental effects, ionizing and non-ionizing radiation including laser radiation

- e.* Operating, test, maintenance, built-in-tests, diagnostics, and emergency procedures (human factors engineering, human error analysis of operator functions, tasks, and requirements; effect of factors such as equipment layout, lighting requirements, potential exposures to toxic materials, effects of noise or radiation on human performance; explosive ordnance render safe and emergency disposal procedures; life support requirements and their safety implications in manned systems, crash safety, egress, rescue, survival, and salvage)

- f.* Those test unique hazards that will be a direct result of the test and evaluation of the article or vehicle

- g.* Facilities, real property installed equipment, support equipment such as provisions for storage, assembly, checkout, Proof testing of hazardous systems and assemblies that may involve toxic, flammable, explosive, corrosive or cryogenic materials and wastes; radiation or noise emitters; electrical power sources

- h.* Training and certification pertaining to hazardous and safety critical operations and maintenance of hazardous and safety critical systems

- i.* Safety related equipment, safeguards, and possible alternate approaches such as interlocks; system redundancy; fail safe design considerations

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using hardware or software controls; subsystem protection; fire detection and suppression systems; personal protective equipment; heating, ventilation, and air-conditioning; and noise or radiation barriers

j. Malfunctions to the system, subsystems, or software. **NOTE:** Each malfunction shall be specified, the cause and resulting sequence of events determined, the degree of hazard determined, and appropriate specification and/or design changes developed.

1B.2.2 Task 2: Perform and Document Subsystem Hazard Analyses

The purpose of this task is to perform and document a Subsystem Hazard Analysis (SSHA) to verify subsystem compliance with safety requirements contained in subsystem specifications and other applicable documents; identify previously unidentified hazards associated with the design of

subsystems including component failure modes, critical human error inputs, and hazards resulting from functional relationships between components and equipment comprising each subsystem; and recommend actions necessary to eliminate identified hazards or control their associated risk to acceptable levels. The Range User shall perform and document an SSHA to identify all components and equipment that could result in a hazard or whose design does not satisfy contractual safety requirements. This will include government furnished equipment, non-developmental items, and software. Areas to consider are performance, performance degradation, functional failures, timing errors, design errors or defects, or inadvertent functioning. The human shall be considered a component within a subsystem, receiving both inputs and initiating outputs, during the conduct of this analysis. The analysis shall include a determination of the following:

a. The modes of failure including reasonable human errors as well as single point and common mode failures, and the effects on safety when failures occur in subsystem components

b. The potential contribution of hardware and software, including that which is developed by other contractors and sources, events, faults, and occurrences such as improper timing on the safety of the subsystem

c. That the safety design criteria in the hardware, software, and facilities specifications have been satisfied

d. That the method of implementation of hardware, software, and facilities design requirements and corrective actions has not impaired or decreased the safety of the subsystem nor has it introduced any new hazards or risks

e. The implementation of safety design requirements from top level specifications to detailed design specifications for the subsystem. **NOTE:** The implementation of safety design requirements developed as part of the PHA shall be analyzed to ensure that it satisfies the intent of the requirements.

f. Test plan and procedure recommendations to integrate safety testing into the hardware and software test programs

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g. That system level hazards attributed to the subsystem are analyzed and that adequate control of the potential hazard is implemented in the design

1B.2.2.1 SSHA Analysis Techniques

If no specific analysis techniques are directed or if Range User recommends that a different technique than specified by Range Safety should be used, the Range User shall obtain approval of techniques to be used prior to performing the analysis.

1B.2.2.2 SSHA Software

a. When software to be used in conjunction with the subsystem is being developed under MIL-STD-498 or MIL-STD-1679 or other development documents; the Range User performing the SSHA shall monitor, obtain, and use the output of each phase of the formal software development process in evaluating the software contribution to the SSHA.

b. Problems identified that require the reaction of the software developer shall be reported to Range Safety in time to support the ongoing phase of the software development process.

1B.2.2.3 Updating the SSHA

The Range User shall update the SSHA as a result of any system design changes, including software design changes, that affect system safety.

1B.2.3 Task 3: Perform and Document System Hazard Analyses

The purpose of this task is to perform and document a System Hazard Analysis (SHA) to verify system compliance with safety requirements contained in system specifications and other applicable documents; identify previously unidentified hazards associated with the subsystem interfaces and system functional faults; assess the risk associated with the total system design, including software, and specifically of the subsystem interfaces; and recommend actions necessary to eliminate identified hazards and/or control their associated risk to acceptable levels.

The Range User shall perform and document a system hazard analysis to identify hazards and assess the risk of the total system design, including software, and specifically of the subsystem interfaces. This analysis shall include a review of subsystem interrelationships to determine the following:

a. Compliance with specified safety design criteria

b. Possible independent, dependent, and simultaneous hazardous events including system failures; failures of safety devices; common cause failures and events; and system interactions that could create a hazard or result in an increase in mishap risk

c. Degradation in the safety of a subsystem or the total system from normal operation of another subsystem

d. Design changes that affect subsystems

e. Effects of reasonable human errors

f. Potential contribution of hardware and software, including that which is developed by other Range Users and other sources or commercial off-the-shelf hardware or software, events, faults and occurrences such as improper timing on the safety of the system.

g. That the safety design criteria in the hardware, software, and facilities specifications have been satisfied

h. That the method of implementation of the hardware, software, and facilities design requirements and corrective actions has not impaired or degraded the safety of the system nor has introduced any new hazards

1B.2.3.1 SHA Analysis Techniques

If no specific analysis techniques are directed or if Range User recommends that a different technique than specified by Range Safety should be used, the Range User shall obtain approval of techniques to be used prior to performing the analysis. The SHA may be combined with and/or performed using similar techniques to those used for the SSHA.

1B.2.3.2 SHA Software

a. When software to be used in conjunction with the system is being developed under DoD-STD-2167 and DoD-STD-2168; or MIL-STD-1679 or other development documents; the Range User performing the SHA shall monitor, obtain, and use the output of each phase of the formal software development process in evaluating the software contribution to the SSHA.

b. Problems identified that require the reaction of the software developer shall be reported to Range Safety in time to support the ongoing phase of the software development process.

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1B.2.3.3 Updating the SHA

The Range User shall update the SHA as a result of any system design changes, including software design changes, that affect system safety.

1B.2.4 Task 4: Perform and Document Operating and Support Hazard Analyses

The purpose of this task is to perform and document Operating and Support Hazard Analysis (O&SHA) to evaluate activities for hazards or risks introduced into the system by operational and support procedures and to evaluate adequacy of operational and support procedures used to eliminate, control, or abate identified hazards or risks.

The Range User shall perform and document an O&SHA to examine procedurally controlled activities. The O&SHA identifies and evaluates hazards resulting from the implementation of operations or tasks performed by persons, considering the following criteria: the planned system configuration and/or state at each phase of activity; the facility interfaces; the planned environments or the ranges thereof; the supporting tools or other equipment, including software controlled automatic test equipment, specified for use; operational and/or task sequence, concurrent task effects and limitations; biotechnological factors, regulatory or contractually specified personnel safety and health requirements; and the potential for unplanned events including hazards introduced by human errors. The human shall be considered an element of the total system, receiving both inputs and initiating outputs during the conduct of this analysis.

The O&SHA shall identify the safety requirements or alternatives needed to eliminate or control identified hazards or to reduce the associated

risk to a level that is acceptable under either regulatory or Range Safety specified criteria. The analysis shall identify the following:

a. Activities that occur under hazardous conditions, their time periods, and the actions required to minimize risk during these activities and time periods

b. Changes needed in functional or design requirements for system hardware and software, facilities, tooling, or support and test equipment to eliminate or control hazards or reduce associated risks

c. Requirements for safety devices and equipment, including personnel safety and life support equipment

d. Warnings, cautions, and special emergency procedures such as egress, rescue, escape, render safe, explosive ordnance disposal, and back-out, including those necessitated by failure of a computer software-controlled operation to produce the expected and required safe result or indication

e. Requirements for packaging, handling, storage, transportation, maintenance, and disposal of hazardous materials

f. Requirements for safety training and personnel certification

g. Effects of non-developmental hardware and software across the interface with other system components or subsystems

h. Potentially hazardous system states under operator control

1B.2.4.1 Assessment of Procedures

The O&SHA shall document system safety assessment of procedures involved in: system production, deployment, installation, assembly, test, operation, maintenance, servicing, transportation, storage, modification, demilitarization, and disposal.

1B.2.4.2 O&SHA Analysis Techniques

If no specific analysis techniques are directed or if the Range User recommends that a different technique than specified by Range Safety should be used, the Range User shall obtain approval of techniques to be used prior to performing the analysis.

1B.2.4.3 Updating the O&SHA

The Range User shall update the O&SHA as a result of any system design or operational changes.

1B.2.5 Task 5: Perform and Document Safety

APPENDIX 1B**1.4 1.4 SYSTEM SAFETY PROGRAM REQUIREMENTS****Assessments**

The purpose of this task is to perform and document a comprehensive evaluation of the mishap risk being assumed prior to test or operation of a system. The Range User shall perform and document a safety assessment to identify all safety features of the hardware, software, and system design and to identify procedural, hardware and software related hazards that may be present in the system being acquired including specific procedural controls and precautions that should be followed. The safety assessment shall summarize the following information:

- a.* The safety criteria and methodology used to classify and rank hazards, plus any assumptions on which the criteria or methodologies were based or derived including the definition of acceptable risk as specified by Range Safety

- b.* The results of analyses and tests performed to identify hazards inherent in the system, including:

- 1.* Those hazards that still have a residual risk and the actions that have been taken to reduce the associated risk to a level contractually specified as acceptable

- 2.* Results of tests conducted to validate safety criteria, requirements and analyses

- c.* The results of the safety program efforts., including a list of all significant hazards along with specific safety recommendations or precautions required to ensure safety of personnel, property, or the environment. **NOTE:** The list shall be categorized as to whether or not the risks may be expected under normal or abnormal operating conditions.

- d.* Any hazardous materials generated by or used in the system

- e.* Conclusion with a signed statement that all identified hazards have been eliminated or their associated risks controlled to levels contractually

specified as acceptable, and that the system is ready to test or operate or proceed to the next acquisition phase

- f.* Recommendations applicable to hazards at the interface of Range User systems with other systems, as required

1B.2.6 Task 6: Perform and Document Engineering Change Proposals, Specification Change Notices, Software Problem Reports, Program or Software Trouble Reports, and Requests

The purpose of this task is to perform and document analyses of Engineering Change Proposals (ECPs), Specification Change Notices (SCNs), Software Problem Reports (SPRs), program or software trouble reports (PTRs, STRs), and requests for deviation or waiver to determine the safety impact on the system.

1B.2.6.1 Engineering Change Proposals

As specified by Range Safety, the Range User shall analyze each ECP to determine the hazards associated with it, assess the associated risk, and predict the safety impact of the ECP on the existing system. The Range User shall notify Range Safety when an ECP changes the level of safety of the existing system.

1B.2.6.2 Specification Change Notices

The Range User shall analyze each SCN to determine the potential effect on safety critical components or subsystems. The Range User shall notify Range Safety if the level of safety of the system changes.

1B.2.6.3 Software Problem Reports

The Range User shall review each SPR to determine the potential safety implications. If safety impacts are identified, the Range User shall notify Range Safety of a decrease in the level of safety of the system.

1B.2.6.4 Program or Software Trouble Reports

The Range User shall review each PTR and STR to determine the potential safety implications. If

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safety impacts are identified, the Range User shall notify Range Safety of a decrease in the level of safety of the system.

1B.2.7 Task 7: Perform and Document Compliance With Safety Requirements

The purpose of this task is to define and perform tests and demonstrations or use other verification methods on safety critical hardware, software, and procedures to verify compliance with safety requirements.

The Range User shall define and perform tests, demonstrations, develop models, and otherwise verify the compliance of the system with safety requirements on safety critical hardware, software, and procedures. Induced or simulated failures shall be considered to demonstrate the acceptable safety performance of the equipment and software.

Where hazards are identified during the development efforts and analysis or inspection cannot determine the adequacy of actions taken to reduce the risk, safety tests shall be specified and conducted to evaluate the overall effectiveness of the actions taken. SSPPs and test plan and procedure documents shall be revised to include these tests.

Where costs for safety testing would be prohibitive, safety characteristics or procedures may be verified by engineering analyses, analogy, laboratory test, functional mockups, or models and simulations when approved by Range Safety. Specific safety tests shall be integrated into appropriate system test and demonstration plans, including verification and validation plans, to maximum extent possible.

Test plans, test procedures, and the results of all tests including design verification, technical operational evaluation, technical data and requirements validation and verification, production acceptance, and shelf-life validation shall be reviewed to ensure:

- a.* Safety of the design, including operating and maintenance procedures, is adequately demonstrated, including verification of such items as safety devices and warning devices for all catastrophic hazards not eliminated by design. Critical, marginal, and negligible hazards shall also be addressed as required by Range Safety.

- b.* Results of safety evaluations of the system are included in the test and evaluation reports on hardware or software.

1B.2.8 Task 8: Perform and Document Compliance with Applicable Codes

The purpose of this task is to perform and document an assessment to identify and verify compliance with military, federal, national, international, and industry codes to ensure safe design of a system, and to comprehensively evaluate the safety risk being assumed prior to test or operation of a system or at contract completion.

The Range User shall perform and document a safety compliance assessment to identify and document compliance with appropriate design and operational safety requirements. The assessment identifies the contractually imposed standards, specifications, and codes appropriate to the safety of the system and documents compliance with these requirements.

The assessment includes necessary hazard analysis, design drawing and procedural reviews, and equipment inspections. The assessment shall incorporate the scope and techniques of the PHA, SSHA, SHA, and O&SHA to the extent necessary to ensure the safe design, operation, maintenance, and support of the system. A safety compliance assessment shall include the following:

- a.* Identification of military, federal, national, international, and industry safety specifications, standards, and codes applicable to the system and documentation of compliance of the design and procedures with these requirements

- b.* Identification of other military, federal, national, international, and industry safety specifications, standards, and codes applicable to the system, that are required by law or the use thereof is considered good engineering practice, and documentation of compliance of the design and procedures with these requirements

- c.* Identification and evaluation of residual hazards inherent in the system or that arise from system unique interfaces, installation, test, operation, maintenance, or support

- d.* Identification of necessary specialized safety design features, devices, procedures, skills, training, facilities, support requirements, and personnel protective equipment

- e.* Identification of hazardous materials and justification for using such a material instead of a less or non-hazardous material and the precautions and procedures necessary for safe storage, hand-lining, transport, use, and disposal of material.

APPENDIX 1C

1.5 1.5 SUBMITTING EWR 127-1 NONCOMPLIANCE REQUESTS

1C.1 INTRODUCTION

1C.1.1 Purpose

Meets intent certifications (MICs), deviations, and waivers are used when Range Users can not meet or feel that they can meet equivalent, though not the exact requirements of the document.

1C.1.2 Content

This Appendix describes the noncompliance categories and the process for submitting MICs, deviations, and waivers.

1C.1.3 Applicability

a. The noncompliance process is applicable to all programs including boosters, solid rocket motors, upper stages, payloads, ground support equipment, facilities, and others that operate at the Ranges or elsewhere if governed under Range personnel unless grandfathered in accordance with the criteria stated below. *b.* The noncompliance process is also applicable to all programs regardless of which version of the old Range Safety Standards (such as AFETR 127-1, ESMCR 127-1, ERR 127-1, WSMCR 127-1, and WRR 127-1) is under contract. *c.* The flight plan approval process does not fall within the intent of this Appendix except when it involves launch vehicle and/or payload hardware.

1C.1.4 Grandfathering Criteria:

Previously approved systems with or without granted MICs, deviations, and waivers will be grandfathered and maintain approval and need not be resubmitted unless it is determined by the Chief of Safety and/or the Range User that one of the following situations exists: *a.* Existing programs make major modifications or include the use of currently approved components, systems, or subsystems in new application (through tailoring if desire) *Exception: Previously approved existing components, systems, or sub-systems that do not increase the risks, do not degrade safety, or can survive new environments are equivalent to or lower than the originally approved qualification levels shall be honored and do not have to meet new requirements as long as data and analyses show that the criteria have been met.*

b. The Range User has determined that it is economically and technically feasible to incorporate new requirements into the system.

c. The system has been or will be modified to the extent that it is considered a new program or that existing safety approvals no longer apply. **NOTE:** Risk and hazard analyses developed jointly by Range Safety and the Range User shall be used to determine applicability of the safety approvals.

d. A previously unforeseen or newly discovered safety hazard exists that is deemed by either Range Safety or the Range User to be significant enough to warrant the change.

e. The system does not meet the requirements existing when the system was originally accepted. **NOTE:** This category includes systems that were previously approved, but when obtaining the approval, the noncompliances to the original requirement were not identified.

f. A system or procedure is modified and a new requirement reveals that a significant risk exists.

g. Accident and incident investigations and reports may dictate compliance with the document.

1C.1.5 Noncompliance Categories

1C.1.5.1 Public Safety

Public safety noncompliance deals with safety requirements involving risks to the general public of the US or foreign countries and/or their property.

1C.1.5.2 Launch Area Safety

Launch area safety noncompliances deal with safety requirements involving risks that are limited to personnel and/or property on VAFB and CCAS, and may be extended to KSC. Launch area safety involves multiple commercial users, government tenants, and/or squadrons.

1C.1.5.3 Launch Complex Safety

Launch complex safety noncompliances deal with safety requirements involving risk that is limited to the personnel and/or property under the control of a single commercial user, full time government tenant organization, or USAF squadron/detachment commander (control authority). Launch complex safety is limited to risks confined to a

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SUBMITTING EWR 127-1 NONCOMPLIANCE REQUESTS

physical space for which the single control authority is responsible.

1C.1.6 Effectivity of Noncompliances

1C.1.6.1 Lifetime

a. Lifetime deviations and waivers are undesirable and shall be limited to those situations where it is virtually impossible to meet the requirement or meet the intent of the requirement.

b. Lifetime MICs are allowed provided equivalent safety is maintained.

1C.1.6.2 Time Limited

a. Time limited deviations and waivers are set for a limited period of time or a limited number of launches. The time constraint is normally determined as a function of cost, impact on schedule, and the minimum time needed to satisfactorily modify or replace the non-compliant system or to modify the non-compliant operation.

b. MICs may be time limited depending on the method by which equivalent safety is accomplished. If excessive procedural controls, personnel, material, or costs are required to maintain equivalent safety, the MIC should be time limited.

1C.1.7 Conditions for Issuance of Deviations, MICs, and Waivers

a. Hazard Mitigation. All reasonable steps shall be taken to meet the intent of the document requirements and mitigate associated hazards to acceptable levels, including design and operational methods.

b. Get Well Plans. All deviations, MICs, and waivers that are not granted for the life of a program shall have a plan to meet the requirements in question by the time the approved effectivity expires.

1C.1.8 Risk-Cost Benefit Analysis

a. Technical disagreements regarding such items as applicable requirements, policy, criteria, or data may be evaluated on a risk-cost benefit basis to determine if the risk is acceptable to delete, modify, deviate from, or waive the requirements.

b. Risk-cost benefit analyses based on the criteria defined in Tables 1-1 and 1-2 of this Chapter shall be submitted to Range Safety.

c. Based on risk-cost benefit analysis data, Range Safety and the Range User shall reach agreement on

the disposition of the requirement in question.

d. If the application of an EWR 127-1 requirement results in a significant reduction of risk at a significant cost benefit, it may be judged by Range Safety to be sufficient to impose the requirement; however, if the benefit is insignificant and/or the cost is high, the requirement may be deviated from, waived, or determined to meet the intent, all with consideration for public safety.

1C.2 SUBMITTING NONCOMPLIANCES

1C.2.1 Format

All noncompliances shall be submitted in writing in letter or memorandum format or the equivalent. An example format may be found in the Range User Handbook. As an alternative, a matrix-type format, containing the same information as the non-compliance request form, may be used if mutually agreeable to the Range User, Range Safety, and the appropriate approving official.

1C.2.2 Content

The following items shall be included in the letter or memorandum:

- a.* Title: MIC, Deviation, Waiver of (requirement a) for (requirement b)
- b.* Descriptive Title of MIC, Deviation, Waiver request
- c.* MIC, Deviation, Waiver category
- d.* MIC, Deviation, Waiver effectivity
- e.* Background
 1. Summary of Range Safety requirement
 2. Statement of the noncompliance
 3. Reason for request
- f.* Conditions for MIC, Deviation, Waiver
 1. Hazard mitigation
 2. Get Well Plan

1C.2.3 Process

a. Requests for MICs, deviations, and waivers shall be submitted to the Office of the Chief of Safety as early as they are known to be necessary.

b. Public safety MICs, deviations, and waivers such as those including flight plan approval, flight termination system design, and toxic propellant storage normally require extensive risk analyses that can take one to two years to perform; therefore, these deviations, MICs, and waivers shall be initiated during the planning phase and be closed out by Wing Commander approval or design

APPENDIX 1C**1.5 1.5 SUBMITTING EWR 127-1 NONCOMPLIANCE REQUESTS**

change prior to manufacture of the booster, spacecraft, flight termination system or other system in question.

c. Launch site safety and launch complex safety MICs, deviations, and waivers normally require two weeks to two months to process depending on the nature of the noncompliance and the requested effectivity.

1C.2.4 Approvals

a. Programs launching from only the ER or WR require only the appropriate 45 SW/SE or 30 SW/SE approvals.

b. Programs launching from both Ranges require approvals from 45 SW/SE and 30 SW/SE.

c. Waivers and deviations dealing with public safety shall be approved by the Wing Commanders or their designated representatives.

d. Waivers and deviations other than public safety shall be approved by the Chiefs of Safety or their designated representatives.

e. MICs shall be approved by appropriate 45 SW/SE or 30 SW/SE section chiefs or their designated representatives.

APPENDIX 1D**1.6 EWR 127-1 ACCEPTABLE RISK CRITERIA****1D.1 INTRODUCTION**

a. The criteria defined in this Appendix is formulated to meet the requirements of PL 60 and apply to all programs and missions operating at the Ranges.

b. All programs and missions are subject to GO/NO-GO decisions based on risk acceptance. The overall risk levels may or may not be an additive value that includes risks resulting from debris, toxic, and blast overpressure exposures. Risk guidance levels in the **Launch Area Safety** and **Launch Complex Safety** sections of this Chapter are derived from the criteria shown in Table 1D-1.

c. These risk guidance levels are provided as guidance for the Wing Commanders and as planning information for Range Users.

d. Range Users should use this guidance to develop their program or mission plans to minimize risk levels.

1D.2 DESCRIPTION OF RISK CRITERIA

a. As shown in Table 1D-1, comparing normally accepted public, day-to-day accident risk exposure to normal launch vehicle and payload launch operating risks indicates that, under any circumstances, the annual collective risk for launch operations is small.

b. A ratio of $1 \times 10^{-3} / 1.8 \times 10^{-4} = 5.7 \times 10^{-8}$ is obtained between the maximum annual launch risks accepted under the guidance limits and the total annual launch risk. Therefore, launch operations risks are only this fraction of the normally accepted risk levels defined in the **Public Safety** section of this document.

c. Individual hazardous activities may exceed guidance levels based on national need or mission requirements. Deviations, meets intent certifications, or waiver requests are required.

Table 1D-1
Comparison of Various Normally Accepted Public Ambient Collective Accident Risks
with Collective ER and WR Launch Risk Guides

Hazardous Events	Average US Individual Casualty Risk per Year	Collective Casualty Risk per Year for Population in ER and WR Launch Area ^a	Equivalent Launch Collective Casualty Risk per Year	Launch Guidance Limits: Collective Casualty Risks per Launch
All Accidents	7.2×10^{-2} ^b	1.8×10^{-4}		
Motor Vehicle Accidents	8.0×10^{-3} ^b	2.0×10^{-3}		
Air Travel Accidents	6.4×10^{-4} ^c	1.6×10^{-2}		
Natural Hazards ^d	2.6×10^{-4} ^e	6.5×10^{-1}		
Hypothetical Nuclear Plant Accident	4.0×10^{-6} ^e	1.0		
Aviation Over flight Accidents		1.8×10^{-2} ^f		
Maximum Risk Acceptable ^g for Accident in One-Time National Need Launch			1×10^{-2}	3×10^{-4} ^h
Maximum Risk Acceptable ^g for Accidents in Launches Unless High Management Review			1×10^{-3}	3×10^{-5} ⁱ

Notes: ^a Total population of 2.5×10^8 assumed exposed to ER or WR launch area Accidents.

^b From total numbers of casualties (at least one-day disability) in *Accident Facts*, 1994, a publication of the National Safety Council, divided by US population of 2.5×10^8

^c From number of fatalities in *Accident Facts*, 1994, multiplied by 200, approximately the average number of casualties (at least one-day disability) experienced in the US for each accident fatality experienced.

^d Lightning, tornadoes, hurricane (earthquake negligible)

^e From *Reactor Safety Study*, WASH-1400/NUREG-75/014, 1975.

^f From Philipson, Lloyd L., *Refined Estimate of the Risk from Aviation Accidents to the Population in the CCAS Area of Concern*, ACTA Inc., Report No. 94-297/46-01, September 1994. (Estimates derived for the ER; assumed to be applicable to the WR as well)

^g Waiver or Deviation Required.

^h At most one such launch per year assumed.

ⁱ From Risk Commonality/Acceptability Workshop, August 1990.

APPENDIX 1E

1.8 MAKING CHANGES TO EWR 127-1

1E.1 INTRODUCTION

1E.1.1 Purpose

Changing the document provides a means for keeping the document current with new technology and processes and allowing for internal and external technical reviews.

1E.1.2 Content

This Appendix describes the process for submitting changes to the document. These changes are global in nature and do not address technical changes that are related to specific and unique program issues.

1E.1.3 Applicability

The document change process is applicable to all Range Users and Range organizations that are responsible for applying the document on contract and monitoring the compliance and implementation of the requirements.

1E.2 CHANGE PROCESS

Changes to EWR 127-1 shall be submitted using the Change Request form. Only one change is allowed per Change Request form and that change is required to stand alone regarding specific subject matter and alphanumeric paragraph number. **NOTE:** A sample of this form may be found in the Range Safety Range User Handbook.

1E.2.1 Completing Change Requests

Change Requests shall include the following information:

- a.* Date of request
- b.* Name of originator
- c.* Name of company or agency
- d.* Address of company or agency
- e.* Telephone and Fax numbers as applicable

f. The alphanumeric designation of the affected paragraph

g. The text for the suggested change

h. The rationale for the suggested change

1E.2.2 Submitting Change Requests

Completed Change Requests shall be submitted to the 45 SW/SE Office of the Chief of Safety, Systems Safety Engineering Support, 1201 Edward H. White II Street, Patrick Air Force Base, Florida 32925-3238. Change Requests can also be submitted electronically via the following Range Safety e-mail address:

ewr1271@patrick.af.mil

1E.2.3 Range User Review

Depending upon the impact of a proposed change, Change Requests may be sent out to Range Users for review and comment prior to final resolution.

In addition, if the proposed change is complex, meetings may be arranged with Range Users as required.

1E.2.4 Disposition of Change Requests

a. 45 SW/SE is the office of primary responsibility and 30 SW/SE will be the office of coordinating responsibility for all EWR 127-1 changes.

b. The disposition of Change Requests falls into the following three categories:

- 1.* Concur As Written
- 2.* Concur With The Intent. In such cases, the Change Request will be rewritten.
- 3.* Do Not Concur. Rationale for not accepting the proposed change will be provided.

1E.2.5 Range User Notification

Approved changes to the document shall be published annually. Changes requiring immediate Range User attention shall be published as required as official document Change Notices. A sample Change Notice is included in the Range User Handbook.

APPENDIX 1F

1.10 1.7 GENERIC PAYLOAD POLICY AND APPROVAL REQUIREMENTS

1F.1 GENERIC PAYLOAD POLICY

The interactive process between Range Safety, payload manufacturers, and launch vehicle companies or government agencies described in this section will ensure minimum impact to payload programs and reduce the cost and time required for the approval process.

Many payload systems are generic, meaning they are built to a common bus structure, using a common launch vehicle, and common Range processing prelaunch and launch procedures. As a result, these generic payloads contain few changes to the baseline system; and the safety data can remain the same from one mission to the next.

To take advantage of previously approved payload systems and generic safety data, the policy described below shall be followed; however, they may be modified to meet individual program requirements:

a. Range Safety and the payload manufacturer in conjunction with the launch vehicle company or government agency shall conduct initial planning meetings to establish a generic payload approval process.

b. Once a baseline system has been approved, Range Safety efforts will focus on specific changes for each new program or mission. **NOTE:** Existing and ongoing previously approved components, systems, and subsystems need not be resubmitted as part of data packages for review and approval.

c. Range Safety, the payload manufacturer, and launch vehicle company, or government agency, shall conduct a safety assessment of each new program or mission to define changes and/or additions that create new, uncontrolled hazards or that increase risks significantly.

d. Based on the joint safety assessment, the parties shall agree on the minimum required documentation to be submitted to Range Safety for review and approval.

e. Data submittal and Range Safety response times shall be established based on the joint safety assessment and modified only upon agreement of all parties.

f. The goal of the generic payload approval process is to achieve final Range Safety approval at least 60 calendar days prior to payload arrival on the launch complex.

1F.2 APPROVAL PROCESS FOR EXISTING PAYLOAD BUSES

For currently existing payload buses, the goal is to grant baseline approvals for generic buses during the first mission after implementation of this approach. Subsequent flights would use the joint assessment process to review and approve changes to the generic bus and/or payload additions for specific missions. Key to the approach is the safety assessment that is used to determine whether changes or additions have created any new uncontrolled hazards or increased the risks significantly. The assessment results will be utilized to determine data required and review and approval requirements.

The approval process for existing payload buses is shown in Figure 1F-1 and described below:

1F.2.1 Launch Services and Mission Orientation Briefing

a. A launch services and mission orientation safety briefing shall be conducted for Range Safety approximately 45 days after contract award for the mission. The briefing shall cover the following topics:

1. Changes to the launch vehicle
2. Changes to the payload bus
3. Planned payload additions for the mission
4. Changes to hazardous systems and operations (the focus of this review)

b. Range Safety concurrence for both the mission concept and schedule for the remaining Range Safety milestones shall be provided during the mission orientation safety briefing or within 14 calendar days after the briefing.

1F.2.2 Data Review and Approval

1F.2.2.1 Mission Unique Missile System Prelaunch Safety Package

a. A Missile System Prelaunch Safety Package (MSPSP) shall be delivered approximately 12 months prior to launch and contain the data requirements identified during the mission orientation safety briefing on the changes to launch vehicle and payload unique for the mission and identified in the initial operation's concept review.

APPENDIX 1F

1.11 1.8 GENERIC PAYLOAD POLICY AND APPROVAL REQUIREMENTS

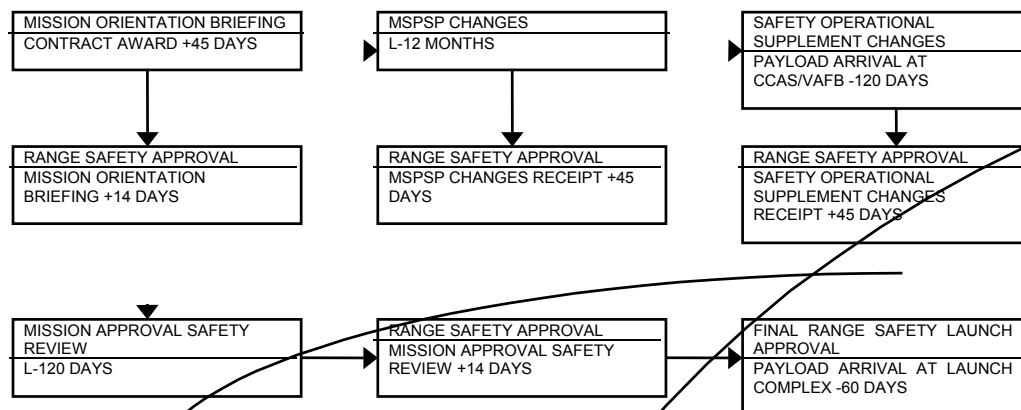


Figure 1F-1
Approval Process for Existing Payload Buses

b. Range Safety shall provide responses 45 calendar days after receipt of the data package.

1F.2.2.2 Ground Operations Plan (GOP) and Hazardous and Safety Critical Procedures

a. A GOP supplement describing changes to approved operations and/or new or modified safety critical or hazardous procedures shall be delivered to Range Safety approximately 120 days prior to payload arrival on the Range. NOTE: This supplement is required only if changes have been made to operations and procedures that affect hazardous levels or risks.

b. Range Safety shall provide responses 45 calendar days after receipt of the data.

1F.2.3 Mission Approval Safety Review

a. A mission approval safety review shall be conducted approximately L - 120 days to obtain Range Safety approval for launch vehicle and payload processing, transport to the payload launch pad, payload launch vehicle mating, and launch pad payload processing.

b. Unless there are significant issues, Range Safety shall provide mission safety approval 14 calendar days after the safety review.

1F.2.4 Final Launch Approval

a. Final approval to proceed with launch vehicle and payload processing up to beginning the final countdown shall be provided by Range Safety at least 60 days prior to payload arrival at the launch complex. NOTE: Flight plan approval for a mission that involves public safety may not be granted

until just prior to the Launch Readiness Review (LRR) depending on the complexity of the public safety issue encountered. For example, typically, at the ER, easterly launch azimuths can be approved at least 120 days prior to launch; on the other hand, high inclination launches may require extensive risk analyses that can delay final flight plan approval until just prior to the LRR.

1F.3 APPROVAL PROCESS FOR NEW PAYLOAD BUSES

For new payload buses, the goal is to grant baseline approvals for generic buses during the first mission after implementation of this approach. Subsequent flights would use the joint assessment process to review and approve changes to the generic bus and/or payload additions for specific missions. Key to the approach is the safety assessment that is used to determine whether changes or additions have created any new uncontrolled hazards or increased the risks significantly. The assessment results will be used to determine data required and review and approval requirements.

The approval process for new payload buses is shown in Figure 1F-2 and described below:

1F.3.1 Concept Orientation Briefing and Safety Review

a. A concept orientation briefing shall be provided to Range Safety early in (no later than 45 days from) the conceptual phase of the development (CDR).

APPENDIX 1F**1.10 1.7 GENERIC PAYLOAD POLICY AND APPROVAL REQUIREMENTS**

b. The generic approval process shall be documented and concept approvals granted so that an audit trail can be established.

c. A concept orientation safety review shall be held in conjunction with this briefing and approval of design concepts, schedule of safety submittals, and Range Safety responses shall be documented.

d. Range Safety concept approvals not granted at this meeting shall be provided within 14 calendar days.

1F.3.2 Preliminary Design Review

a. A preliminary design review (PDR) shall be held at least 12 months prior to scheduled launch and will to provide necessary MSPSP data for initial Range Safety approval before the final payload design and prelaunch processing is initiated.

b. Range Safety shall provide approvals within 45 calendar days after the meeting.

1F.3.3 Critical Design and Data Review

a. Prior to initiating hardware manufacture, a critical design review (CDR) shall be held to provide Range Safety the necessary MSPSP data to grant final design approval and prelaunch processing initial procedure review.

b. Range Safety shall provide a response in 45 calendar days after meeting.

c. A Ground Operations Plan describing operations and containing safety critical and hazardous procedures shall be delivered to Range Safety approximately 120 days prior to payload arrival on the Range.

d. Range Safety shall provide responses within 45 calendar days.

1F.3.4 Mission Approval Safety Review

a. A mission approval safety review shall be conducted approximately L - 120 days to obtain Range Safety approval for launch vehicle and payload processing, transport to the payload launch pad, payload launch vehicle mating, and launch pad payload processing.

b. Unless there are significant issues, Range Safety shall provide mission safety approval 14 calendar days after the safety review.

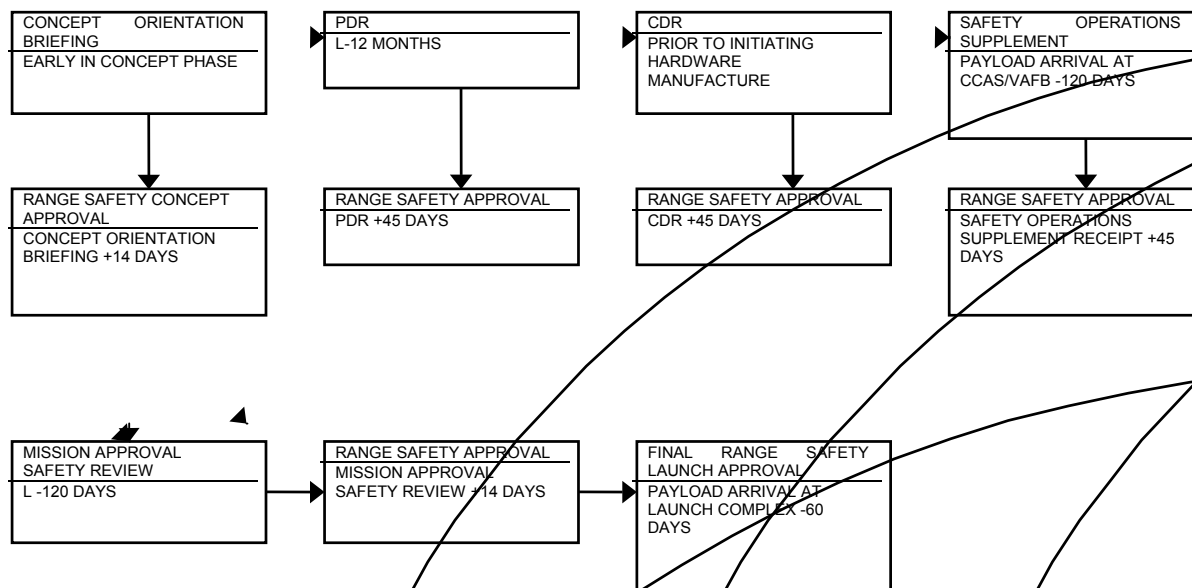


Figure 1F-2
Approval Process for New Payload Buses

APPENDIX 1F**1.11 1.8 GENERIC PAYLOAD POLICY AND APPROVAL REQUIREMENTS****1F.3.5 Final Launch Approval**

Final approval to proceed with launch vehicle and payload processing up to beginning the final countdown shall be provided by Range Safety at least 60 days prior to payload arrival at the launch complex. **NOTE:** Flight plan approval for a mission that involves public safety may not be granted until just prior to the LRR, depending on the complexity of the public safety issue encountered. Typically, easterly launch azimuths can be approved at least 120 days prior to launch. On the other hand, high inclination launches may require extensive risk analyses that can delay final flight

plan approval until just prior to the LRR.

1F.4 INCIDENTAL RANGE SAFETY ISSUES

Incidental Range Safety issues such as component failures, test failures, and the discovery of unforeseen hazards occurring after baseline approvals shall be worked in real time as part of the final approval process for an individual launch. Typically these issues involve the launch vehicle, not the payload.

APPENDIX 1G

1.12 1.9 LAUNCH COMPLEX SAFETY TRAINING AND CERTIFICATION

1G.1 INTRODUCTION

1G.1.1 Purpose

This appendix provides 45 SW/SE and 30 SW/SE operational safety training and certification requirements for launch complex safety. These requirements shall be used by Range Users who wish to assume control authority for launch complex safety. **NOTE:** These requirements may be jointly tailored by the Range User and Range Safety to meet special or unique program requirements in accordance with Appendix 1A. Minimum standards, roles, and responsibilities for a launch complex safety program are defined in this appendix.

1G.1.2 Applicability

The requirements in this appendix apply to all full-time government tenant organizations, single commercial users, or USAF squadron/detachment commanders who assume control authority and responsibility for hazardous procedures identified by Range Safety as *launch complex safety* operations. Responsibilities and authorities are defined in Chapters 1 and 6 of EWR 127-1.

1G.2 LAUNCH COMPLEX OPERATIONS SAFETY PROGRAM GENERAL REQUIREMENTS

a. The Range User shall establish and maintain a launch complex operations safety program to support efficient and effective achievement of overall operations safety objectives. **NOTE:** The safety training and certification program shall be referred to as the *launch complex operations safety program*.

b. The Range User shall implement the requirements defined in this appendix using a Range User-prepared operations safety training and certification plan.

1G.2.1 Safety Management System

The Range User shall establish a safety management system to implement provisions of this appendix. The launch complex safety control authority shall be responsible for the following:

a. Establishing, controlling, incorporating, directing, and implementing the launch complex

operations safety program policies

b. Establishing internal reporting systems and procedures for investigation and disposition of launch complex safety operations mishaps and incidents, including potentially hazardous conditions not yet involved in a mishap or incident and reporting such matters to Range Safety

c. Reviewing and approving launch complex safety hazardous procedures

1G.2.2 Launch Complex Operations Safety Personnel Responsibilities and Qualifications

1G.2.2.1 Safety Manager

1G.2.2.1.1 Safety Manager Responsibilities.

The Range User shall establish and maintain a launch complex operations safety manager directly responsible to the launch complex safety control authority. At a minimum, the Range User safety manager shall be responsible for the following:

a. Approving all launch complex safety operations analyses, reports, and documentation

b. Approving all launch complex safety hazardous procedures and verifying they comply with OSHA/EPA operation requirements and the requirements of EWR 127-1, particularly those defined in Chapter 6.

1G.2.2.1.2 Safety Manager Qualifications.

The launch complex safety operations safety manager shall have a minimum of 10 years of applicable managerial or supervisory experience including at least seven years experience in three of the four functional areas listed below. A Bachelor of Science in Engineering and a CSP are also required.

a. Large missile, space vehicle, rocket, torpedo, pre-launch, launch, post-launch operations and/or recovery operations

b. System safety hazard analysis and design or research and development testing of ordnance, explosives, other types of munitions, pyrotechnics, cryogenic, toxic/hypergolic propellants, high pressure gases, radioactive materials, or other hazardous systems/components

c. Nuclear safety and/or ionizing/non-ionizing radiation

d. Preparation and/or review and approval of hazardous operating procedures for missile and weapons systems

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LAUNCH COMPLEX SAFETY TRAINING AND CERTIFICATION

1G.2.2.2 Safety Personnel

1G.2.2.2.1 Safety Personnel Responsibilities.

Safety personnel shall be directly responsible to the launch complex safety operations safety manager. At a minimum, Range User launch complex safety personnel shall be responsible for the following

- a. Reviewing launch complex safety operations analyses, reports, and documentation
- b. Performing a detailed safety engineering review of launch complex safety hazardous procedures to ensure compliance with federal, state, local OSHA/EPA operation requirements and the requirements in EWR 127-1, particularly those defined in Chapter 6.
- c. Performing safety, surveillance, and monitoring of all launch complex safety hazardous operations

1G.2.2.2.2 Safety Personnel Qualifications.

Launch complex safety personnel shall meet rigid qualification standards and shall be fully experienced, trained, and certified to perform launch complex safety duties.

- a. All safety personnel shall have at least four years of applicable experience in at least three of the four functional areas identified in 1G.2.2.1.2.

- b. Personnel who provide detailed safety engineer review of launch complex safety analyses, reports, documentation, and hazardous procedures shall have a Bachelor of Science degree in Engineering and a CSP.

- c. The launch complex safety work force shall be composed of the following levels of experience.

NOTE: An Engineering degree may be used to satisfy three years of the required experience, or an equivalent combination of education, experience, and training may be deemed acceptable by 45 SW/SE.

1. At least 30 percent shall have more than eight years of applicable experience in at least three of the four functional areas identified in 1G.2.2.1.2.

2. An additional 50 percent shall have at least six years applicable experience in at least three of the four functional areas identified in 1G.2.2.1.2.

3. An additional 10 percent shall have at least four years applicable experience in at least

three of the four functional areas identified in 1G.2.2.1.2.

4. The remaining 10 percent may be trainees.

1G.2.3 Launch Complex Operations Safety Personnel Training Requirements

The launch complex safety operations safety manager and safety personnel shall have initial and refresher training in the following areas every three years:

- a. Recognition of launch complex safety hazards including:

1. Overhead and mobile crane and hoists
2. Sling assemblies
3. Handling structures
4. Personnel work platforms
5. Acoustic hazards
6. Non-ionizing radiation
7. Laser systems
8. Ionizing radiation sources
9. Hazardous materials
10. Airborne and ground pressure systems
11. Airborne and ground cryogenic systems
12. Airborne and ground hypergolic systems
13. Airborne and ground ordnance systems
14. Solid propellants
15. Airborne and ground electrical and electronic equipment.
16. Motor vehicles
17. Forklifts
18. Computer controlled systems such as cranes and robots
19. Facilities

- b. Failure modes for launch complex systems including cause and effect

- c. Preventive and control measures for launch complex safety hazards

- d. Safety devices for launch complex systems

- e. Protective equipment

- f. Monitoring and warning devices for launch complexes

- g. Operations hazards analysis techniques

- h. Human engineering principles

- i. Emergency procedures

- j. Hazardous procedures approval and deviation process

- k. Preparation and hazards of hazardous materials

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1.12 1.9 LAUNCH COMPLEX SAFETY TRAINING AND CERTIFICATION

l. Federal (OSHA/EPA), state, local, and Air Force (EWR 127-1, particularly those in Chapter 6) hazardous operations requirements

m. Accident investigations

n. Non-destructive examination techniques

o. Single failure point analysis

1G.2.4 Compliance

Compliance with all launch complex safety operations requirements of federal, state, and local regulations, EWR 127-1 (particularly those defined in Chapter 6) is mandatory. When the Range User launch complex safety operations safety program plan is approved by Range Safety, it provides a basis of understanding between the Range User and Range Safety as to how the launch complex operations safety program will be accomplished.

1G.2.5 Conflicting Requirements

When conflicting requirements or deficiencies are identified in launch complex operations safety program requirements or with other program requirements, the Range User shall submit notification with proposed solutions or alternatives and supporting rationale to Range Safety for resolution.

1G.3 FOUNDATION OF LAUNCH COMPLEX OPERATIONS SAFETY PROGRAM

This section describes the foundation of a launch complex operations safety program. The requirements are as follows:

a. Establishing and executing a launch complex operations safety program which meets the tailored requirements of this appendix

b. Developing a planned approach for safety task accomplishment, providing qualified people to accomplish the tasks, establishing the authority for implementing the safety tasks through all levels of management, and allocating appropriate resources, both manning and funding, to ensure the safety tasks are completed

c. Establishing a launch complex operations safety organization with function and lines of communication within the program organization and with associated organizations (government and contractor)

d. Establishing interfaces between launch complex operations safety and other functional elements of the program

e. Designating the organizational unit responsible for executing each safety task

f. Establishing the authority for resolution of identified launch complex operational hazards.

g. Defining launch complex operational safety program milestones and relate these to major program milestones, program element responsibility, and required inputs and outputs.

h. Establishing an incident alert and notification, investigation and reporting process, to include notification of Range Safety.

i. Establishing and executing a launch complex safety operations safety program that complies with the following:

1. Launch complex safety operation requirements in EWR 127-1, particularly those defined in Chapter 6

2. OSHA 1910.119 (c): Employee participation

3. OSHA 1910.119(d)(1)(2): Process safety information

4. OSHA 1910.119(f): Operating procedures

5. OSHA 1910.119(g): Training

6. OSHA 1910.119(h): Contractors

7. OSHA 1910.110(I): Pre-startup safety

8. OSHA 1910.119(j)(2)(3)(4)(5): Mechanical Integrity

9. OSHA 1910.119(k): Hot work permit

10. OSHA 1910.119(l): Management of Change

11. OSHA 1910.119(m): Incident investigation

12. OSHA 1910.119 (n): Emergency planning and response

13. OSHA 1910.119(o): Compliance Audits

14. OSHA 1910.119(p): Trade secrets

15. Air Force Occupational and Environmental Instruction, AFI 91-301

1G.4 LAUNCH COMPLEX OPERATIONS SAFETY PROGRAM PLAN

a. The Range User shall develop a launch complex operations safety program plan (LCOSPP) that describes the tasks and activities of launch complex safety operations safety management and safety personnel required to identify,

APPENDIX 1G

LAUNCH COMPLEX SAFETY TRAINING AND CERTIFICATION

evaluate, eliminate, and control launch complex operations hazards.

b. The approved plan shall account for all EWR 127-1 (particularly those in Chapter 6) and federal, state, and local regulations pertaining to launch complex safety operations on an item-by-item basis.

c. The Range User shall submit a draft LCOSPP to Range Safety for review and approval within 90 days of the date the Range User wishes to assume control authority for launch complex safety operations.

d. The LCOSPP shall include the following sections:

1G.4.1 Launch Complex Operations Safety Organization

The Organization section shall describe the following:

a. The launch complex operations safety organization using charts to show the organizational and functional relationships and lines of communication

b. The organizational relationship between other functional elements having responsibility for tasks with launch complex safety operations impacts and the launch complex operations safety organization

c. Review and approval authority of applicable tasks by launch complex operations safety

d. The responsibility and authority of launch complex operations safety personnel, other Range User organizational elements involved in the system safety effort, contractors, and system safety groups

e. A description of the methods by which safety personnel may raise issues of concern directly to the program manager or the program manager's supervisor within the organization

f. Identification of the organizational unit responsible for performing each task

g. Identification of the authority responsible for resolving launch complex safety operations hazards

h. The staffing of the launch complex operations safety organization for the duration of the program including personnel loading and a summary of the qualifications of safety personnel assigned to the effort, including those who possess coordination and approval authority

i. The process by which Range User management decisions are made, including such decisions as timely notification of unacceptable risks, necessary action, incidents or malfunctions, and waivers to operations safety requirements

j. Details of how resolution and action relative to launch complex operations safety will be accomplished at the program management level possessing resolution authority.

NOTE: See Appendix 1B.1.3.1 for additional guidance.

1G.4.2 Launch Complex Operations Safety Program Milestones

The LCOSPP shall:

a. Provide a program schedule of safety tasks, including start and completion dates, reports, and reviews

b. Identify subsystem, component, and software safety activities as well as integrated system level activities such as design analyses, tests, and demonstrations applicable to the launch complex operations safety program but specified elsewhere to avoid duplication.

NOTE: See Appendix 1B.1.3.2 for additional guidance.

1G.4.3 LCOSPP Data

The LCOSPP shall provide the following data:

a. A list of all analyses, reports, and documentation used by safety personnel to review and approve hazardous launch complex safety procedures and execute the safety program

b. A list of all hazardous procedures categorized as launch complex safety procedures by Range Safety

c. The procedures for accessibility of the data by Range Safety and for retention of the data for historical and legal requirements

1G.4.4 Interfaces

The LCOSPP shall identify the following interfaces in detail:

a. The interface between launch complex operations safety and all other applicable safety disciplines such as nuclear safety, Range Safety, explosive and ordnance safety, chemical and biological safety, and laser safety

b. The interface between launch complex operations safety, systems engineering, systems safety

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1.12 1.9 LAUNCH COMPLEX SAFETY TRAINING AND CERTIFICATION

engineering, and all other support disciplines such as maintainability, quality control, reliability, software development, human factors engineering, and medical support (health hazards assessments)

c. The interface between launch complex operations safety and all system integration and test disciplines

NOTE: See Appendix 1B.1.3.4 for additional guidance.

1G.4.5 Internal Reviews and Audits

The LCOSPP shall describe the procedures for accomplishing the following:

a. Annual review of the launch complex operations safety program to verify compliance, relevancy, adequacy, and ensure documentation is current

b. Launch complex safety management and operational reviews (self-audits) to identify program deficiencies and ensure safety program effectiveness

1G.5 LAUNCH COMPLEX OPERATIONS SAFETY HAZARDS ANALYSIS

The Range User shall perform and document the following safety hazard analyses in accordance with the requirements specified in referenced sections of Appendix 1B:

a. A Launch Complex Safety Operating and Support Hazard Analysis (O&SHA) in accordance with the requirements in Appendix 1B.2.4, Task 4

b. Safety analyses of Engineering Change Proposals (ECPs), Specification Change Notices (SCNs), Software Problem Reports (SPRs), Program or Software Trouble Reports (PTRs, STRs), and requests for EWR 127-1 (Chapter 6) deviation or waiver to determine the launch complex safety impact on the system in accordance with the requirements in Appendix 1B.2.6, Task 6

c. A safety compliance assessment to identify and verify compliance with Air Force, federal, state, local, and industry codes to ensure that the hazardous systems are being operated properly in accordance with the requirements in accordance with Appendix 1B.2.8

1G.6 RANGE SAFETY AUDITS

a. Launch complex safety audits shall be conducted by Range Safety on a periodic basis.

b. The audit shall measure the status of each safety task, interrelationship between safety and other program disciplines, identification and implementation of safety requirements/criteria, and documented evidence which reflects planned vs. actual safety accomplishment.

c. Each audit shall evaluate program milestones, safety program milestones and incompatibilities that require remedial corrective action.

d. The Range User shall initiate positive corrective actions where deficiencies are revealed by the audits.

e. Components, equipment, conditions, designs, or procedures that provide unusual safety problems, shall be audited.

f. Audits shall include verification or corrective action on problems revealed by previous audits.

g. The Range User shall support these Range Safety audits by providing access to documentation that substantiates compliance with federal, state, local, and EWR 127-1 (particularly Chapter 6) launch complex operations safety requirements.

1G.7 45 SW/30 SW SAFETY PROGRAM APPROVAL

The Range User launch complex operations safety program shall be approved by the 45 SW/CC or 30 SW/CC, as appropriate, once the following tasks have been accomplished:

a. The Range User shall submit a letter to the 45 SW/30 SW Commander stating that they wish to exercise control authority over launch complex safety operations, and the commander has agreed.

b. The Range User shall identify those launch complex safety operations/procedures they wish to have control authority for, and provides this list to Range Safety.

c. Range Safety will identify those operations/procedures that can be classified as launch complex safety operations

d. The Range User and Range Safety will jointly tailor this appendix and Chapter 6 of EWR 127-1.

e. The Range User shall prepare the launch complex operations safety program plan and submit to Range Safety for review and approval.

f. The Range User shall prepare operating hazards analysis (as required) and submit to Range Safety for review and approval.

g. The Range User control authority for launch complex safety shall submit a certification of

APPENDIX 1G

LAUNCH COMPLEX SAFETY TRAINING AND CERTIFICATION

compliance and substantiating data to Range Safety for review and approval.

1G.8 SAFETY PROGRAM DECERTIFICATION

a. As appropriate, the Range User launch complex operations safety program can be decertified by the 45 SW/CC or 30 SW/CC for the following reasons:

1. The safety program, as implemented, does

not comply with the Range approved launch complex operations safety program requirements

2. Internal audits or Range Safety of safety program indicate serious deficiencies that are not being corrected in a time frame acceptable to Range Safety

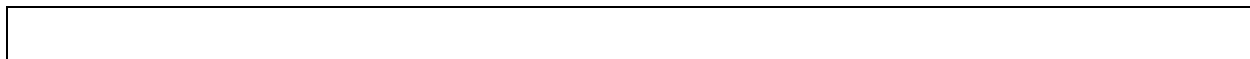
3. Numerous anomalies and/or accidents caused by operational deficiencies in the safety program

b. Possible 45 SW/CC, 30 SW/CC actions following safety program decertification include:

1. Range Safety and its operations safety contractor will assume control of launch complex safety operations

2. Launch complex safety operations will be terminated until the safety program is approved by 45 SW/CC or 30 SW/CC, as appropriate.

2 CHAPTER 2



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GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

30 SW/SEY - 30th Space Wing, Flight Analysis

45 LG - 45th Logistics Group

45 and 30 MDG - 45th and 30th Medical Groups

45 and 30 OG/CC - 45th and 30th Operations Groups, Operations Group Commander

45 and 30 OG - 45th and 30th Operations Group

45 and 30 RANS - 45th and 30th Range Squadron

45 and 30 SPTG - 45th and 30th Support Group

45 and 30 SW/SE - 45th and 30th Space Wing, Offices of the Chiefs of Safety

45 and 30 SW/SEO - 45th Space Wing, Mission Flight Control and Analysis and 30th Space Wing, Mission Flight Control

45 SW/SEOE - 45th Space Wing, Expendable Launch Vehicle Operations Support and Analysis

45 SW/SEOO - 45th Space Wing, Mission Flight Control

45 SW/SEOS - 45th Space Wing, Space Transportation System Operations Support and Analysis

45 and 30 SW/XP - 45th and 30th Space Wing, Plans Office

A - reference area

Accepted risk - a residual hazard that has been accepted by the Range Commander

Acs - cross-sectional area

AFI - Air Force Instruction

AFR - Air Force Regulation

AFSPC - Air Force Space Command

ANSI - American National Standards Institute

A_c - area of potential casualty

AGL - above ground level

A_p - area of population center

ASCII - American Standard for Information Interchange

beta - ballistic coefficient ($W/C_d A$)

cal - calorie, calories

Casualty Area - area about a hypothetical impact point of a fragment in which a defined injury to persons may occur

CCAS - Cape Canaveral Air Station

CCC - Central Computer Complex

CCP - Committed Coverage Plan

C_d - coefficient of drag

CEP - circular error probability

C_L - coefficient of lift

Command Destruct - the process whereby a command is issued from a ground station or center that, when executed by the flight system, causes the launch vehicle to destroy itself

crossrange direction - measured along the Y axis of the X, Y, Z coordinate system. Left crossrange is measured in the direction of the negative Y axis and right crossrange is measured in the direction of the positive Y axis

CVFA - continuous variable flight azimuth

deg - degree

DEP - Directed Energy Plan

deviation - a term used when a noncompliance is known to exist prior to hardware production or an operational noncompliance is known to exist prior to operations at CCAS or Vandenberg Air Force Base

dispersion impact area - an area surrounding an approved impact point; the extent and configuration of the area is based on the vehicle or stage dispersion characteristics

DoDD - Department of Defense Directive

downrange direction - measured in the direction of the positive X axis of the X, Y, Z coordinate system

drag impact points - debris impact points corrected for atmospheric drag

EFG - Geocentric Non-inertial Cartesian Coordinate system; also called Earth Centered Rotational (ECR)

E_c - casualty expectancy, expectation of casualty

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

ER - Eastern Range

ERR - Eastern Range Regulation

FAA - Federal Aviation Administration

FFDP - Final Flight Data Package

FFPA - Final Flight Plan Approval

flight azimuth - the instantaneous angular direction of the flight trajectory of a launch vehicle measured in degrees from true North

FMECA - Failure Modes and Criticality Effects Analysis

FPA - Flight Plan Approval

FTS - Flight Termination System

ft - foot, feet

ft² - square feet, an area

FTS - Flight Termination System

h - hour, hours

hazard, hazardous - equipment, systems, events, and situations with an existing or potential condition that may result in a mishap

hazard analysis - the analysis of systems to determine potential hazards and recommended actions to eliminate or control the hazards

head winds - winds blowing from the reference launch azimuth.

IIP - instantaneous impact point

impact dispersion area - an area surrounding an approved impact point; the extent and configuration of the area is based on the launch vehicle and/or payload dispersion

INSRP - Interagency Nuclear Safety Review Panel

IRIG - Inter-Range Instrumentation Group

ISP - Intended Support Plan

jettisoned body - vehicle components separated at planned event times. Examples of components include stages, fairings, thrust termination ports, solid rocket motors, and associated hardware

KMR - Kwajalein Missile Range

Laser Class (1-4) - laser categories assigned in

ANSI Z136.1; Class 4 being the most dangerous

L-Time (L-X) - the absolute time prior to the scheduled launch time. L-Time may be measured in seconds, minutes, hours, and days and includes all scheduled countdown holds. L-Time will always be equal or greater than T-Time.

launch area - the facility, in this case CCAS and KSC or Vandenberg Air Force Base, where launch vehicles and payloads are launched; includes any supporting sites on the Eastern and Western Ranges; also known as launch head

launch azimuth - the horizontal angular direction initially taken by a launch vehicle at lift-off; measured clockwise in degrees from true North

launch site - the specific geographical location from which a launch takes place

launch vehicle - a vehicle that carries and/or delivers a payload to a desired location; this is a generic term that applies to all vehicles that may be launched from the Eastern and Western Ranges; includes, but is not limited to airplanes; all types of space launch vehicles, manned launch vehicles, missiles, and rockets and their stages; probes; aerostats and balloons; drones; remotely piloted vehicles; projectiles, torpedoes, and air-dropped bodies

lb - pound, pounds

lbf - pounds force

lead time - the time between the beginning of a process or project and the appearance of its results

LSWG - Laser Safety Working Group

LWO - Launch Weather Officer

MFCO - Mission Flight Control Officer; a United States Air Force officer or civilian who monitors the performance of launch vehicles in flight and initiates flight termination action when required; the direct representative of the Range Commander during the prelaunch countdown and during launch vehicle powered flight

MIL-STD - Military Standard

min - minute

MPE - maximum permissible exposure

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

MSP - Mission Support Position

NASA - National Aeronautics and Space Administration

NASC - National Aeronautics and Space Council

NFS - near field signature

nm - nautical mile

nominal vehicle - a properly performing launch vehicle whose instantaneous impact point (IIP) does not deviate from the intended IIP locus

normal vehicle - a properly performing launch vehicle whose instantaneous impact point (IIP) does not deviate more than +/- three standard deviations from the intended IIP locus

NOTAM - Notice to Airmen and Mariners

NOTMAR - Notice to Mariners

NSC - National Security Council

NTM - Notice to Mariners, also known as NOTMAR

OD - Operations Directive

OI - Operating Instruction

OP - Operations Plan

operation - a scheduled activity where Range assets are necessary to support Range User requirements for a specified time period

OR - Operations Requirement document

OSTP - Office of Science and Technology Policy

PAFB - Patrick Air Force Base, located in Florida

payload - the object(s) within a payload fairing carried or delivered by a launch vehicle to a desired location; this is a generic term that applies to all payloads that may be delivered from the Eastern Range and Western Range; includes, but is not limited to, satellites, other spacecraft, experimental packages, bomb loads, warheads, reentry vehicles, dummy loads, cargo, and any motors attached to them in the payload fairing

PD - Presidential Directive

P_I - probability of impact

PFDP - Preliminary Flight Data Package

PFPA - Preliminary Flight Plan Approval

PI - Program Introduction

PRD - Program Requirements Document

program - the coordinated group of tasks associated with the concept, design, manufacture, preparation, checkout, and launch of a launch vehicle and/or payload to or from, or otherwise supported by the Eastern and Western Ranges and the associated ground support equipment and facilities

PDR - Preliminary Design Review

psf - pounds per square foot

QE - quadrant elevation

radians - a unit of angular measure

Range Users - clients of Cape Canaveral Air Station and Vandenberg Air Force Base, such as the Department of Defense; non-Department of Defense, United States government agencies; civilian commercial companies; and foreign government agencies that use Eastern and Western Range facilities and test equipment to conduct prelaunch, launch, and impact operations or require on-orbit support

RIIP - the arc ground range from the launch point to the launch vehicle instantaneous impact point

risk study - the analysis of systems (hardware, software, firmware, and procedures) to determine potential hazards that could result in loss of personnel, injury to personnel, loss or degradation of the system or loss of life or injury to the public; *see also hazard analysis*

ROCC - Range Operations Control Center

RSD - Range Safety Display

RSOR - Range Safety Operations Requirements

RTDR - Range Technical Services Data Reduction office

RTS - Range Tracking System

RTSC - Range Technical Services Contractor

RV - reentry vehicle

RWO - Range Weather Officer

sec - second, seconds

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

single flight azimuth - an operation or mission in which the flight azimuth remains fixed throughout the launch window

sps - samples per second

SPWR - Space Wing Regulation; also SWR

SRM - solid rocket motor

support agency - any agency acting in support of a primary Range User

SVFA - step-wise variable flight azimuth

SW - Space Wing

SWR - Space Wing Regulation

tail winds - winds blowing toward the launch azimuth

TLCF - Technical Laboratory Computer Facility

TMIG - Telemetered Internal Guidance

TNT - trinitrotoluene

T minus Time (T-X) - countdown clock time; T-0 is launch time; time prior to the scheduled launch time not including built-in holds in the countdown; normally measured in seconds, minutes, and hours

UDS - Universal Documentation System

uprange direction - measured in the direction of the negative X axis of the X, Y, Z coordinate system

USAF - United States Air Force

variable flight azimuth - an operation or mission in which the flight azimuth of the trajectory varies either continuously or step-wise (in discreet steps) throughout the launch window

vehicle - launch vehicle and/or payload

waiver - a designation used when, through an error in the manufacturing process or for other reasons, a hardware noncompliance is discovered after hardware production or an operational noncompliance is discovered after operations have begun at CCAS or VAFB

W - weight

W/C_dA - ballistic coefficient; *see also beta*

WR - Western Range

WRR - Western Range Regulation

X dot - velocity in the X direction

Y dot - velocity in the Y direction

Z dot - velocity in the Z direction

REFERENCED DOCUMENTS

30 RANS OI 55-33, *Air Control/Area Control Procedures*

30 SW RSOR, *30th Space Wing Range Safety Operations Requirements*

45 SWI 13-201, *Eastern Range Air Space Management Procedures*

AFI 13-201, *U.S. Air Force Airspace Management*

AFI 91-110, *Nuclear Safety Review and Launch Approval for Space or Missile Use of Radioactive Material and Nuclear Systems*

ANSI Z136.1, 1993, *American National Standard for Safe Use of Lasers*

Department of Defense Directive (DoDD)
3200.11, *Major Range and Test Facility Base*

DoDD 4540.1, *Use of Airspace by U.S. Military Seas*

EWB 127-1, Annex to Chapter 2, *Flight Trajectory and Data Manual*

MIL-STD-1543, *Reliability Program Requirements for Space and Launch Vehicles*

MIL-STD-1629, *Procedures for Performing a Failure Mode Effects and Criticality Analysis*

NASC, *Nuclear Safety Review and Approval Procedures of Minor Radioactive Sources in Space Operations*

PD/NSC-25, *Scientific or Technological Experiments with Possible Large Adverse Environmental Effects and Launch of Nuclear Systems Into Space*

CHAPTER 2

FLIGHT ANALYSIS REQUIREMENTS

2.1 INTRODUCTION

2.1.1 Purpose of the Chapter

Chapter 2 establishes the minimum requirements for trajectory data and system characteristics for vehicles launched from the Eastern Range (ER) and Western Range (WR). The following topics are addressed:

- 2.2 Responsibilities and Authorities
- 2.3 Flight Analysis Policies
- 2.4 Flight Analysis Approvals
- 2.5 Documentation and General Data Requirements
- 2.6 Ballistic Missiles and Space Vehicles Specific Data Requirements
- 2.7 Cruise Missiles and Remotely Piloted Vehicles Specific Data Requirements
- 2.8 Small Unguided Rockets or Probe Vehicles Specific Data Requirements
- 2.9 Aerostat or Balloon Specific Data Requirements
- 2.10 Projectile, Torpedo, Air-Dropped Body, and Device Specific Data Requirements
- 2.11 Air-Launched Vehicle Specific Data Requirements
- 2.12 Collision Avoidance
- 2.13 45 SW Range Safety Requirements for the ER

2.1.2 Applicability

The requirements in this Chapter are applicable to the following programs: ballistic missile and space vehicles; cruise missile and remotely piloted vehicles; small unguided rockets or probes; aero-

stat or balloon systems; projectiles, torpedoes, non-propulsive air-dropped bodies, or any small devices to be flight tested; intended support plans for ships and aircraft; aircraft and aeronautical systems; directed energy systems; and the launch of large nuclear systems into space.

2.2 RESPONSIBILITIES AND AUTHORITIES

In this Chapter, references to the Commanders, their Staff Offices and Groups refer to both the 45th and 30th Space Wings (SW) unless otherwise noted.

2.2.1 Commanders, 45th Space Wing and 30th Space Wing

In accordance with Department of Defense Directive (DoDD) 3200.11, the Commanders (Range Directors), 45th Space Wing (45 SW) and 30th Space Wing (30 SW) have final authority and responsibility for the safety of launch vehicles and payload launch operations and all other programs conducted on the Ranges. Programs involving the use of large nuclear devices, explosive warheads, and other high risk missions shall be approved by the Commanders.

2.2.2 Chiefs of Safety, 45th Space Wing and 30th Space Wing

The Chiefs of Safety, 45th Space Wing (45 SW/SE) and 30th Space Wing (30 SW/SE) or their designated representatives are responsible for approving the proposed flight plan or mission, determining the need for flight termination systems (FTSs), and developing flight safety criteria.

2.2.3 Operations Support and Analysis, 45th Space Wing and Flight Analysis, 30th Space Wing

Operations Support and Analysis, 45th Space Wing (45 SW/SEOE and SEOS) and Flight Analysis, 30th Space Wing (30 SW/SEY) are responsible for estimating the risks associated with Range operations and determining the constraints necessary to protect life and property for the duration of the scheduled operation. For launch operations, this extends to the time of final impact, the time of orbital insertion, or the time of thrust termination, whichever is greater. **NOTE:** Unless specifically noted in this Chapter, the term *Range Safety* refers to Operations Support and Analysis and Flight Analysis. Operations Support and Analysis and Flight Analysis are responsible for the following:

- a. Determining the need for FTSs
- b. Reviewing and approving requested flight plans that include operation constraints
- c. Reviewing and approving Intended Support Plans (ISP)
- d. Reviewing and approving the use of Directed Energy systems
- e. Reviewing and approving the use of Large Nuclear systems
- f. Developing destruct criteria and Range Safety displays used by Mission Flight Control Officers (MFCOs).
- g. Preparing or assigning and evaluating risk studies
- h. Providing technical support to the MFCO prior to launch on all operation matters
- i. Reviewing and approving launch sites
- j. Providing the Range User with instructions on submission and distribution of trajectory data on tapes, floppy disks, or other media
- k. Receiving, preparing, and distributing copies of tapes, floppy disks, or other media and print-outs or microfiche to Range Support agencies as required

2.2.4 Operations Groups, 45th Space Wing and 30th Space Wing

The Operations Groups, 45th Space Wing (45 OG) and 30th Space Wing (30 OG) are responsible for the following services for Range Safety:

- a. For continuing programs, advising Range Safety of operations requiring their support at the earliest practical time
- b. Assisting in ensuring the Range User and as-

sociated operation support agencies are aware of appropriate Range Safety data requirements

- c. As requested, collecting and forwarding data to support Range Safety approvals such as Flight Plan Approval (FPA) and ISPs

- d. Issuing hazard notification messages based on Range Safety requirements

- e. Coordinating the evacuation, control and/or closure of public parks, oil rigs, railroads, and land, sea and air areas in accordance with Range regulations based on Range Safety requirements

2.2.5 Plans Offices, 45th Space Wing and 30th Space Wing

The Plans Offices, 45th Space Wing (45 SW/XP) and 30th Space Wing (30 SW/XP) are responsible for providing the following services for Range Safety:

- a. For new programs, advising Range Safety of operations requiring their support at the earliest practical time

- b. Ensuring Range Safety requirements are considered in the planning phase

- c. As requested, collecting and forwarding preliminary Range Safety approval data

2.2.6 Range Users

Range Users are responsible for the following:

- a. Submitting all data identified as requirements for Range Safety support of planned operations

- b. Complying with data submission lead times and Range Safety approval conditions

- c. Advising Range Safety of changes to operational scenarios to determine if approvals are affected

- d. Providing specific data required for the scheduled operation day

- e. Ensuring accuracy and relevancy of all data to support the requests for approvals

- f. Providing appropriate media and two print-outs of theoretical trajectory data to the lead Range when the program requirements document (PRD) is submitted, when mission trajectories are changed, or when additional trajectories are added. **NOTE:** Requirements for flight trajectory data preparation, submittal, and processing are described in EWR 127-1, Annex to Chapter 2, "Flight Trajectory and Data Manual".

- g. Revising theoretical trajectory data when use of the trajectory, as supplied, will adversely affect the support needed by either planning or operational phases of the Range User program

2.3 FLIGHT ANALYSIS POLICIES

No hazardous condition is acceptable if mission objectives can be attained from a safer approach, methodology, or position.

2.3.1 Flight Analysis Approval

Flight Analysis approval is a necessary prerequisite for conducting operations covered by this Chapter. By itself, Flight Analysis approval does not constitute permission to conduct an operation.

2.3.2 Additional Requirements

Although the requirements in this Chapter are intended to be complete, special launches, flight tests, or circumstances may make it necessary to request additional information.

2.3.3 Flight Termination System

All vehicles launched on the Ranges shall be equipped with an FTS capable of terminating thrust on all stages at any time in flight, up to orbital insertion or until the final impact point is established. The need for flight termination action may be extended to the orbital stages and/or payloads depending on their capability to hazard protected areas. *EXCEPTION: Launch vehicles whose impacts can be adequately controlled by prelaunch restrictions may be excluded from this requirement.* The design of the FTS is discussed in Chapter 4 of this document. Safing of the FTS for the stage that injects the vehicle into orbit shall be accomplished automatically by the vehicle after it has attained orbit and terminated thrust.

2.3.4 Impact Restrictions

a. No launch vehicle, payload, or jettisoned body shall be intentionally impacted on land unless designated as a target and approved by the Chief of Safety. Proposed flights shall be planned and trajectories shaped so that normal impact dispersion areas for such items do not encompass land.

b. If any jettisoned body remains buoyant after impact and presents a hazard to maritime vessels or platforms, a means of sinking or recovering the body shall be provided.

c. For space vehicles, if a stage contains multiple-burn engines, the impact dispersion area corresponding to any planned cutoff before orbital insertion shall be entirely over water. Critical events such as arming of engine cutoff circuits and sending of backup engine cutoff commands shall

be sequenced to occur when the impact dispersion areas are entirely over water.

d. In accordance with DoDD 4540.1, all operations shall operate with due regard for the safety of all air and surface traffic. Areas for activities shall be selected so as not to interfere with established air routes and ocean shipping lanes.

2.3.5 Data Submission

In meeting the requirements of this Chapter, much of the information submitted by the Range User may not change from operation to operation. In such cases, the information only needs to be supplied once. However, for each operation, the Range User must state in writing which data are applicable and specify the document, paragraph, and page number where each required item can be found. This statement shall be submitted to Range Safety according to established lead times.

2.3.6 Land Overflight

Whenever possible, the overflight of any inhabited land masses is discouraged and is approved only if operation requirements make overflight necessary, and risk studies indicate probability of impact and casualty expectancy are acceptable.

2.3.7 Trajectory Safety Margins

a. The flight trajectory shall be designed to accommodate Range Safety capability to control launch related risks.

b. A sufficient safety margin shall be provided between the intended flight path and protected areas so a normal vehicle does not violate destruct criteria.

c. During the initial launch phase, the launch profile shall not be so steep that critical coastal areas cannot be protected by standard safety destruct criteria.

2.3.8 Hazard Assessment

The identification of operation-related hazards and the assessment and quantification of risk shall be used to determine operation constraints. **NOTE:** The hazards associated with each source of risk (debris impact, toxic chemical dispersion, and acoustic overpressure) have an associated set of critical parameters and thresholds of acceptability. Changes in launch parameters such as azimuth, payload, and launch site and the need for flight safety controls including the evacuation of personnel, enforcement of roadblocks, and restriction

of sea lanes or airspace depend on the results of the hazard assessments.

2.4 FLIGHT ANALYSIS APPROVALS

The Range User should initiate Flight Analysis approval at the earliest practical date to establish that the proposed program is acceptable from a safety standpoint. Early action by the Range User keeps data requirements to a minimum and ensures that the effort and expense of planning a program or computing pre-operation trajectories is not wasted. The specific approval depends on the type of program activity. Developing the safest operation consistent with program objectives can take several months while changes in the proposed plan are made.

2.4.1 Flight Plan Approval

Flight plan approval (FPA) is applicable to the following programs:

- a. Ballistic missile and space vehicles
- b. Cruise missile and remotely piloted vehicles
- c. Small unguided rockets or probes
- d. Aerostat or balloon systems
- e. Projectiles, torpedoes, non-propulsive air-dropped bodies, or any small devices to be flight tested

2.4.1.1 Flight Plan Approval Overview

The FPA process incorporates two formal approval phases: Preliminary Flight Plan Approval (PFPA) and Final Flight Plan Approval (FFPA).

a. Programs usually fall into two categories: new or existing. New programs include existing programs whose FPA supporting data has changed significantly. New programs shall submit the data requirements for both PFPA and FFPA. Existing programs generally shall submit the data requirements for only FFPA. For either new or existing programs that do not involve long lead times for planning or payload development, approval may, of necessity, occur only a few months prior to the desired operation date.

b. In each FPA phase, Range Safety shall respond to the Range User written request for approval by issuing a letter of approval or disapproval, by requesting that a change in the proposed plan be made or investigated, or by delineating additional data requirements before a decision can be made. After all requested data have been provided and evaluated, the Range User shall be given an approval, conditional approval, or dis-

approval letter. If the flight plan or mission is approved, the letter shall specify the conditions of approval pertaining to such things as launch azimuth limits, trajectory shaping, wind restrictions, locations of impact areas, times of discrete events, and number of operations for which the approval applies. The approval will be final as long as the operation or operations remain within the stated conditions. If significant changes to the flight plan occur after approval has been granted, further analysis of the revised plan may be necessary. The Range User is responsible for advising Range Safety of any such changes or anticipated changes as early as possible.

2.4.1.2 Preliminary Flight Plan Approval

The flight plan approval process for all new programs begins with an introductory meeting followed by the submittal of required data and a formal written request for a Preliminary Flight Plan Approval (PFPA). Existing programs shall also request a PFPA when previously approved supporting data is not applicable to the planned operation. The purpose of the PFPA is to ensure Range Safety requirements are included in the overall system design and to determine if the specific program is conceptually acceptable. In preliminary meetings, Range Safety can define acceptable flight limits and conditions, specify which parts of the flight plan need special emphasis, and identify requirements applicable to the program. Data regarding anticipated flight trajectories, booster configuration, FTS configuration, and more, are included. Lack of some pertinent data should not be cause for delaying the initial written request, particularly if preliminary discussions have not been held. The Range User should begin PFPA action during the Preliminary Design Review (PDR) phase of program planning or, in any event, immediately after Range Safety has replied to the Program Introduction in a Statement of Capability. For new programs, the PFPA usually occurs at least two years (one year for existing programs) prior to the planned operation.

2.4.1.3 Final Flight Plan Approval

The Final Flight Plan Approval (FFPA) is applicable to each program operation. The FFPA is based on detailed analysis of the operation objectives, vehicle performance, and other data items required. In response to the Range User request, the FFPA is issued when the Chief of Safety is

satisfied that a specific operation can be supported within the limits of flight safety control capabilities to provide positive protection to life and property. Any constraints or conditions identified in the PFPA may be superseded by those stated in the FFPA. The FFPA applies to a specific operation and does not guarantee that similar operations will receive an FFPA. If a program consists of identical operations, a blanket FFPA may be granted that would remain in effect throughout the life of the program as long as the operations remain within the specified safety constraints. The request for FFPA and the supporting data are typically received by Range Safety at 120 calendar days (new programs), or 60 calendar days (existing programs), prior to the planned operation. Past data submittals may be referenced if that data has not changed from previous operations.

2.4.2 Ship/Aircraft Intended Support Plan Approval

2.4.2.1 Purpose

The purpose of the ISP approval is to ensure maximum safety consistent with the operation objectives. To the extent possible, this means that support positions and flight plans should be established outside impact limit lines. When the required support data cannot be collected from such remote locations, support positions located in relatively hazardous areas must be carefully planned to minimize the ship or aircraft hit probability. Hazards to ships and aircraft exist primarily in the launch area, along the flight azimuth where jettisoned stages and components reenter and breakup, and in the target area where reentry vehicles and final stages impact.

2.4.2.2 Applicability

ISP approval is applicable to each ship and aircraft supporting an operation requirement identified in the Universal Documentation System (UDS) or participating in an operation on a non-interference basis. Policies and procedures for control of test support aircraft are given in 45 SWI 13-201 or 30 RANS Operating Instruction (OI) 55-33." Similar regulations for ships do not exist.

2.4.2.3 ISP Development and Submittal

ISPs for ships and aircraft shall be developed either by the Range User or by support agencies that are responding to requirements contained in the Program Requirements Document (PRD) or the

Operation Requirements (OR) document. In either case, the developing organization shall furnish the ISP for review and approval, either directly to Range Safety or through the Range Squadron.

2.4.3 Directed Energy Plan Approval

2.4.3.1 Purpose

The purpose of the Directed Energy Plan (DEP) approval is to ensure the operation is conducted safely with consideration for the operation requirements and national need.

2.4.3.2 Applicability

The DEP approval applies to programs using directed energy systems. These systems include, but are not limited to, lasers and neutral particle and ion beams, with any combination of surface, air, or space locations for the energy source and target. In this Chapter, the term *laser* is used as a generic reference to all directed energy systems. **NOTE:** Laser design, test, and documentation requirements are also addressed in the **Laser System Design Requirements** section of Chapter 3 of this document.

2.4.3.3 Categories Subject to Review

In general, those laser operations in the following categories are subject to review:

- a. Laser operations requesting Range support through the provisions of the UDS.
- b. Laser illumination, for which an Operations Directive (OD) does not exist, conducted in conjunction with a scheduled Range operation for which an OD does exist.
- c. Laser operations having the potential to impair Range Safety controls or reduce the reliability of Range Safety systems.

2.4.3.4 Laser Program Evaluation

a. At the ER, the laser program is evaluated by the Laser Safety Working Group (LSWG), made up of representatives from each section of the Safety Office. The LSWG was chartered to provide a central and coordinated venue for assessing hazards associated with specific categories of laser operations. It is also responsible for providing customer guidance towards satisfying safety requirements.

b. At the WR, the laser program is evaluated by Range Safety. Responsibilities include:

1. Providing guidance for the Range User in satisfying safety requirements

2. Assessing hazards associated with specific categories of laser operations
3. Recommending laser safety constraints
4. Issuing an advisory laser operation approval letter

2.4.3.5 DEP Submittal

a. Requests for DEP approval shall be forwarded directly to Range Safety or through either the Plans Office for new programs or the Range Squadron for existing programs.

b. Lead times and requirements may vary and will be tailored depending on the specific characteristics of the system and proposed operating scenario. Lead times for data requirements reflect the dependence of mission success on planned laser operations. For instance, laser operations performed on a non-interference basis using scheduled launches as a target of opportunity will have lead times different than laser activities that are integral to a scheduled operation. Laser operations considered mandatory by the Range User shall be included as part of the Program Introduction (PI). If the laser operation is not mandatory in accordance with Range User requirements, the initial request for laser program approval is desired at least one year prior to the planned operation date. Requests for Range Safety review of recurring laser operations are desired 30 calendar days prior to each planned operation date. Modifications to existing laser systems or changes to current operating plans should be discussed with Range Safety during the planning phase to determine the need for additional data requirements and establish mutually agreeable lead times for submission of additional data.

2.4.4 Large Nuclear Systems Approval

Range Users employing radioactive material that exceed Category A established by the Office of Science Technology Policy (OSTP) shall comply with Presidential Directive/NSC-25. The Range User shall provide Range Safety with a copy of the following documents. **NOTE:** Nuclear system design, test, and documentation requirements are also addressed in the **Radioactive (Ionizing Radiation) Design Requirements** section of Chapter 3 of this document.

- a. Environment Impact Statement: L-3 years
- b. Final Safety Analysis Report: L-1 year
- c. Interagency Nuclear Safety Review Panel (INSRP) Safety Evaluation Report: L-7 months.

NOTE: In the event that the INSRP is not impaneled by the OSTP, the provisions of AFI 91-110 (21 Mar 94), "Nuclear Safety Review and Launch Approval for Space or Missile Use of Radioactive Material and Nuclear Systems," shall be performed by the USAF Directorate of Nuclear Surety and the results provided to Range Safety in lieu of the INSRP Safety Evaluation Report.

d. Certification of Presidential approval for flight: L-10 days. A copy of the OSTP approval letter or the National Security Council approval letter meets this certification requirement.

2.5 DOCUMENTATION AND GENERAL DATA REQUIREMENTS

This section lists the documentation and general data requirements applicable to all programs covered by this Chapter. Sections 2.6 through 2.11 list the specific data requirements for each program operation.

2.5.1 Security

The Range User shall provide a security classification guide for all classified program information.

2.5.2 Lead Times

Before Range Safety approval is granted, the Range User must provide required data in specified formats in accordance with lead times in Table 2-1. In some cases, other Range regulations may establish lead time requirements that exceed those established here. Lead times may be modified depending upon the complexity of the program. If the requirements are not provided within the lead time specified, Range Safety may not be able to prepare all necessary safety criteria in time to support a proposed operation. In this event, the operation shall not be conducted until Range Safety can make adequate safety preparations.

2.5.3 Items Marked With Double Asterisks

In this Chapter, certain required data items are marked with double asterisks (**); for example, the time interval at which turn angle graphs are required. The asterisks mean the magnitude, inter-

TABLE 2-1

Documentation Lead Times and Data Requirement References

Vehicle/Missile	Lead Time Before Launch (Calendar Days)

TABLE 2-1
Documentation Lead Times and Data
Requirement References

Vehicle/Missile	Lead Time Before Launch (Calendar Days)
Ballistic Missile:	
PFFA (New/Existing)	2 Y/ 1Y
FFPA (New/Existing)	120 D/60 D
Space Vehicle: Single Flight Azimuth	
PFFA (New/Existing)	2 Y/1 Y
FFPA (New/Existing)	120 D/60 D
Space Vehicle: Variable Flight Azimuth	
PFFA (New/Existing)	2 Y/1Y
FFPA (new/Existing)	12M/6M
Project Firing Tables	9 D
Cruise Missile/Remotely Piloted Vehicle:	
PFFA (New/Existing)	2 Y/1 Y
FFPA (New/Existing)	120 D/60 D
Small Unguided Rocket:	
PFFA (New/Existing)	2 Y/1 Y
FFPA (New/Existing)	120 D/60 D
Aerostat/Balloon:	
PFFA (New/Existing)	2 Y/1 Y
FFPA (New/Existing)	120 D/60 D
Projectile, Torpedo, Air-Dropped Body or Device:	
PFFA (New/Existing)	2 Y/1 Y
FFPA (new/Existing)	120 D/60 D
Ship and Aircraft ISP	20 Days
Directed Energy Systems (New/Existing)	1 Y/30 D
Large Nuclear Systems	See para 2.4.4

All lead times are based on the standard calendar year

val, or duration for the required item varies from program to program and that the value given is typical. For each program, Range Safety provides the Range User with the particular value to use for each parameter marked with double asterisks.

2.5.4 Range Tracking System Performance Requirements

The Range Tracking System (RTS) is made up of the hardware, software, and manpower required to transmit, receive, process, and display launch vehicle data required for Range Safety purposes. An RTS including at least two adequate and independent instrumentation data sources is mandatory and shall be maintained from T-0 throughout each phase of powered flight up to the end of Range Safety responsibility. See Chapters 4 and 7 for additional requirements.

2.5.4.1 Tracking Source Adequacy

Each tracking source provided for Range Safety shall provide real-time state vector (position and velocity) accuracy, timeliness, and reliability so that when extrapolated to IIP space, the following criteria are met:

2.5.4.1.1 Accuracy. The three-sigma IIP uncertainty resulting from all error sources shall be no greater than the following:

a. ER: The launch area IIP uncertainties shall not exceed 100 ft in either crossrange or downrange directions. For downrange IIP uncertainties, the displayed crossrange IIP error shall not exceed one-half percent of the vacuum impact range and the displayed downrange IIP error shall not exceed five percent of the vacuum impact range. The allowed error values are computed as follows:

$$\text{Crossrange error} = \begin{cases} 100 \text{ ft}, 100 \text{ ft} \geq 0.5\% \text{ RIIP} \\ 0.5\% \text{ RIIP}, 100 \text{ ft}, < 0.5\% \text{ RIIP} \end{cases}$$

$$\text{Downrange error} = \begin{cases} 100 \text{ ft}, 100 \text{ ft} \geq 5.0\% \text{ RIIP} \\ 5.0\% \text{ RIIP}, 100 \text{ ft}, < 5.0\% \text{ RIIP} \end{cases}$$

b. WR: The Launch Area IIP uncertainties shall not exceed 1000 ft. The midcourse IIP uncertainties shall not exceed 1 percent of the IIP range. The terminal area IIP uncertainties shall not exceed 7000 ft. **NOTE 1:** The accuracy is given in terms of the radius of a circle that contains three-sigma of all possible instantaneous impact points. **NOTE 2:** The launch area accuracy applies until the hazardous debris impact areas are entirely over water. **NOTE 3:** The terminal area accuracy applies only to ballistic vehicles with a maneuverable upper stage targeted for the Kwajalein Missile Range (KMR).

2.5.4.1.2 Timeliness.

a. The IIP display update rate shall be at least 10 samples per second (sps), and each update shall meet the requirements of paragraphs 2.5.4.1.1 and 2.5.4.1.2 *b.*

b. The time delay between vehicle event and firing of the vehicle ordnance, exclusive of the MFCO reaction time, shall be within the total Range Safety System response time budget. This budget includes hardware and software delays inherent to both airborne and ground equipment. The budget for the ER is 1.5 sec and 3.5 sec depending on the time of flight and Range Safety System configuration for each operation. The WR

budget is 1 sec except for ballistic operations targeted for the Kwajalein Atoll and orbital operations with a low launch azimuth (typically less than 170°) for which the budget is 500 milliseconds during critical portions of flight.

2.5.4.1.3 RTS Reliability (Ground Segment only). The reliability of the RTS ground segment shall be at least 0.999 at a 95 percent confidence level for a 1 h duration during the period of Range Safety responsibility.

2.5.4.2 Tracking Source Independence

Each tracking source provided for Range Safety shall be electrically, mechanically, and structurally separate from the vehicle guidance and telemetry systems and any other tracking source, so that one tracking source will not influence another tracking source. See exceptions in Chapter 4.

2.5.5 Telemetered Vehicle Information

2.5.5.1 Telemetered Inertial Guidance Data

Telemetered Inertial Guidance (TMIG) data is a mandatory tracking source for programs using a launch vehicle inertial guidance system. The TMIG data is required in the standard Inter-Range Instrumentation Group (IRIG) format at a 20 sps update rate from T-0 through the end of Range Safety responsibility.

2.5.5.2 Telemetry Data

Telemetered performance, guidance, and FTS data are required. The items required in real time shall be defined by Range Safety during the initial meeting with the Range User. Data shall typically include, but are not necessarily limited to:

2.5.5.2.1 Performance Data: Chamber pressure, fuel pressure, accelerometer outputs, steering information, and discrete events such as staging and payload or reentry vehicle (RV) release

2.5.5.2.2 Guidance Data. Position (X,Y,Z), velocity (\dot{X} , \dot{Y} , \dot{Z}), guidance phase and internal cycle status (for example, major and minor cycles), steering commands, accelerometer inputs and sums, malfunction detection indicators and discrete initiations

2.5.5.2.3 FTS Data: Received signal strength and decoded outputs or commands

2.5.6 Risk Study

If deemed necessary, the Range User may be re-

quired to conduct a risk study (hazard analysis).

2.5.6.1 Rationale for Conducting a Risk Study

Range Safety approval is granted or a deviation or waiver request is approved when, in the Range Director's judgment, the hazards associated with the proposed operation appear reasonable and the objectives of the operation cannot be met in a safer fashion. A risk study quantifies the hazards associated with the proposed operation in terms of the probability of impact and expectation of casualty to protected areas and serves as one basis for deciding if hazards are reasonable. To complete the study, most of the data required for program approval (for example, debris data, failure rates, trajectory, turn data) must have already been computed.

2.5.6.2 Conditions Requiring a Risk Study

For FPA, a study may be required if the flight plan involves any of the following hazardous conditions:

- a. Direct overflight of land prior to thrust termination or orbital injection
- b. Flight so close to land that destruct criteria may be violated by a normal vehicle or debris could impact land if a destruct event were to occur
- c. A launch area trajectory so steep that critical coastal areas or launch area facilities cannot be protected by standard destruct criteria without endangering a normal missile.
- d. A period during flight when land areas cannot be protected from a malfunctioning vehicle because the vehicle has no FTS, premature separation destruct capability, or Range Safety System capability is surpassed by the vehicle performance

2.5.6.3 Risk Study Components

At a minimum, the study shall consist of the major components listed below. Additional procedures and requirements pertaining to the study will be specified during the early part of the approval process.

- a. Determination of failure probabilities and failure density functions; a description of how these functions were computed and the failure modes considered
- b. Computation of dwell times over land
- c. Probability of impact density functions for each failure or malfunction mode in terms of downrange and crossrange components
- d. A list of all population centers or the popula-

tion density along the flight path that could have debris impacting on them after a destruct event. The list shall include the name of the population center, area (A_p) in ft^2 , population center centroid in geodetic latitude and longitude, the total number of persons in the population center (N), and the number of persons in each shelter category within each population center. The shelter categories are defined as follows:

1. Heavy - Blockhouse bunkers and heavily reinforced structures
2. Medium - Buildings with concrete or reinforced roofs, and all floors except the top floor in multi-story buildings

3. Light - Single story buildings, trailers, and top floors of multi-story buildings

4. Exposed - No protection from falling debris

- e. Evaluation of casualty area (A_C) based on vehicle breakup analysis.

- f. Probability of Impact (P_I) for each population center computed by summing the individual failure mode probabilities of impact over all fragment groups; the failure rates for each of the failure modes and the flight dwell time over each population center are included in the computation.

- g. Casualty Expectation (E_C) for each population center. Total population center E_C is computed by summing the E_C values over all fragments affecting each population center. In simplified terms, not accounting for possible sheltering of persons,

$$\text{Total } E_C = N / A_p * \sum_i (P_{I_i} * A_{C_i})$$

Where: i is a fragment in the fragmentation group

- h. Sample calculations and supporting documentation

2.5.7 Statement of Program Justification

The Range User may be asked to provide the following additional supporting data and justification before an approval can be made. The need for this information will be established in preliminary discussions or in the Chief of Safety's response to a written request for approval.

- a. Complete statement of the operation objectives

- b. Statement about the operation objectives that will not be met if the proposed plan must be modified as suggested by Range Safety or is not approved

- c. Alternate or modified plans that will accomplish the operation objectives

- d. Effects on the operation such as cost, schedule, data requirements, vehicle reliability, reserve propellants, launch window, if the plan must be modified or if the plan is not approved

- e. Other data the Range User may wish to submit

2.5.8 Flight Plan Approval Data Requirements

Data requirements for PFPA and FFPA are found in two sections. The first is a general section that applies to all programs, and the second is a detailed section that applies to a specific program (see Sections 2.6 - 2.11). All sections may be tailored by Range Safety as required. The PFDP and the FFDP are submitted in support of the PFPA and FFPA, respectively. The data packages may be submitted in any convenient format. The following general format, that conforms to the order in which requirements are established, is suggested for any Range User who desires a standard submission form. If this format is adopted and the information submitted in response to a requirement cannot easily be placed in the data package, it should be made an appendix to the specific part. For example, the magnetic tapes and listings for trajectories would be an appendix to Part 3.

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Part 1: Introduction

Part 2: General Vehicle Data

Part 3: Trajectory Data

Part 4: Additional Data

2.5.8.1 Preliminary Flight Data Package

These data requirements apply to requests for PFPA for all missiles, space vehicles, rockets, and other items as specified in paragraph 2.4.1. The program-specific PFDP requirements in Sections 2.6 - 2.11 are also required before a PFPA can be issued. The need for additional information will be established in early discussions with the Range User or in the response to the written request for PFPA. The request for PFPA shall specify the operation designation, intended operation date, and references to all applicable supporting data products. In meeting these requirements, reference may be made to documentation previously submitted. If this is done, the Range User shall specifically identify applicable supporting data, and indicate

the document, page number, and paragraph where each required item can be found.

2.5.8.1.1 General Requirements.

a. Basic program description and objectives including number, designation, and purpose of operations(s) for which the proposed flight plan is applicable

b. General operation scenarios and proposed target areas and a statement indicating whether the proposed trajectory (or flight plan) is similar to some prior operation

c. Intended launch or flight test date(s)

d. Map and listing of downrange and cross-range vacuum instantaneous impact points for each second of powered flight time

e. General description of launch vehicle and payload in sufficient detail for hazard assessment providing the following information:

1. Type, weight, and TNT equivalency of propellants

2. Description of ordnance items

3. Description of toxic and radioactive materials

4. Characteristics of high pressure vessels, lasers, and batteries

5. Description of materials, thickness, and safety factors of pressure vessels

6. Thrust and burn times of motors and thrusting devices

7. Description of guidance and control systems

8. Drawings and diagrams showing structural arrangement and layout of significant components in each stage or payload

f. General description and location of the airborne FTS (made up of the command and automatic destruct subsystems), or statement indicating that the planned system is similar to one already in use. **NOTE:** Range Safety must be involved prior to the Preliminary Design Review time frame if a new design is to be considered.

g. Preliminary estimate of fragment characteristics such as number, composition, dimensions, and weight due to all potential modes of vehicle breakup such as destruct, and aerodynamic loading

h. Tracking aids such as C-Band transponder installed in the vehicle that can be used for flight safety purposes and their locations in the stages or sections

i. Telemetry measurement listing and data

word definitions

j. Description of launch site facilities, support buildings, and the structural integrity information for each of these

k. Geodetic latitude, longitude, and designation of proposed launch site, or location on the earth's surface for launches that occur above or below the earth's surface. If launch or test initiation can occur inside an area rather than at a single specified location, this area shall be defined.

l. Launch azimuth for single azimuth launches or desired azimuth sector(s) for variable azimuth launches

m. Estimates of the nominal impact point, and the three-sigma drag-corrected impact dispersion area for each jettisoned body

n. Buoyancy analysis of all impacted, jettisoned bodies. For bodies that remain buoyant after impact and present a hazard to maritime vessels or platforms, a means of sinking or recovering the body is required. If recovery is desired, a recovery procedure shall be identified.

2.5.8.1.2 Reliability and Malfunction Analysis Data Requirements. Reliability of each stage and probability of a normal mission or failure rate data for each stage shall be provided. The following data shall be included:

a. Description of failure modes that can result in abnormal impacts. An analysis of all subsystems shall be made to determine failure modes that would result in a catastrophic event. Typical malfunctions that should be considered include failure of the hydraulic and electrical systems, failure of the guidance and control system, failure of separation mechanisms between stages, failures that lead to premature thrust termination, overshoot, or shifting of the platform reference.

b. An estimate of the probability of occurrence or failure rate (versus time) for each failure mode; any other information considered pertinent with respect to critical portions of flight, such as vehicle stability characteristics and structural limits

c. Description of all credible failed vehicle response modes. A response mode is a category of vehicle dynamic response, including vehicle breakup, that results from one or more failure modes. At a minimum, the response modes should include on-trajectory failures such as thrust termination and explosion and malfunction turn (loss of thrust vector control, tumble turn, nozzle burn-

through) failures. On-trajectory failures should be subdivided according to the type of breakup (for example, aerodynamic or explosive) that will result. Malfunction turns should be subdivided into tumble turns and trimmed turns if trimmed turns are a credible response mode.

d. Summary of past vehicle performance giving number launched, launch location, number that performed normally, behavior and impact location for any that malfunctioned, time and nature of malfunction, and corrective action

2.5.8.1.3 Propellant Description. If a vehicle has the capability of exploding as a result of self-initiation, FTS activation, or ground or water impact; or if a vehicle uses propellants that are toxic in gaseous or vapor states due to combustion or release to the atmosphere, the following data are required:

a. Types of propellants or a statement indicating the same propellants are already in use

b. TNT equivalency versus flight time and explosion scenario for each separate stage (or motor) and each possible combination of stages that could result from malfunction conditions

c. The probability of explosion versus flight time for each of the following: self-initiation, FTS activation, and ground or water impact

d. Description of methods used to minimize the possibility of explosion

e. Time of day when launches will be scheduled and the number of launches

f. Maximum total quantities of liquid and solid propellants

g. Nominal vehicle altitude (meters AGL) versus time through 3,000 m in the following format:

$$t = a * z^b + c$$

Where:

t = time (sec) after initial ignition

z = height (m) of the vehicle above the launch pad, and *a*, *b*, *c* are coefficients found by a least squares fit to an estimated time-height profile for this booster.

h. Heat (cal) released by the solid fuel when combusted to an equilibrium state of the exhaust products and the time required for the exhaust products to reach chemical equilibrium

i. Burn time and expenditure rate of solid propellant for nominal launch and a catastrophic abort occurring at lift-off, including fuel frag-

mentation and expenditure rate assumptions used to generate the atmospheric abort parameters

j. Liquid propellant expenditure rate (grams per sec) for nominal launch

k. Fractions of the following species released from liquid and solid propellant combustion during nominal and catastrophic scenarios: hydrogen chloride, carbon dioxide, carbon monoxide, aluminum oxide, hydrazine, unsymmetrical dimethylhydrazine, monomethylhydrazine, nitrogen tetroxide, nitrogen dioxide, nitrosodimethylamine, and formaldehyde dimethylhydrazine

l. Initial Exhaust Cloud Data. The following information is needed to specify the initial exhaust cloud parameters. These values describe the exhaust ground cloud when the horizontal momentum produced by the ducting in the launch mount becomes negligible compared to the buoyant forces within the cloud for the nominal launch scenario.

1. Initial exhaust ground cloud central radius in meters for nominal launches and radius of area over which solid fuel fragments are dispersed for catastrophic abort cases

2. Vertical velocity of cloud centroid in meters per sec for nominal and catastrophic cases

3. Initial ground cloud centroid height in meters AGL

2.5.8.1.4 Explosive Reentry Vehicle or Warhead Information. An operation that includes the use of an explosive reentry vehicle (RV) or warhead shall not be conducted without the approval of the Range Director. For these operations, the following data are required:

a. A complete justification for the proposed operation

b. The proposed position and altitude of the RV or warhead detonation point

c. The effects of the detonation on the missile and RV or warhead in terms of number, weights, cross-sectional areas, ballistic coefficients, and velocities imparted to the pieces

d. The impact dispersion area for all fragments including diffusion and dispersion of any toxic or radioactive clouds or fragments and the radiation exposure characteristics

2.5.8.2 Final Flight Data Package General Requirements

These data requirements apply to requests for FFPA for all missiles, space vehicles, rockets, and

other items as specified in paragraph 2.4.1. The program specific FFDP requirements in Sections 2.6 - 2.11 are also required before a FFPA is issued. The FFDP shall include items that were changed from or not provided in the PFDP. The FFDP is made up of the data requirements used to produce the final set of operation rules and flight control criteria and ensures all data complies with the conditions of the PFPA and data format requirements. The request for FFPA shall specify the operation designation, intended operation date, and references to all applicable supporting data products. In meeting the FFPA requirements, some of the information submitted by the Range User may not change from the PFDP or from operation to operation. In such cases, the information need be supplied only once. However, for each operation, the Range User shall state in writing which supporting data are applicable and specify the document, page number and paragraph where each required item can be found. In other cases where the proposed plan deviates from the PFPA or previously accepted limits, additional data shall be provided.

2.5.9 Statement of Vehicle Performance

Within one to three months after an operation has been conducted, a statement of vehicle performance is required. This information may be provided by letter or by lending Range Safety the performance evaluation documents prepared for other purposes. This is information needed for evaluation of vehicle performance capabilities upon which changes in safety abort criteria are based and for updating the failure rate information used in the various risk analysis models. Information required includes:

- a. Qualitative statement about the performance of each stage and various subsystems
- b. Failures that occurred and resulting flight conditions produced
- c. Probable cause of failure and corrective action taken
- d. Impact points for stages

e. Miss distances for weapon system tests and orbital parameters for space vehicle flights

f. Comparison of planned and achieved cutoff conditions for each stage

g. Performance of on-board safety instrumentation systems

2.5.10 Intended Support Plan Data Requirements

For operations requiring support aircraft or ships, the following additional information is required 20 calendar days prior to the mission. All identifying points and positions shall be time correlated using the operation start time as a reference.

2.5.10.1 Aircraft Flight Profile Information

a. Type of aircraft

b. Aircraft physical dimensions as described in Jane's aircraft publications. The following data shall be provided as a minimum:

1. 1/2 wing span - the length of the wing measured from the fuselage to the wing tip edge
2. Maximum width of fuselage measured in the top planform view
3. Average depth of wing measured in the side planform view
4. Average fuselage depth measured in the side planform view
5. Area measured in the top planform view
6. Perimeter measured in the top planform view

c. Call sign ("N" number, tail number, etc.)

d. Warning area and mission area penetration points (entry and exit)

e. Holding fixes and altitudes

f. Primary and alternate Mission Support Position (MSP) including geodetic latitude, longitude, heading, speed, and time of arrival

g. Written and graphic flight path location describing the maneuvers within 200 miles of the MSP giving orbit or loiter locations, positions along ground track in latitude and longitude, turn points, turn radii where applicable, speeds, and headings

h. Course, speed, and altitudes to the MSP; (the terminal end of the data run)

i. Departure route after mission completion, including maneuvers after MSP for departure to recovery base

j. Final staging and recovery base

2.5.10.2 Ship Cruise Profile Information

- a. Class of ship
- b. Dimensions of ship measured in the top plan-form view
- c. Call sign (registration number, name, etc.)
- d. Warning area and mission area penetration points (entry and exit).
- e. Primary and Alternate MSPs including geodetic latitude, longitude, heading, and speed
- f. Course and speed to the MSP (terminal end of the data run)
- g. Planned location (support plan) both written and graphic, of vessel during period from launch until operation termination or impact

2.5.11 Directed Energy Plan Data Requirements

The data requirements in this section apply to all forms of directed energy systems. **NOTE:** Laser design, test, and documentation requirements are also addressed in the **Laser System Design Requirements** section of Chapter 3 of this document. Reasonable and prudent operational procedures shall be established so that hazards from laser operations present virtually no risk to the general public. A risk study may minimize the effect of the following operational procedures on the program.

2.5.11.1 Laser Operational Procedures

2.5.11.1.1 Avoidance Volume. The avoidance volume shall encompass that portion of the laser beam that is capable of causing either permanent or temporary ocular impairment. The radial distance of the avoidance volume from the center of the laser beam depends on several variables, including laser operating parameters, time delays between aircraft detection and laser termination, average aircraft speeds, and reliability of system controls.

2.5.11.1.2 Airspace Surveillance. Organizations conducting laser operations shall provide for an airspace surveillance capability and procedures that ensure the laser operation can be terminated before a non-participating aircraft enters the pre-defined laser beam avoidance volume.

2.5.11.1.3 Airspace Control. The *American National Standard (ANSI) for Safe Use of Lasers*, Z136.1, 1993, paragraph 4.3.11.2 requires coordination with the Federal Aviation Administration

when laser programs include the use of Class 3a, 3b, and 4 lasers within navigable airspace. For Range Safety purposes, airspace control is a desirable safety measure; however, it is considered a secondary protection measure to surveillance requirements. Airspace controls shall be initiated by Range Safety when the value added to safety is justifiable.

2.5.11.1.4 Laser Beam Azimuth and Elevation Restrictions. Laser beam azimuth and elevation restrictions shall be defined so that the laser beam avoidance volume is constrained to airspace for which an approved surveillance capability has been established.

2.5.11.1.5 Weather Constraints. The laser operation shall be terminated during periods when weather conditions obstruct or adversely affect an approved surveillance method.

2.5.11.1.6 General Data Requirements. The following data are required for each operation or group of operations. Additional data may be required depending on the laser system.

- a. Complete description of surveillance methods, surveillance range limits, and a description of the procedures used to terminate laser operations when necessary
- b. General information on the purpose of the operation
- c. Description of the laser and its operation
- d. Laser classification in accordance with ANSI Z136.1
- e. Description of operation scenarios and proposed target areas, if known
- f. Copies of safety analyses and test procedures conducted on the system
- g. Laser Emission Characteristics
 - 1. Mode of operation (continuous wave or pulsed)
 - 2. Wavelength (meters)
 - 3. Energy per pulse in Joules for pulsed lasers, or power in Watts for continuous wave lasers
 - 4. Pulse repetition frequency (Hertz)
 - 5. Pulse width and pulse separation (sec)
 - 6. Beam diameter between 1/e points at the exit aperture, or at the waist if convergent beam (centimeters)
 - 7. Beam divergence angle at the aperture or waist (radians)
- h. Number and designation of laser operations

to which the proposed operation applies

i. A statement indicating whether the proposed operation is similar in its safety aspects to that of some prior operation for which documentation is available

j. Intended operation dates

k. Functional description of the target acquisition and laser firing process and of any error/failure detection and correction or termination capability, including its reliability and response time

2.5.11.2 Nominal Mission Data

2.5.11.2.1 Scenario Type. (Can be any combination of the following):

- a.* Fixed laser and/or target
- b.* Moving laser and/or target

2.5.11.2.2 Laser and Target(s) Position Data.

a. Fixed - latitude, longitude, and altitude where the laser beam exits the protective housing and of each target

b. Moving - position and velocity vector versus time of each object in an Earth Centered Rotating (EFG) Coordinate System.

2.5.11.2.3 Nominal Operation Scenario Data.

a. Desired operating azimuth and elevation sectors

b. Event times; for example, acquisition, arming and firing on/off times

c. Duration of each laser firing (sec)

d. Slew rate (radians/sec)

e. Hardware and software stops (angles from forward direction, radians)

f. Pointing accuracy (radians); brief description of laser beam pointing aids including their location

g. Laser platform/vehicle attitude control accuracy (static, radians; dynamic, radians/sec)

2.5.11.2.4 Target Data.

a. Target size - radius or height, width, and length

b. Orientation - angle of each target surface with respect to the incident beam

c. Type of reflection possible such as specular or diffuse

d. Reflection coefficients

2.5.11.2.5 Exposure Controls. (Calculated in accordance with ANSI Z136.1)

a. Maximum permissible exposure (MPE) level, nominal optical hazard distance in a vac-

uum, and other applicable hazard ranges for each laser

b. Description of the maximum region around each target that can be hazarded during a nominal operation

c. Reflection characteristics of other significant objects in the hazard region around each target. **NOTE:** The hazard region is the zone where the laser radiation levels may exceed the MPE level.

2.5.11.3 Risk Study Data Requirements For A Non-Nominal Mission

If a risk study is required, the following data shall be submitted:

2.5.11.3.1 Probability of Occurrence Data.

The probability of occurrence versus time of operation for each of the following generic hazard modes (modes of beam control error or failure): Pointing Error, Inadvertent Slewing, Premature Firing, Delayed Firing, Beam Focusing Error, Loss of Focus, and other modes such as Wrong Target Acquisition applicable to the system. If the probability of occurrence is non-zero for any of these hazard modes, then probability distributions for the random hazard mode parameters describing how each mode can occur over time shall be provided. The following parameters describe each of the stated failure modes.

a. Pointing Error Hazard Mode: offset angle (radians) between the correct laser to target pointing direction and the incorrect pointing direction (angle assumed constant during a firing)

b. Inadvertent Slewing Hazard Mode

1. Time (sec) during firing at which the inadvertent slewing starts

2. Azimuth angle (radians, measured from North) of the slew plane. It is assumed that, over time, the laser-to-target line remains contained in a plane.

3. The angular rate (radians/sec) of slewing in the plane (rate assumed constant)

4. Duration of the slewing (sec), if other than that of the nominal firing time remaining after the start of the slewing

c. Premature Firing Mode: number of seconds prior to the nominal start time that laser firing occurs

d. Delayed Firing Termination Mode: number of seconds after the nominal termination time that laser cutoff occurs

e. Beam Focusing Error Mode: range (meters) along the laser-to-target vector at which the convergent beam is misfocused. The incorrect range can either be too long or too short relative to the nominal focus range.

f. Loss of Focus Mode

1. Time (sec) during firing at which the loss of focus occurs

2. Beam divergence angle (radians) that measures the spreading of the beam (assumed to remain centered on the laser-to-target vector)

2.5.11.3.2 Failure Modes, Effects, and Criticality Analysis. Applicable hazard modes shall be defined and documented by a failure modes, effects, and criticality analysis (FMECA) in accordance with MIL-STD-1543 and MIL-STD-1629 or the equivalent. Their probabilities of occurrence and the probability distributions of their descriptive parameters shall be quantified with fault tree analyses or the equivalent. The level of analysis conducted in each case shall be the level at which appropriate component error/failure data are available. If necessary for confidence in the results, analyses of the effects of the uncertainties in the component data shall be carried out.

2.5.11.3.3 Alternative Data Submission. The Range User may arrange to have the risk study done by Range Safety. The following data shall be provided to support this option:

a. System design description and performance data and functional and reliability block diagrams for portions of the system affecting beam control, including platform attitude control

b. Associated component (including hardware, software, and human) reliabilities or, as a minimum, component and component environment descriptions allowing the estimation of these reliabilities

2.5.11.4 Coordination with the US Space Command Space Control Center

Coordination with the US Space Command CMOC/J3OXY (Special Operations Section) is required for all Class 3 and 4 lasers operated outside of a confined laboratory environment. For these systems, unless waived by the CMOC/J3OXY (Special Operations Section), firing time coordination shall be accomplished to verify that

on-orbit objects of national interest are not affected by the laser operation.

2.6 BALLISTIC MISSILES AND SPACE VEHICLES SPECIFIC DATA REQUIREMENTS

The trajectory and performance data requirements in this section apply to ballistic missiles and space vehicles. The following items are required for each missile/space vehicle flight or group of similar flights and should be updated as changes to vehicle configuration occur or revised information becomes available.

2.6.1 Preliminary Flight Data Package Requirements

These data are required in addition to the data requirements specified in section 2.5.8.1.

2.6.1.1 FTS Requirements Evaluation

The threat from any payload or stage without an FTS shall be analyzed to determine the risk associated with a malfunctioned launch vehicle whose payload or stage may separate prematurely. The Range User shall provide a residual thrust dispersion analysis and an intact impact analysis for the payload or stage deemed hazardous by Range Safety. The results of these analyses shall be provided to Range Safety three** months prior to the time that a waiver of the FTS is required. If the resulting dispersions are small enough for inclusion as offsets in the Range Safety destruct computations, there may be no need for a risk study. In any event, before making a residual thrust dispersion or intact impact analysis, the Range User shall reach agreement with Range Safety on the assumptions and approaches to be used and the output data required. Analyses shall consider the following:

a. Functional description of structural, mechanical, and electrical inhibits or safeguards for preventing premature separation and ignition of payload or stage propulsion systems; extent to which such inhibits are independent; simplified schematics and operational description of propulsion system ignition circuits; extent to which circuits and systems are shielded

b. Failure modes that can lead to premature separation and/or ignition of upper-stage and payload propulsion systems; probability of occurrence for each failure mode including method of derivation and a fault tree analysis if multiple

components or subsystems are involved

c. Probability of stable flight and stability characteristics of prematurely separated and thrusting stage, stage and payload, and payload alone, both within and outside the sensible atmosphere; effects of structural confinement such as payload fairing on prematurely separated upper stage or payload

d. Risk Study: Results of the study shall include the impact probability for critical facilities and land areas that can be endangered by the payload or stage prior to orbital injection. Additional requirements will be established by Range Safety depending on the potential hazards associated with the payload or stage.

e. Residual Thrust Dispersion Analysis: The dispersion analysis is to show the extent to which the impact point(s) can deviate from nominal if the payload or stage separate prematurely and the propulsion system ignites. Computations are generally required from liftoff until upper stage fuel depletion or orbit insertion.

f. Intact Impact Analysis: Explosive effects of solid rocket and liquid motors upon ground impact. This analysis shall contain piece description, number of pieces, and range the explosion propels pieces from the motor impact point.

2.6.1.2 Nominal Trajectory

Position and velocity (X, Y, Z, α , ϕ , ψ) as functions of time from liftoff until vehicle attains an altitude of 100,000 ft**. If position and velocity components are not available, ground range and altitude may be substituted for X, Y, Z, and the total earth-fixed velocity relative to the pad and the path angle may be substituted for α , ϕ , ψ . The data should be provided in time increments no larger than five** seconds. If trajectory data cannot be provided, the steepness of the trajectory in the launch area should be compared with the trajectory from any prior similar operation.

2.6.1.3 Vehicle Maximum Turn Capabilities

The vehicle maximum turn capability describes the furthest distance the vehicle impact point can deviate from nominal if a malfunction should occur. See Appendix 2B for details.

2.6.1.4 Maps

a. A map showing the planned vacuum locus of impact points for the intended flight azimuth or

azimuth sector. The vacuum impact point at times of discrete events; such as arming of engine cutoff circuits, ignition of upper stages, firing of retro-rockets, and the end of burns that occur prior to orbital injection shall be indicated.

b. A map showing the best estimates of mean impact points and the three-sigma drag-corrected impact dispersion area for each jettisoned body.

2.6.1.5 Orbit Parameters and Sequence of Events

The following data shall be provided for space vehicles only:

a. Apogee, perigee, period, and inclination of intended orbits

b. The approximate times from liftoff when engine cutoff circuits are armed, when upper stages will be cutoff by backup devices, and when control modes will be switched

2.6.2 Final Flight Data Package Requirements

These data are required in addition to the data requirements specified in paragraph 2.5.8.2.

a. Detailed information concerning the nature and purpose of the flight

b. A scaled diagram of the arrangement and dimensions of the missile or space vehicle

c. Approximate elapsed time from receipt of an FTS signal at the command antenna until FTS charges explode

2.6.2.1 Limits of a Useful Mission

The information requested in this paragraph applies to space operations only. It is used to establish guidelines or limits for land overflight prior to orbital injection. The permissible limits for overflight depend not only on this information, but also on estimated overflight hazards, the operational objectives potentially achievable, and the importance of these objectives. Since the derivation of the following items may be lengthy and costly, Range User best engineering estimates will be acceptable when a more exact study is not economically feasible. **NOTE:** A risk study (paragraph 2.5.6) shall be submitted for overflight conditions.

a. The launch azimuth limits for which the primary operation objectives can be met and for which a useful orbit can be attained

b. The operation objectives that will be met, or the extent to which the primary objectives will be

degraded

c. Description of limiting orbit(s) (apogee, perigee, period, and inclination) as a function of over-flight azimuth

d. The circumstances or types of malfunctions that can cause the vehicle to fly outside the three-sigma limits of normality but remain within the limits for which a useful orbit can be attained

e. The probability of occurrence of such malfunctions

f. A discussion on the effects of such malfunctions on the success of succeeding burns or stages

g. The most lofted and depressed trajectories for which the primary operation objective can be met and for which a useful orbit can be attained, giving the information requested in paragraphs 2.6.2.1.a through 2.6.2.1.f. In deriving these trajectories, only perturbations that result in deviations in the pitch plane should be considered. If these trajectories cannot be provided, the following may be substituted:

1. If the stage that normally achieves orbit does not contain an FTS, provide the upper and lower altitude limits at shutdown of the last sub-orbital stage if the succeeding stage is to attain a useful orbit.

2. If the stage that normally achieves orbit contains an FTS, provide the upper and lower altitude limits as the vacuum impact point reaches the continent to be overflowed by the first orbital stage if this stage is to attain a useful orbit.

3. Provide the minimum impact range that the last suborbital stage must achieve if the succeeding stage is to attain a useful orbit and a minimum orbit (perigee of at least 70 miles).

2.6.2.2 Trajectories

This paragraph identifies the types of trajectories required for the following flight plans. All trajectories are to be developed using the procedures and format described in Appendix 2A.

a. Single Flight Azimuths. See Appendix 2A, Table 2A-1 (Items 1-8).

b. Variable Flight Azimuths. Space vehicle launches with variable flight azimuths shall pro-

vide a complete set of firing tables detailing launch times and flight azimuths for each day of the launch window. See Appendix 2A, Table 2A-2.

c. Multiple Liquid Propellant Engines Thrusting at Liftoff. For single or variable azimuth flight plans with launch vehicles having multiple liquid propellant engines that normally thrust at liftoff, the trajectories in Table 2A-3 of Appendix 2A are required for engine-out (not thrusting) conditions. The precise engine-out condition(s) shall be specified by Range Safety after the vehicle configuration is known.

2.6.2.3 Malfunction Turn Data

The turning capability of the vehicle velocity vector as a function of thrust vector offsets or other parameter characterizing the turn. See Appendix 2B.

2.6.2.4 Fragment Data

Effects of flight termination action and other potential modes of structural failure on each stage. See Appendix 2C.

2.6.2.5 Jettisoned Body Data

Nominal impact point, associated drag data, and impact dispersion data for each jettisoned body. See Appendix 2D.

2.6.2.6 Sequence of Events

Times from liftoff of discrete events such as ignition, cutoff, and separation of stages, firing of ullage rockets, jettisoning of components, firing of separation rockets, initiation and termination of various control and guidance modes, starting and ending of coast periods and control modes, arming of engine cutoff circuits, and settings for backup engine cutoff signals

2.6.2.7 Solid Propellant Characteristics

a. Burning rate of solid propellants (in/sec) as a function of pressure, including ambient atmospheric pressures

b. Percent propellant TNT equivalency for each stage as a function of relevant impact parameters such as weight of propellant, impact velocity, surface composition, and impact geometry

c. Stage ignition and burntime, propellant weight versus time, and propellant density

2.6.2.8 Acoustic Intensity Contours

a. Acoustic intensity contours above 85 dB at 10 dB intervals that are generated during launch of the vehicle

b. The predominant acoustical bands above 85 dB at distances of .5, 1, 2, and 3 nm surrounding the launch pad

2.6.2.9 High Q Flight Region

A statement indicating the flight time interval when the vehicle is experiencing the "high q" flight region. **NOTE:** This region is defined as the time during flight when the dynamic pressure causes vehicle aerodynamic breakup during a malfunction turn with the result of creating little or no crossrange displacement.

2.6.2.10 Orbital Parameters for Space Vehicles

a. Apogee, perigee, inclination, and period of orbits to be achieved; the time, altitude, latitude, and longitude of the submissile point for post-injection events such as ignition and cutoff of each stage, separation of payload, and reignition of upper stages

b. The state vector (position and velocity components) at the beginning and ending of each thrusting phase after initial orbit insertion

c. The state vector (position and velocity components) for any separated stage or component at the beginning of its final coast or free-flight phase

2.6.2.11 Air-Launched Vehicle Data

For air-launched ballistic and space vehicles, the data in Section 2.11 is required.

2.6.3 Sonic Boom Analysis Data

The following information may be required for a sonic boom hazard analysis:

2.6.3.1 Control Information

a. R - distance (ft) from vehicle where the Near Field Signature (NFS) is determined

b. LM - length (ft) of model of vehicle

c. LR - vehicle length (ft)

2.6.3.2 NFS Data with Exhaust Plume

a. θ - roll angle (deg)

b. M - mach number

c. N - number of points in NFS

d. X - vehicle station (ft) on model where pressure perturbation was measured

e. $\Delta P / P$ - pressure perturbation divided by ambient pressure

2.7 CRUISE MISSILES AND REMOTELY PILOTED VEHICLES SPECIFIC DATA REQUIREMENTS

The trajectory and performance data requirements in this section apply to cruise missiles, remotely piloted vehicles, or drone aircraft. In general, cruise missile operations involving intentional land overflight (except for launch and landing) will not be approved. In highly unusual situations where the operation objectives dictate otherwise and preliminary flight plan approval has been granted, the information requested in paragraph 2.7.2.1 will be used to establish guidelines or limits for land overflight. The permissible limits will depend not only on this information but also on estimates of overflight hazards, the operation objectives, and the importance of these objectives. The following items are required for each flight or group of similar flights and should be updated as vehicle configuration changes occur or revised information becomes available.

2.7.1 Preliminary Flight Data Package Requirements

These data are required in addition to requirements in paragraph 2.5.8.1.

a. Position and velocity (X, Y, Z, α , β , \dot{C}) as a function of time from launch until cruise altitude or a cruise condition is reached. If position and velocity components are not available, ground range and altitude may be substituted for X, Y, Z, and the total earth-fixed velocity relative to the pad and the path angle may be substituted for α , β , \dot{C} . The data are to be provided in time increments no larger than five seconds. If trajectory data cannot be provided, the steepness of the trajectory in the launch area should be compared with the trajectory from any prior similar operation.

b. Vehicle maximum turn capabilities. The maximum turn describes the furthest distance the vehicle impact point can deviate from nominal if a malfunction should occur. See Appendix 2B for details.

c. A map showing the expected flight path over the earth's surface. Times are to be indicated at regular intervals along the path.

d. A graph showing an altitude profile correlated with the flight path. Times are to be indi-

cated at regular intervals along the path.

e. A map showing the estimate of nominal impact points and three-sigma drag-corrected impact dispersion areas for each jettisoned body.

2.7.2 Final Flight Data Package Requirements

These data are required in addition to requirements in paragraph 2.5.8.2.

a. General information concerning the nature and purpose of the flight

b. A scaled diagram of the general arrangements and dimensions of the vehicle

c. Tracking aids, such as S or C band transponder and telemetry transmitter, in the vehicle that can be used for flight safety purposes; the stage or section where each is located

d. Trajectory deviations or other conditions beyond which the Range User is willing to accept flight termination action even though the vehicle has not reached a dangerous position or attitude

e. Approximate elapsed time from receipt of an FTS signal at the command antenna until FTS charges explode or recovery sequence is initiated

f. Graphs of fuel weight (lbs) vs time (sec or min)

g. Graphs of gross weight (lbs) vs time (sec or min)

h. Graph of maximum cruising speed (ft/sec) vs altitude (ft)

2.7.2.1 Land Overflight Data

a. The flight azimuth limits or the maximum deviations from the nominal flight path for which the primary operation objectives can be met

b. The flight azimuth limits or the maximum deviations from the nominal flight path for which a useful operation can be accomplished, even though the vehicle is outside the normal three-sigma limits

c. The operation objectives that will not be met or the extent to which primary objectives will be degraded if land overflight is not permitted when the missile is outside the three-sigma normal limits

d. Circumstances or types of malfunctions that can cause the missile to fly outside the three-sigma limits of normality but still accomplish useful objectives

e. The probability of occurrence of the malfunctions listed in response to paragraph 2.7.2.1.d.

above

2.7.2.2 Trajectories

This paragraph identifies the types of trajectories required for the following flight plans. All trajectories are to be developed using the procedures and format described in Appendix 2A.

a. Single flight azimuths. See Appendix 2A, Table 2A-1.

b. Variable Flight Azimuths. Operations with variable flight azimuths shall provide a complete set of firing tables detailing launch times and flight azimuths for each day of the launch window. See Appendix 2A, Table 2A-2.

c. Multiple Liquid Propellant Engines Thrusting at Ignition. For single or variable azimuth flight plans with vehicles having multiple liquid propellant engines that normally thrust at liftoff, the trajectories in Table 2A-3 of Appendix 2A are required for engine-out (not thrusting) conditions. The precise engine-out condition(s) will be specified by Range Safety after the vehicle configuration is known.

2.7.2.3 Malfunction Turn Data

The turning capability of the vehicle velocity vector as a function of thrust vector offsets or other parameter characterizing the turn. See Appendix 2B.

2.7.2.4 Fragment Data

Effects of flight termination action and other potential modes of structural failure on each stage. See Appendix 2C.

2.7.2.5 Jettisoned Body Data

Nominal impact point, associated drag data, and impact dispersion data for each jettisoned body. See Appendix 2D.

2.7.2.6 Sequence of Events

Using the launch or drop time as the zero reference, time of discrete events such as ignition, cut-off, separation of booster stages, jettisoning of components, starting and ending of control modes, and initiation of recovery devices.

2.7.2.7 Solid Propellant Characteristics

a. Burning rate of solid propellants (in/sec) as a function of pressure, including ambient atmospheric pressures.

b. Percent propellant TNT equivalency for each

stage as a function of relevant impact parameters such as weight of propellant, impact velocity, surface composition, and impact geometry.

c. Stage ignition and burntime, propellant weight versus time, and propellant density

2.7.2.8 Air-Launched Vehicle Data Requirements

For air-launched vehicles, the information in Section 2.11 is required.

2.8 SMALL UNGUIDED ROCKETS AND PROBE VEHICLES SPECIFIC DATA REQUIREMENTS

The trajectory and performance data requirements in this section apply to all small rockets. Although the term *small unguided rocket* is not precisely defined here, it generally refers to one and two-stage rockets having maximum impact ranges less than 100 nm. Small rockets are not required to carry FTSs when dispersion analyses and control of launch conditions indicate that all vehicle components can be contained within predetermined safe areas. Unguided rockets of more than two stages or with impact ranges greater than 100 nm normally are required to carry an FTS. In this event, the data requirements specified in Section 2.6 for ballistic missiles and space vehicles will apply. The following vehicle related items are required for each rocket flight or group of similar flights and should be updated as vehicle configuration changes occur or revised information becomes available.

2.8.1 Preliminary Flight Data Package Requirements

These data are required in addition to requirements in paragraph 2.5.8.1.

- a. Burn time of each stage
- b. Graphs of impact range vs launch elevation angle for the planned elevation angle sector
- c. Graphs of ground range vs altitude for the planned elevation angle sector
- d. Proposed flight azimuth limits
- e. Elevation angle limits
- f. Summary of past vehicle performance giving number launched, launch location, number that performed normally and number that malfunctioned, behavior and impact location for those that malfunctioned, nature of malfunction and corrective action. This requirement can be met by submission of portions of the Reliability and Mal-

function Analysis Data Requirements (paragraph 2.5.8.1.2.).

2.8.2 Final Flight Data Package Requirements

These data are required in addition to requirements in paragraph 2.5.8.2.

2.8.2.1 General Data

a. General information concerning the purpose and objectives of the operation, such as data to be obtained, number of launches planned, and a brief description of the payload, giving approximate weights

b. Scaled diagram of vehicle

c. Geodetic latitude and longitude of launch point or launcher

d. Desired launch azimuth and launch elevation angle. Give the variation in azimuth and elevation angles that are acceptable from the standpoint of the operation objectives. Indicate which of the operation objectives actually determine the acceptable limits for azimuth and elevation angle.

e. A brief description of the type of launcher; for example, zero length or short rail, travel distance of rocket to clear launcher, the amount of effective guidance, launcher adjustments available in quadrant elevation angle (QE) and azimuth, and the smallest increment for these adjustments

f. Total vehicle weight at liftoff

g. Total propellant weight in each stage at liftoff

h. Inert weight of each stage and separable component after burnout or jettison

2.8.2.2 Jettisoned Body Data

Nominal impact point, associated drag data, and impact dispersion data for each jettisoned body. See Appendix 2D.

2.8.2.3 Wind Effects Data

In most cases, wind is the largest independent factor causing displacement of unguided vehicle impact points. Accompanied by tabulations, charts, and a comprehensive discussion of their formulation, the following data are required to predict the magnitude and direction of this effect:

a. Ballistic wind-weighting factors vs altitude in feet. The effects of booster and first-stage wind drifts are of prime importance since the first-stage motor impact point is usually near the launch site. The wind-weighting factor shall be presented in

percent of wind effect for specific wind altitude intervals or for specific altitude interval as a percentage of the total wind effect. The ballistic wind-weighting factors shall include the effects of both weather cocking and drift.

b. Change in the nominal impact point location due to missile weather cocking and drift as a result of ballistic winds (head, tail and cross; or resultant wind effect). The deviation is required in feet or nautical miles per foot per second of the wind. Since deviations vary significantly with a change in launch quadrant elevation angle (QE), values shall be supplied in a table of launcher QE vs unit wind effect. The table shall cover the range of elevation angles for which launches are to occur with an elevation angle interval no greater than 2 degrees and include plus and minus 12 degrees from the desired resultant QE up to a maximum launcher setting of 88 degrees.

c. Launcher adjustment curve or launcher tilt effect to correct the launcher in azimuth and elevation for wind effects. A discussion of methods to be employed in adjusting the launcher settings to compensate for winds is required. This data is required only if the Range User desires to adjust the launcher azimuth and elevation to correct for wind effects and shall be supplied for all desired resultant QEs. Wind compensation minimizes the area clearance problem by maintaining a constant impact point. A thorough description of the correction method and the expected accuracies to be achieved are required in addition to the proper curves and tabulation of data.

d. A graphical and tabular presentation of the impact point displacement due to earth rotation vs QE. Calculations for this information are based upon the latitude of the launcher and the desired launch azimuth. The table shall have a minimum interval of 2 degrees and include plus and minus 12 degrees from the desired resultant QE up to a maximum of 88 degrees.

e. When a computer program is used to perform the calculation required for adjustment of the launcher in QE and azimuth, the Range User shall include a discussion of the intended use of the program. If the Range User uses one of the computer programs available at the Range, Range Safety should be consulted to make sure that data requirements in paragraphs 2.8.2.3.a through 2.8.2.3.d above, are presented in a form compatible with the computer input requirements.

2.8.2.4 Analyses for Long Range Probes

All analyses for long-range probes (500 nm plus) shall be calculated using a rotating spherical or ellipsoidal gravity field. In contrast to the majority of probe vehicles, long-range probes normally require an FTS incorporated into the vehicle. The data requirements are the same as those specified in Section 2.6 for guided ballistic missiles. A risk study (paragraph 2.5.6) is required to evaluate requests to waive the requirement for an FTS on a long-range probe vehicle.

2.8.2.5 Launch Aircraft Data

For air-launched rockets or probes, the data items in section 2.11 are required.

2.8.2.6 Trajectory Requirements

See Appendix 2A.

2.8.2.7 Graphs

In addition to the tabular nominal trajectory data, graphs of the following shall be provided for each stage and payload weight.

- a.* Impact range vs launch elevation angle (ft or nm vs deg)
- b.* Apogee altitude vs launch elevation angle (ft vs deg)
- c.* Ground range vs altitude (ft or nm vs ft)

2.8.3 Statement of Vehicle Performance

In addition to the data requested in paragraph 2.5.9, the following data are required:

- a.* Vehicle type and number, launch location, operation number, payload type and weight
- b.* Actual launcher azimuth and elevation setting (deg)
- c.* For each stage and payload, the predicted range (nm) and azimuth (deg) from the launcher to the impact point based upon the predicted winds at time of launch
- d.* Actual range (nm) and azimuth (deg) from the launcher to the impact point for each stage and payload
- e.* Actual impact range (nm) for each stage and payload giving components measured along and perpendicular to the predicted impact azimuth. Where a stage is not tracked to impact, the impact point should be computed using the best estimates of the drag characteristics and of the winds at launch.
- f.* Predicted effective QE (deg) of trajectory for each stage

g. Actual effective QE (deg) of trajectory for each stage

h. Predicted range (nm) and altitude (ft) of apogee for each stage

i. Actual range (nm) and altitude (ft) of apogee for each stage

j. A tabulation of the reduced wind data used in the launcher-setting calculations giving speed (ft/sec) and direction (deg) as a function of altitude (ft)

k. A reference list of all documents, graphs, and tabulations that were used in making the launcher setting calculations (wind-weighting curves, ballistic wind-weighting factors, and unit wind effect)

l. Description of the tracking data source

2.9 AEROSTAT AND BALLOON SPECIFIC DATA REQUIREMENTS

The trajectory and performance data requirements in this section apply to large unmanned, untethered, and tethered aerostats and balloons. They do not apply to small weather balloons and other such objects that are released routinely throughout the country and the world for scientific purposes.

2.9.1 Preliminary Flight Data Package Requirements

These data are required in addition to requirements in paragraph 2.5.8.1.

a. Description of the proposed flight plan giving particulars about the location and boundaries of the proposed test area, time sequence and description of significant events, flight duration, altitude, and speed limits

b. Method of control, including emergency control procedures

2.9.2 Final Flight Data Package Requirements

These data are required in addition to requirements in paragraph 2.5.8.2.

2.9.2.1 Untethered Aerostats/Balloons

Large unmanned and untethered aerostats and/or balloons flight tested on the Range shall carry an approved FTS capable of causing rapid deflation upon command. The following vehicle related items are required for each flight or group of similar flights. The data should be updated as ve-

hicle configurations vary or revised information becomes available.

a. Detailed information concerning the purpose and objectives of the mission, data to be obtained, number of flights planned, proposed flight dates

b. A statement indicating whether the vehicle and proposed flights are similar to prior flights either on the Range or elsewhere

c. A description of the vehicle giving dimensions, component weights, materials, and characteristics of propulsion, control, and recovery systems including estimates of system reliability

d. Accuracy of guidance and control system in maintaining desired aerostat position

e. Description and location of FTS

f. Description and location of tracking aids

g. Wind restrictions for launch and flight

h. Description of proposed flight plan

1. Location of proposed test area

2. Graph of altitude (ft) vs time (min) from release until float altitude is reached

3. Total duration of flight

4. Graph of altitude (ft) vs time (min) for entire operation or indication of how altitude will be varied throughout flight

5. Maximum possible altitude without bursting

6. Maximum aerostat speed in still air as function of altitude

7. Location and size of impact dispersion areas for any bodies jettisoned during flight

8. Location and size of final impact dispersion area or intended recovery area

i. Coefficient of drag (C_d) vs Mach number giving reference area and weight for each jettisoned body and for the entire vehicle (or resulting components) after activation of the FTS. **NOTE:** The same data should also be provided for a normal recovery sequence if different from the above.

2.9.2.2 Tethered Aerostats/Balloons

Tethered aerostats/balloons shall carry an approved automatic FTS that will cause rapid deflation if the balloon escapes its mooring or the tether breaks. The following vehicle-related items are required for each flight or group of similar flights. The data should be updated as vehicle configurations vary or revised information becomes available.

a. Detailed information concerning the purpose and objectives of the mission, data to be obtained, number of flights planned, proposed flight dates

- b. Description and location of FTS
- c. Description of mooring tethering system giving lengths and breaking strength of tether
- d. Operational method of measuring tension in tether
- e. Wind and weather restriction for launch and flight
- f. Maximum float altitude
- g. Planned and maximum duration of flight

2.10 PROJECTILE, TORPEDO, AIR-DROPPED BODY, AND DEVICE SPECIFIC DATA REQUIREMENTS

The data requirements in this section apply to projectiles and small devices that normally would not contain an FTS and that may or may not be propulsive.

2.10.1 Preliminary Flight Data Package Requirements

In addition to the data requested in paragraph 2.5.8.1, the following data are required:

- a. Description of the proposed flight plan giving particulars about the location and boundaries of the proposed operation area, time sequence and description of significant events
- b. Burn or thrust time of each thrusting item
- c. Graphs of impact range (nm) vs launch-elevation angle (deg) for the planned elevation-angle sector or drop-altitude sector
- d. Ground range (nm) vs altitude (ft) for the planned elevation-angle sector or drop-altitude sector
- e. Nominal impact location in geodetic latitude (deg) and longitude (deg) for each jettisoned or impacting body
- f. Estimates of the three-sigma dispersion area in downrange (ft or nm) and crossrange (ft or nm) measured from the nominal impact location

2.10.2 Final Flight Data Package Requirements

In addition to the data requested in paragraph 2.5.8.2, the following data are required:

- a. Detailed information concerning the purpose of the operation, data to be obtained, description

of objects, number of operations in the program, and proposed operation dates

- b. Scaled diagram of vehicle

c. Latitude and longitude of the desired drop or launch point and the maximum region around the point where drop or launch could occur. **NOTE:** This information may be provided in distances downrange and crossrange relative to the expected drop point or by providing the geodetic latitude and longitude of the corners of the area.

- d. Jettisoned Body Data. (See Appendix 2D.)

1. Latitude and longitude of the desired impact or target point

2. The three-sigma downrange and cross-range impact dispersions or circular error probability (CEP) of impact points for each impacting body. **NOTE:** This information may be provided in distances downrange and crossrange relative to the expected drop point or by providing the geodetic latitude and longitude of the corners of the area.

3. For air-dropped bodies, the effect of a three-sigma aircraft position and velocity error at drop

4. If the body descends on a parachute or other device, drag data before and after chute opening

e. For air-dropped bodies, the data items in the **Air-Launched Vehicle Specific Data Requirements** (Section 2.11) of this Chapter shall be provided.

f. The effect of head wind, tail wind, and cross wind on the impact point location in terms of displacement distance (ft or nm) per knot (or ft/sec) of wind

g. Trajectory Requirements. The following trajectory data items are required for each operation or group of similar operations.

1. A graph of the nominal trajectory, including a plot of altitude (ft) vs downrange distance (ft or nm); timing marks (sec), including the impact time, shall be indicated along the trajectory. **NOTE:** Separate graphs are required for each planned drop altitude or other condition.

2. The maximum horizontal distance (ft or nm) that can be traveled by the objects from the drop or launch point to impact

3. If the objects descend on a parachute, a plot of altitude (ft) vs range (ft or nm) for the case where the chute fails to open

2.11 AIR-LAUNCHED VEHICLE SPECIFIC DATA REQUIREMENTS

The data requirements in this section apply to all programs that use an aircraft as the originating platform for the operation.

2.11.1 General Data Requirements

- a.* General information concerning the nature and purpose of the flight
- b.* Specify minimum weather requirements for the operation.
- c.* Emergency Requirements. Specify special emergency requirements including:
 1. Search and Rescue support requirements
 2. Emergency Recovery Plan, including minimum field length(s)
 3. Description of ditching characteristics, if known
 4. Description of secondary communication procedures to be used in the event of primary communications failure
 5. If structural flight and systems tests are to be conducted, any weather minimums and special requirements

2.11.2 Aircraft Data Requirements

- a.* Aircraft type (chase, tanker, etc.) and "N" or tail number and performance capability of aircraft, such as turn rate, climb rate, and velocity
- b.* For other than level flight launches, an additional statement describing how the aircraft path angle and launch azimuth are determined for vehicle release
- c.* Description of guidance system used and how ignition time and altitude are determined

2.11.3 Aircraft Flight Plan Data Requirements

- a.* Description of drop aircraft flight plan, such as aircraft flight azimuth (degrees true), speed (kts), altitude (ft), flight path angle (deg) of velocity vector relative to local horizontal at vehicle drop point; a map showing the flight path over the earth's surface with altitudes and speeds indicated at appropriate check points
- b.* The expected maximum region around the drop point, (a drop point envelope where the operation is conducted) provided as distances downrange, uprange, and crossrange relative to the expected drop point and perpendicular to the launch azimuth or by the geodetic latitude and longitude of the corners of the drop box

c. A definition and description of events occurring prior to vehicle release and to time of vehicle engine ignition

d. Predicted impacts of jettisoned hardware associated with the vehicle drop system and their impact dispersion

e. For ballistic air-dropped bodies, altitude of the aircraft, true air speed, and dive angle beginning 60 sec prior to drop and continuing through drop

2.11.4 Launched Vehicle Data Requirements

a. A nominal flight profile for each stage from launch to impact, showing altitude (ft) vs downrange (ft) is required. Profiles shall include parachute opening, parachute not opening, all unignited and non-separation conditions of the vehicle. Timing marks in seconds shall be indicated on the trajectory, as well as total time of flight for each object dropped.

b. The drop rate of launched vehicle and description of stabilizing system used

c. Method of ignition and position of the vehicle relative to the earth at ignition

2.11.5 Sonic Boom Data Requirements

In accordance with AFI 13-201, a sonic boom report may be required if supersonic flights are to be conducted. If a sonic boom report is required, the following information shall be provided for a sonic boom hazard analysis:

2.11.5.1 Control Information

- a.* R - distance (ft) from aircraft where NFS is determined
- b.* LM - length (ft) of model of vehicle
- c.* LR - vehicle length (ft)

2.11.5.2 NFS Data

- a.* θ - roll angle (deg)
- b.* M - Mach No
- c.* N - number of points in NFS
- d.* X - Aircraft station (ft) on model where pressure perturbation was measured
- e.* $\Delta P / P$ - pressure perturbation divided by ambient pressure

2.11.5.3 Flight Profile Data

- a.* Time (sec)
- b.* Vehicle altitude (ft) above reference sphere

- c. Geodetic latitude (deg) of vehicle
- d. Longitude (deg) of vehicle
- e. Vehicle freestream Mach number
- f. Vehicle flight path angle (deg) measured up from horizontal
- g. Vehicle heading (deg) from true North
- h. \dot{M} - The time rate of change of Mach number (per sec)
- i. Time rate of change of flight path angle (deg/sec)
- j. Time rate of change of heading (deg/sec)
- k. Roll angle (deg) from horizontal up to right wing as viewed from behind the vehicle.

2.12 COLLISION AVOIDANCE

- a. The Collision Avoidance (COLA) program shall be used in the minus count to protect manned orbiting objects from collision with a launch vehicle or its jettisoned debris.
- b. The COLA program shall compute the closest approach for all launch vehicles exhibiting the potential to collide with the defined orbiting objects.
- c. COLA runs shall be scheduled in a letter from Flight Analysis to Range Scheduling.
- d. COLA data shall be used to establish unsafe launch intervals based on a closest approach criteria of 200 km for manned objects.
- e. COLA closure periods shall be designated for launch intervals whose closest approach distances are less than the above criteria.
- f. A COLA closure period will result in a launch hold or may cause a launch scrub depending on closure interval and the remaining opportunities in the launch window.

2.13 45 SW RANGE SAFETY REQUIREMENTS FOR THE ER

NOTE 1: Similar requirements for 30 SW Range Safety are found in the 30 SW RSOR. **NOTE 2:** In this section, *Range Safety* refers to 45 SW/SEOE and SEOS only. Other 45th Space Wing Range Safety offices are specified, as required.

2.13.1 Pre-flight Planning Requirements

- a. Pre-flight computations and plots shall be made at the Central Computer Complex (CCC), Range Operations Control Center (ROCC), and the Technical Laboratory Computer Facility (TLCF).
- b. Requirements for computer support at the

CCC/ROCC and TLCF shall be levied by Range Safety via Requests for Computer Services.

- c. The appropriate ER agencies shall provide computational, plotting, and reproduction services for Range Safety planning and pre-flight requirements as follows:

1. Operating computing and plotting equipment at the CCC/ROCC and TLCF
2. Performing analytical studies, formulating mathematical models, and developing computer programs to meet specifications established by Range Safety
3. Maintaining, documenting, and operating the computer programs listed in the current Semi-annual Computer Program Survey document
4. Processing magnetic tapes and providing computer listings and trajectory output files
5. Computing random and systematic errors for the instrumentation systems used for flight control. **NOTE:** Errors must be converted to appropriate statistical parameters to evaluate the magnitude of real-time present position and impact predictor errors throughout thrusting flight.
6. Calculating acquisition times, look angles, aspect angle, and signal strengths to arrive at tracking, telemetry, and command destruct expected coverage estimates
7. Maintaining the real-time impact prediction program and other related real-time and prelaunch programs
8. Evaluating time delays in the real-time program and in associated instrumentation systems
9. Providing miscellaneous reproduction and photographic services including the preparation of view graphs and briefing slides as required

2.13.2 Telemetry Data Requirements for Impact Prediction

- a. If available, launch vehicle real-time telemetry guidance data shall be used to generate an impact point for the MFCO.
- b. 45 LG shall provide 45 SW/SEOO and Range Safety with coverage periods for which this data is valid in the Committed Coverage Plan (CCP).

2.13.3 RSD Verification Test Requirements

- a. In accordance with Operations Directive (OD) 16, Annex B, an RSD verification test shall be performed.
- b. At least seven working days prior to each major vehicle launch, Range Safety shall provide the following RSD requirements to the range contractor

for preparation of the Range Safety backgrounds:

1. Type, number, and scale factors of displays
2. Disk file locations for trajectories and destruct criteria
3. Other data needed to prepare the RSD background display tapes
 - c. At least five working days before launch, Range Safety shall forward additional data and details required to prepare RSD background display verification tapes.
 - d. The Range Technical Services Contractor (RTSC) prepares final display and verification tapes, reviews them for accuracy and completeness, and corrects obvious discrepancies before the scheduled verification date.
 - e. RSD verification shall be completed no later than F-4 days prior to launch.
 - f. After the RSD display tapes have been verified by Range Safety, no changes shall be made to the tapes or any interrelated real-time program if the change can affect the real-time RSD displays.

2.13.4 Requirements for Notice to Airmen and Mariners

- a. By F-10 days, Range Safety shall provide 45 RANS with the areas hazardous to ships and aircraft for all normally jettisoned and impacting stages.
- b. 45 RANS is responsible for disseminating the Notice to Airmen (NOTAM) and Notice to Mariners (NTM) to aircraft and shipping interests.

2.13.5 Range Safety Displays

- a. Range Safety Trajectory Display System. A Trajectory Display System for unclassified video presentation of RSD displays is required in the Range Safety areas, PAFB, Building 423, Room C-301D.
- b. Range Safety Video Displays. The following displays shall be transmitted to a multi-channel monitor located in the Range Safety area, PAFB Building 423, Room C-301D:
 1. IIP
 2. Unclassified presentation of the trajectory display (IIP) from L-10 min to orbital insertion or impact
 3. Unclassified presentation of the vertical plane (VP) trajectory display from L-10 min
 4. Display of the weather forecast channel, including audio, by L-60 min, or 5 min prior to the scheduled launch weather briefing, whichever is earliest

5. Display of unclassified surveillance control charts no later than L-90 min
6. Display of NASA Select, with audio, during Space Shuttle launches no later than L-120 min

2.13.6 Wind Data Requirements for Major Launches

- a. For all major launches from CCAS and KSC, the RWO shall provide Range Safety with a forecast of launch winds on F-1 day, on launch day, and at other times during the launch when requested.
- b. The following procedure shall be used in providing wind data to Range Safety:

1. Using the most current wind observations, the RWO shall provide forecasts at times specified in a Range Safety "Range Safety Wind Requirements" letter to the Meteorological Systems Office.
2. In developing wind forecasts, the latest available balloon data and met-rocket data shall be combined to produce the best possible estimate of T-0 winds. For manned launch vehicles, the rocketsonde data shall be no older than 72 hours. For unmanned launch vehicles, the rocketsonde data will be the latest available. The following procedure shall be used to produce the best possible estimate of T-0 winds for both manned and unmanned launch vehicles:

(a) If the balloon bursts between 90,000 and 150,000 ft, all the rawinsonde/windsonde data available shall be used. Appended to it shall be the latest rocketsonde data producing a wind speed and direction file at 1,000 ft increments to an altitude of 150,000 ft with the appropriate data headers.

(b) If the balloon bursts between 60,000 and 90,000 ft altitude, the rawinsonde/windsonde data shall have appended to it the most current available rawinsonde/windsonde data up to 90,000 ft altitude. Above 90,000 ft up to 150,000 ft altitude, the latest rocketsonde data shall be appended, producing a wind speed and direction file at 1,000 ft increments to an altitude of 150,000 ft with the appropriate data headers.

(c) If the balloon bursts before reaching 60,000 ft altitude and time is available, another windsonde shall be released and the data as in paragraphs 2.12.6.b.2 (a) and 2.12.6.b.2 (b) above shall be added. If time is not available, the data available from the aborted balloon shall be used. Appended to it shall be the most current rawinsonde/windsonde data up to 90,000 ft altitude. Above 90,000 ft up to 150,000 ft altitude the latest

rocketsonde data shall be used to produce a wind speed and direction file at 1,000 ft increments to an altitude of 150,000 ft with the appropriate data headers.

3. For unmanned launch vehicles, statistical winds data are provided in the "Range Safety Wind Requirements" letter as a possible replacement for the latest available rocketsonde data. Range Safety will determine on F-1 and on launch days if the statistical winds will be used in lieu of the rocketsonde data. RTDR data reduction personnel will merge the statistical wind data with the rawinsonde/windsonde data per the instructions given above for rocketsonde data.

4. In general, the launch day balloon shall be released no earlier than L-8 h.

5. The duty meteorologist should make changes based on the measured winds to ensure the highest accuracy in forecasts.

c. Forecasts of resolved winds (2,000 ft increments) and unresolved winds (1,000 ft increments) for one or more specific azimuths shall be required

up to 150,000 ft in altitude. **NOTE:** The sign convention shall be positive for head winds and negative for tail winds.

d. The data shall be made available to Range Safety as specified in the "Range Safety Wind Requirements" letter within two hours after balloon release.

e. After the wind forecast has been prepared, a Launch Weather Officer (LWO) shall discuss the degree of confidence in the predicted winds with Range Safety personnel. The likelihood of any changes in wind speed or direction before the launch and the magnitude of any such changes shall also be discussed. As a result of this briefing and prelaunch analysis, Range Safety shall determine whether additional wind observations and computer runs shall be required.

f. If the wind forecast should subsequently change because of launch delays or other circumstances, the meteorologist shall inform the MFCO and Range Safety representative immediately. Estimates of quantitative changes in wind speed and direction as a function of altitude shall be provided.

g. At L-60 min, the RWO shall provide a weather forecast briefing for the launch area using closed circuit television and direct line or network communications.

APPENDIX 2A TRAJECTORY DATA

2A.1 INTRODUCTION

This appendix provides background information and details about Range Safety trajectory requirements. It is applicable to ballistic, space, cruise, remotely piloted, and small unguided vehicles. Trajectories are to be provided in accordance with EWR 127-1, Annex to Chapter 2, "Flight Trajectory and Data Manual." The trajectory and two printouts with a letter of transmittal are required.

2A.2 TRAJECTORY DETAILS

2A.2.1 The X, Y, Z, coordinates referred to in this Chapter shall be referenced to an orthogonal, earth-fixed, left-handed system with its origin at the launch point or at a point on the earth's surface above or below the launch point. The XY plane shall be tangent to the ellipsoidal earth at the origin, the positive X axis shall coincide with the launch azimuth, and the positive Z axis shall be directed away from the earth, and the Y axis shall be positive to the right looking downrange.

2A.2.2 Trajectory Data Item Requirements

The required trajectories from Table 2A-1 through Table 2A-3 shall be calculated using a six degree-of-freedom program. Table 2A-4 lists the data items to be provided for each required trajectory. The data items are required in 1 sec intervals.

a. Ballistic Missiles and Space Vehicles. All trajectories except the three-sigma launch area trajectories shall be provided from launch up to a point in flight where effective thrust of the final stage has terminated, or to thrust termination of that stage or burn that places the vehicle in orbit. The launch area trajectories are required from lift-off until the vehicle attains an altitude of 100,000** ft.

b. Cruise Missiles and Remotely Piloted Vehicles. The data items are required in tabular form in one sec intervals for the first two** minutes of flight, in 15-sec** intervals from this point until the missile reaches cruise altitude, in one-minute** intervals throughout the cruise phase until the terminal phase of flight is reached, and at 15-sec** intervals thereafter until operation termination or impact. The time 0.0 sec shall correspond to first motion for pad-launched missiles

and to the instant of drop for air launches.

c. Small Unguided Rocket or Probe Vehicle. Table 2A-4 (Items 5 - 13) lists the data items to be provided for each trajectory from launch until burnout of the final stage for each desired nominal quadrant elevation angle and payload weight. These items shall be provided in tabular form as a function of time with each column of the table containing only a single parameter. Time shall be given at even intervals, not to exceed one sec increments during thrusting flight, and for times corresponding to ignition, thrust termination or burnout, and separation of each stage. If stage burning times are less than four sec, time intervals should be reduced to 0.2 sec or less.

2A.2.3 Nominal (Reference) Trajectory

The nominal or reference trajectory is the trajectory that the vehicle would fly if all vehicle parameters were exactly as expected, if all vehicle systems performed exactly as planned, and there were no external perturbing influences.

2A.2.4 Three-Sigma Dispersed Trajectories

The three-sigma dispersed trajectories define the downrange and crossrange limits of normality for the vehicle instantaneous impact point (IIP) at any time after launch. The three-sigma trajectories should be computed using annual wind profiles unless the launch is to be conducted at a particular time of the year and only at that time. Care should be exercised in the selection of the cumulative percentage frequency of the wind profile used for the computation of these trajectories. Selecting a wind profile as severe as the worst wind conditions when a launch would be attempted is usually recommended. In critical instances, this has the disadvantage of limiting the allowable launch azimuth or reducing the allowable launch day winds in the flight safety restrictions for wind drift of vehicle fragments resulting from FTS action. The flight termination criteria, allows for as much vehicle deviation due to wind as shown in these trajectories, but does not account for wind conditions that exceed those used in these computations.

APPENDIX 2A TRAJECTORY DATA

Table 2A-1
Trajectory Types for Single Flight Azimuths

Item #	Program	Trajectory Type	Ref. Para.
1	All programs	Nominal or reference.	2A.2.3
2	Ballistic Missile and Space Vehicle	Three-sigma maximum-performance	2A.2.4.1
3		Three-sigma minimum-performance	2A.2.4.1
4		Three-sigma lateral left	2A.2.4.2
5		Three-sigma lateral right	2A.2.4.2
6		Three-sigma steep launch area	2A.2.4.3
7		Three-sigma lateral launch area	2A.2.4.3
8		Fuel-exhaustion.	2A.2.4.4
9	Cruise Missile and Remotely Piloted Vehicles	Three-sigma maximum-altitude. The maximum altitude deviations (ft) above nominal as a function of ground range from the launch or drop point may be substituted for Table 2A-4, Item 3.	2A.2.4.1 2A.2.4.1.1
10		Three-sigma minimum-altitude. The maximum altitude deviations (ft) below nominal as a function of ground range from the launch or drop point may be substituted for Table 2A-4, Item 3.	2A.2.4.1 2A.2.4.1.1
11		Three-sigma lateral. The maximum lateral deviations (ft or nm) from the nominal flight path as a function of ground range from the launch or drop point may be substituted for Table 2A-4, Item 3	2A.2.4.2 2A.2.4.2.4
12		Fuel-exhaustion. Table 2A-4, Items 3 and 4, are required from launch or drop until the vehicle reaches a steady-state cruise condition. The three-sigma high-performance trajectory should define the vehicle capability limits in climbing to maximum altitude at the maximum possible rate.	2A.2.4.4 2A.2.4.4.1

Table 2A-2
Trajectory Types for Variable Flight Azimuths

Item #	Trajectory Type	Ref. Para.
1	Nominal, reference, central, or middle trajectory.	2A.2.3
2	Extreme right-hand nominal or steepest nominal trajectory.	2A.2.3
3	Extreme left-hand nominal or shallowest nominal trajectory.	2A.2.3
4	Three-sigma maximum-performance trajectory for the centrally located flight azimuth	2A.2.4.1
5	Three-sigma minimum-performance trajectory for the centrally located flight azimuth	2A.2.4.1
6	Three-sigma lateral trajectories for the centrally located flight azimuth	2A.2.4.2
7	Three-sigma steep launch area	2A.2.4.3
8	Three-sigma lateral launch area	2A.2.4.3
9	Fuel-exhaustion	2A.2.4.4

Table 2A-3
Trajectory Types for Multiple Liquid Propellant Engines Thrusting at Liftoff

Item #	Trajectory Type	Ref. Para.
1	Three-sigma steep launch area trajectory with one or more engines not thrusting	2A.2.4.3
2	Three-sigma lateral launch area trajectory with one or more engines not thrusting	2A.2.4.3

APPENDIX 2A TRAJECTORY DATA

**Table 2A-4
Trajectory Data Items**

Item #	Data Item	Comments
1	A brief discussion of the parameters considered, their standard deviations, and all assumptions and procedures used in deriving each of the dispersed trajectories.	
2	A graph and tabular listing of the wind profiles used (wind magnitude and direction vs altitude)	The source of the wind profiles used in the computations shall be identified.
3	X, Y, Z vs Time (ft and sec)	Cruise Missile and Remotely Piloted Vehicles: Units are ft or nautical miles and sec or minutes. After the first 2** minutes of flight, with Range Safety approval, X,Y,Z, may be replaced by ground range along the earth's surface from launch point to sub-missile point vs time, altitude above earth's surface vs time, and cross range displacement from nominal vs time.
4	✱, ✱, C vs time (ft/sec and sec)	Cruise Missile and Remotely Piloted Vehicles: Units are the nearest one-tenth ft/sec and sec or minutes. After the first 2** minutes of flight, with Range Safety approval, ✱, ✱, C may be replaced by speed (ft/s) vs time and path angle (deg) of velocity vector relative to local horizontal vs time.
5	Speed vs. time (ft/sec and sec)	
6	Path angle of velocity vector relative to local horizontal vs time (deg and sec)	
7	Altitude above the sub-vehicle point on the reference spheroid vs time. (ft and sec)	
8	Total weight vs time. (lb and sec)	
9	Ground range along reference spheroid from the origin (launch point) to a point directly beneath the missile vs time (nm and sec)	For Small Unguided Rocket or Probe Vehicle: Ground range units are ft.
10	Thrust vs time (lb and sec)	
11	Instantaneous impact point data	Geodetic latitude, longitude, impact range (nm) and remaining flight time (sec) vs time (sec).
12	Launch azimuth	Degrees measured clockwise from true North.
13	The name, coordinates, and mean sea level elevation of the coordinate system origin (launch pad).	
14	Name of reference spheroid used in trajectory calculations.	

To generate a single composite three-sigma trajectory in terms of instantaneous impact range, the following procedure is suggested: **NOTE:** If the following procedure is not used, a description of the method used to generate the three-sigma trajectories is required.

Step 1: Identify individual parameters such as thrust, weight, specific impulse, and atmospheric density that significantly affect the performance of the vehicle instantaneous impact point (IIP). Estimate three-sigma dispersions for these parameters.

Step 2: Run a series of trajectory computations or simulations where three-sigma values of sig-

nificant perturbing parameters are introduced one at a time. At a suitable number of time points, tabulate the IIP deviations from nominal that have been caused by perturbing each parameter.

Step 3: At each time point and direction, calculate the square root of the sum of the squares of all deviations to arrive at the three-sigma IIP deviations.

Step 4: By further trajectory computations or simulations, generate a thrusting flight trajectory (a three-sigma, no-wind trajectory) that matches as closely as possible the three-sigma deviations calculated in Step 3. This may be done by perturbing

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only a few key parameters at varying magnitudes throughout the run.

Step 5: Compute the required three-sigma trajectory using worst-case winds together with the parameter magnitudes used to calculate the three-sigma no-wind trajectory. The wind dispersed trajectories indicate vehicle performance deviations due to the effects of severe winds. This data should be supplied until the vehicle attains an altitude where there is essentially no wind effect. It is usually sufficient to use 100,000 ft as this altitude limit. Computations should not be limited to wind drift but include all wind effects.

2A.2.4.1 Three-Sigma Maximum and Minimum Performance Trajectories

The three-sigma maximum and three-sigma minimum-performance trajectories define at any time after launch the limits of normality as far as impact downrange is concerned. The three-sigma maximum-performance trajectory provides the maximum downrange distance of the vacuum instantaneous impact point (IIP) for any given time and the three-sigma minimum-performance trajectory provides the minimum downrange distance of the IIP for any time. In calculating these trajectories, head and tail-wind profiles should be used that represent the worst wind conditions for which a launch would be attempted. For any particular time after launch, approximately 99.73 percent of all normal vehicles (assuming a normal Gaussian distribution) that are subjected to the assumed wind will have impact ranges lying between the extremes achieved at that time by three-sigma maximum performance and three-sigma minimum-performance vehicles. Of the 0.27 percent of the normal vehicles that fall outside the three-sigma limits, approximately half would be short and half would be long. It is recognized that it may not be possible for a normally performing, fully guided vehicle to fly either the three-sigma maximum or minimum-performance trajectory as defined above. However, what is wanted is a single trajectory having an impact range at any time greater than the impact range of 99.865 percent of all normal vehicles, and a single trajectory with an impact range at any time less than the impact range of 99.865 percent of all normal vehicles. Any deviation outside of three-sigma limits indi-

cates that the vehicle is probably behaving in an abnormal, though not necessarily dangerous, fashion. Those parameters having a significant effect upon impact range, such as thrust, specific impulse, weight, variation in firing times of different stages, and fuel flow rates, should be combined in the best considered fashion to produce the required results.

2A.2.4.1.1 Cruise Missiles and Remotely Piloted Vehicles. The three-sigma maximum and minimum-altitude trajectories define for any ground range the limits of normality as far as altitude is concerned. In other words, for any particular ground range approximately 99.73 percent of all normal vehicles (assuming a normal Gaussian distribution) will have altitudes between the extremes defined by three-sigma maximum altitude and three-sigma minimum-altitude trajectories. Any deviation outside these limits indicates that the vehicle is behaving in an abnormal, though not necessarily dangerous, fashion. However, the MFCO may destroy such a vehicle if it is approaching land or threatening to get outside or below the command destruct coverage area.

2A.2.4.2 Three-Sigma Lateral Trajectory Requirements.

2A.2.4.2.1 Definition. Three-sigma lateral trajectories define the crossrange limits of normality for the vacuum instantaneous impact point (IIP). Both a three-sigma left and a three-sigma right trajectory must be provided. These trajectories should be calculated using the worst lateral wind conditions for which a launch would be attempted. For any downrange distance, the IIP traces for 99.73 percent of all normal vehicles subjected to the assumed winds lie between the three-sigma lateral IIP traces. For variable azimuth launches, a three-sigma left trajectory for the smallest flight azimuth in the approved azimuth sector and a three-sigma right trajectory for the largest flight azimuth in the approved sector are required in addition to three-sigma lateral trajectories for a centrally located flight azimuth. Unless the procedure is invalid, the assumption will be made that the three-sigma left and right trajectories provided for the centrally located azimuth can be used to produce a reasonable approximation of the three-sigma left and right trajectories for other flight

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azimuths by reorienting the X and Y axis of the data. For example, if the three-sigma lateral trajectories have been computed for a central flight azimuth of 100 degrees, the three-sigma lateral trajectories for a 90 degrees flight azimuth will be determined simply by assuming that the X axis is 90 degrees instead of 100 degrees. If this assumption is not reasonable, additional trajectories shall be provided to define the extreme left and right lateral limits.

2A.2.4.2.2 Use. Three-sigma lateral trajectories are needed to determine whether a normal vehicle experiencing a three-sigma deviation will violate flight safety destruct criteria. They may also be used as guidelines by the MFCO in deciding whether a vehicle will be allowed to continue in flight or to over fly land. When used for comparison with the impact predictor destruct criteria, the vacuum IIP data are required. When used on the present-position display, values of X, Y, Z along the three-sigma lateral trajectories are required. The three-sigma lateral trajectories, as defined in paragraph 2A.2.4.2.1 in terms of IIP, may not provide three-sigma deviations of the lateral position Y as a function of X, although this is normally assumed to be the case. If this assumption is not valid, the Range User should also submit three-sigma trajectories that define the lateral limits of Y in terms of X.

2A.2.4.2.3 Calculation. In calculating a three-sigma lateral trajectory, those parameters having a significant effect on the lateral deviation of the IIP (or of the position Y in terms of X) should be combined in the best considered fashion to produce the required results. The procedures described in paragraphs 2A.2.4 and 2A.2.4.1 for calculating three-sigma maximum and minimum-performance trajectories is also suggested here.

2A.2.4.2.4 Cruise Missile and Remotely Piloted Vehicles. The three-sigma lateral trajectory defines the lateral limits within which 99.73 percent of all normal missiles are expected to remain. This trajectory should be calculated using the worst lateral wind condition for which a launching would be attempted. Since only one three-sigma lateral trajectory is requested, the assumption will be made that the three-sigma left and three-sigma right trajectories are symmetric about the nominal

trajectory. If this assumption is not reasonable, then both three-sigma left and three-sigma right trajectories must be provided. A missile that deviates outside the three-sigma lateral limits is subject to possible destruction if it is approaching land or threatening to get outside or below the command destruct coverage area.

2A.2.4.3 Dispersed Launch Area Trajectories. If the dispersed launch area trajectories are computed as specified and the proposed flight plan is approved, the launch agency can be certain that a normal vehicle will not violate the safety destruct criteria in the launch area, irrespective of the actual winds existing at launch. Unfortunately, there is also a distinct disadvantage in using extreme winds to calculate the dispersed trajectories. To arrive at destruct lines that will not be violated by vehicles flying the extreme trajectories, the allowances made for wind effects in the destruct line computations must be kept small. This in turn means that wind restrictions must be imposed on launch day. The wind profile used in the destruct calculations may be much smaller than the extreme wind profiles used to calculate the dispersed trajectories. In general, the greater the wind profile used in calculating the dispersed launch area trajectories, the steeper the trajectories are; and the steeper the dispersed trajectories, the more severe the Range Safety wind restriction must be on launch day to have acceptable destruct criteria. Reducing the wind profile in calculating the dispersed trajectories lessens the probability of a hold due to wind, but increases the probability that a normal vehicle will fly outside the limits defined by the dispersed trajectories. This in turn increases the probability that a normal vehicle will be destroyed. For those vehicle flights for which severe launch area wind restrictions are required, it may be necessary for the Range User to supply dispersed launch area trajectories for two or three different wind profiles. By so doing, the probability of a safety hold due to wind is thus reduced.

2A.2.4.3.1 Three-Sigma Steep Launch Area Trajectory. The three-sigma steep launch area trajectory should maximize Z as a function of X', where the azimuth of the X' axis must be specified by Range Safety for each program or group of similar flights. The positive X' axis is directed

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downrange from the launch point directly away from the uprange impact limit line so the negative X' axis intersects the impact limit line at right angles. In calculating this trajectory a head wind (or tail wind) blowing toward (or away from) the impact limit line, that is, blowing from (or toward) the positive X' direction, should be used. This wind profile should represent the worst conditions for which a launch would be attempted. If other perturbing factors such as gyro drift or high thrust add significantly to the uprange deviations caused by wind, these factors should also be included in the calculations. The steep launch area trajectory is a three-sigma trajectory in that, for any X' , the value of Z along the three-sigma steepest trajectory would be greater than the corresponding values of Z achieved by 99.865 percent of all normal missiles subjected to the assumed head wind.

2A.2.4.3.2 Three-Sigma Lateral Launch Area Trajectory. The three-sigma lateral launch area trajectory should maximize Z as a function of Y' , where the azimuth of the Y' axis must be specified by the Flight Safety Analysis Section for each program or group of similar flights. When looking down-range, the negative Y' axis is laterally directed to the right with respect to the intended flight line, the actual direction being perpendicular to the lateral impact limit line being protected. In calculating this trajectory, a lateral wind blowing toward (or away from) the impact limit line, that is, blowing from (or toward) the positive Y' direction should be used. This wind profile should represent the worst conditions for which a launch would be attempted. Other perturbing factors that add significantly to the vehicle lateral movement,

such as gyro drift, roll program error, and alignment errors, should also be included in the calculations. The lateral launch area trajectory is a three-sigma trajectory in that, for any Y' , the value of Z along the three-sigma lateral launch area trajectory would be greater than the corresponding values of Z achieved by 99.865 percent of all normal missiles subjected to the assumed lateral wind.

2A.2.4.4 Fuel-Exhaustion Trajectory. For many flights, a programmed thrust termination may be scheduled well in advance of fuel exhaustion. To know whether a potential safety problem can arise if the vehicle should fail to cut off, trajectory data through fuel exhaustion are needed. For ballistic missile flights, the information should be provided only for the last stage in accordance with assumptions mutually agreed to by the User and Range Safety. For orbital flights the fuel exhaustion trajectory should be provided for the last suborbital stage. The requirement should be met by extending either the nominal or three-sigma maximum-performance trajectory through fuel exhaustion, depending on which produces a greater impact range.

2A.2.4.4.1 Cruise Missile and Remotely Piloted Vehicles. The three-sigma high performance trajectory should define the vehicle capability limits in climbing to maximum altitude at the maximum possible rate. It defines at any time after launch the limits of normality as far as impact range is concerned. The three-sigma high-performance trajectory provides the maximum downrange distance of the vacuum instantaneous impact point (IIP) for any given time. In calculating this trajectory, a tail-wind profile should be used that represents the worst wind conditions for which a launching would be attempted. For any particular time after launch, approximately 99.73 percent of all normal vehicles (assuming a normal Gaussian distribution) will have impact ranges less than the range achieved at that time by a three-sigma high performance mission.

APPENDIX 2B MALFUNCTION TURN DATA

2B.1 INTRODUCTION

This appendix provides background information and details about Range Safety malfunction turn data requirements. It is applicable to ballistic, space, cruise, and remotely piloted vehicles. The turn data shall describe the turning capability of the vehicle velocity vector as a function of thrust vector offset or other parameters characterizing the turns. This information is used to determine how fast a vehicle or, more exactly, a vehicle impact point can deviate from the nominal if a malfunction occurs. Velocity vector turn data is required only for the thrusting periods from launch up to a point in flight where effective thrust of the final stage has terminated or to thrust termination of that stage or burn that places the vehicle in orbit

2B.2 TURN DEFINITIONS

yaw turn - the angle turned in the lateral direction by the total velocity vector, not the angle turned in the horizontal plane by the horizontal component

maximum turn capability - the envelope of the maximum-rate trim and all tumble velocity vector turn angle curves for a given malfunction time, irrespective of how unlikely this rate is to occur.

trim turn - a turn resulting from a malfunction that causes the launch vehicle thrust moment to balance the aerodynamic moment while imparting a constant rotation rate to the vehicle longitudinal axis. The maximum-rate trim turn is the trim turn made at or near the greatest angle of attack that can be maintained while the aerodynamic moment is just balanced by the thrust moment, whether the vehicle is stable or unstable.

tumble turn - the family of tumble turns that results if the airframe rotates in an uncontrolled fashion at various angular rates, each rate being brought about by a different, constant value of the thrust vector offset angle or constant value of another parameter that defines the tumble turn

90 degree option - the turn produced by directing and maintaining the vehicle thrust at about 90 degrees to the velocity vector without regard for how this situation can be brought about

2B.3 MALFUNCTION TURN COMPUTATION REQUIREMENTS

a. Turning information need be computed for the nominal or reference trajectory only.

b. In the various velocity vector turn computations, it should be assumed that the vehicle performance is normal up to the point of the malfunction that produces the turn.

c. The effects of gravity shall be omitted from the final turn data calculations.

d. If pitch and yaw turn angles are essentially the same except for the effects of gravity, the yaw turn angles may be determined from pitch calculations that, in effect, have had the gravity component subtracted out at each step in the computations

e. During the first 100** sec of flight both pitch and yaw turns shall be provided. After 100** sec, turns need be computed only in the yaw plane. *EXCEPTION: During the first 100** sec of flight, when neglecting gravity, if the pitch and yaw turns are the same, only the yaw turns are required.*

f. Malfunction turn data are required for malfunctions initiated at even 4** sec intervals beginning 4** sec after first motion continuing for the first 100** sec of flight or through the first-stage thrusting phase and into the second-stage phase for at least one time point, and at even 8** sec intervals thereafter.

g. One possible difficulty needs to be mentioned in connection with calculating tumble turns for aerodynamically unstable missiles. In the high aerodynamic region it often turns out that no matter how small the initial deflection of the rocket engine, the airframe tumbles through 180 deg or one-half cycle in less than the specified time period for which the calculations are to be carried out. In such a case, if the computation is carried out for the specified time period, part of the angle turned by the velocity vector during the first half cycle is then canceled out during the second half cycle of the turn. If only tumble turns were considered in such cases, the conclusion would be reached that the vehicle velocity vector can turn through a greater angle in a shorter time period than it can in a longer time period. This is an unacceptable conclusion from a safety view

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point. The envelope of the family of tumble turns must rise continuously throughout the specified malfunction time period. One generally acceptable way to satisfy this requirement is to compute tumble turn angles without considering aerodynamic forces. Although such a vacuum turn cannot actually be simulated in the atmosphere by means of a constant engine deflection, in all likelihood there is some particular intelligent behavior of the engine that can approximate the turn fairly closely. If, however, vacuum tumble turns are considered unrealistic and unjustifiable, other types of malfunctions must be considered.

h. The turn data shall be defined for a series of malfunction modes such as thrust vector offset. Turn data computations shall include a credible distribution (range) of parameter values to demonstrate the variation of the turn characteristics caused by each malfunction mode. If the turns can occur as a function of more than one malfunction mode (e.g., SRM thrust vector offset angle for thrust vector control failures and thrust dissipation time for SRM nozzle burn through), turn data are required for each mode. Where possible, the same set of malfunction modes shall be used for each turn initiation time.

2B.4 TURN TRAJECTORIES

Although velocity vector turning computations are not required for the three-sigma maximum and three-sigma minimum performance trajectories, a method for applying the turn angles to these trajectories must be provided. The trajectory data items of paragraph 2A.2.2 must also be applied for the trajectory used to start the turn computations, if this trajectory is not one of those provided in response to paragraph 2A.2.1. Although desirable, this trajectory need not be submitted in the format described in EWR 127-1, Annex to Chapter 2, "Flight Trajectory and Data Manual." A columnar or block printout is acceptable. In addition, a complete discussion is required of assumptions made, methods of calculation, and equations used in deriving the malfunction turns.

2B.5 DETERMINING TYPES OF TURNS TO SUBMIT

In determining the maximum turn capability of a vehicle, the usual procedure is for the Range User to consider both trim turns and tumble turns, in

both the pitch and yaw planes. However, with Range Safety approval, the Range User may elect to calculate turn rates using the 90-degree option in lieu of trim and tumble turns. If the 90 degree option is ruled out, the criteria for each of the vehicle conditions listed in paragraphs 2B.5.2 through 2B.5.4 should be used to determine whether trim turns, tumble turns, or both should be provided at each turn initiation time.

2B.5.1 90-Degree Option. In some cases, Range Safety may accept turning angles or rates computed on the basis of the 90 degree assumption even though it is extremely unlikely for the missile to achieve these turn rates. This option is usually quite disadvantageous to the Range User, since larger turning angles (higher turn rates) lead to more restrictive destruct criteria. Such unduly restrictive criteria could necessitate the revision of a proposed flight plan that may otherwise have been allowed, or could result in somewhat earlier destruction of an erratic missile.

2B.5.2 Condition 1: For Vehicles Aerodynamically Unstable at All Angles of Attack. During that part of flight where the maximum trim angle of attack is small, it may be obvious that tumble turns lead to greater turning angles. If the maximum trim angle of attack is large, trim turns will in all probability lead to higher turning angles than tumble turns, and hence to more restrictive destruct criteria.

a. If the Range User can state that the probability of flying a trim turn even for a period of only a few seconds is virtually zero, only tumble turns are required.

b. If the Range User cannot so state, a series of trim turns (that includes the maximum-rate trim turn) and the family of tumble turns shall be provided.

2B.5.3 Condition 2: For Vehicles Stable at All Angles of Attack

a. If the vehicle is so stable that the maximum thrust moment cannot produce tumbling, but produces a maximum-rate trim turn at some angle of attack less than 90 degrees, a series of trim turns that includes the maximum-rate trim turn shall be provided.

b. If the maximum thrust moment results in a maximum-rate trim turn at some angle of attack

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greater than 90 degrees, a series of trim turns shall be provided only for angles of attack up to and including 90 degrees

2B.5.4 Condition 3: For Vehicles Unstable at Low Angles of Attack but Stable at Some Higher Angle of Attack Region

a. If large engine deflections result in tumbling, whereas small engine deflections do not, a series of trim and tumble turns should be generated as prescribed in paragraph 2B.5.2 for aerodynamically unstable missiles. **NOTE:** The same difficulty discussed in paragraph 2B.3.e with tumble turns may arise here, namely, the envelope of the computed tumble turns may fail to rise continuously throughout the entire time period for which the calculations are to be carried out. In this event, either tumble-turn calculations neglecting aerodynamic forces or trim-turn calculations must be made as discussed in paragraph 2B.5.2.

b. If both large and small constant engine deflections result in tumbling, irrespective of how small the deflection might be, the turn data achieved at the stability angle of attack, assuming no upsetting thrust moment, are required in addition to the turn data achieved by a tumbling vehicle. **NOTE:** This situation arises because the stability at high angles of attack is insufficient to arrest the angular velocity that is built up during the initial part of a tumble turn where the vehicle is unstable. Although the missile cannot arrive at this stability angle of attack as a result of the constant engine deflection, there is some deflection behavior that will produce this result. If arriving at such a deflection program is too difficult or too time consuming, it may be assumed that the vehicle somehow instantaneously rotated to the trim angle of attack and stabilizes at this point. If so, tumble turn angles may be used in Range Safety destruct calculations during that part of flight for which the envelope rises continuously for the duration of the computation.

2B.6 TURN DURATION

The malfunction turn data (turn angle and velocity magnitude curves) are to be provided at one** sec intervals, for at least 12** sec into the turn and until one of the following two conditions are met. **NOTE:** Various time intervals or time delays must be considered, since the delays that are built into the range safety destruct calculations depend

upon the accuracy, sensitivity, and type of presentation associated with a particular instrumentation system as well as missile characteristics.

a. The vehicle reaches a critical loading condition that will cause breakup.

b. The vehicle is tumbling so rapidly that the effective thrust acceleration is negligible; for example, the projected vacuum impact point is no longer moving significantly.

2B.7 TURN DATA FORMAT

Malfunction turn data shall be delivered in the form of graphs. Scale factors of plots must be selected so the plotting and reading accuracies do not degrade the basis accuracy of the data. In addition, tabular listings of the data used to generate the graphs are required in ASCII format files on floppy disks with corresponding hard copies.

a. Velocity Turn Angle Graphs. For turn angle graphs the ordinate represents the total angle turned by the velocity vector in degrees, and the abscissa the time duration of the turn in sec.

b. Velocity Magnitude Graphs. For velocity magnitude graphs the ordinate represents the magnitude of the velocity vector in ft per sec and the abscissa the time duration of the turn in sec.

2B.8 TURN DATA ITEMS

The following data items are required for each malfunction initiation time. The information that describes the turn is required at intervals of one sec or less.

a. Velocity Turn Angle. One graph is required for each malfunction mode at each initiation time. For tumble turns, each graph is to include the envelope of all tumble turns for all possible constant thrust vector offset angles (or other parameter). In this case, plots of the individual tumble turn curves that are used to define the envelope are required on the same sheet with the envelope. For trim turns, a series of trim turn curves for representative values of thrust vector offset (or other parameter) is required. The series of trim turn curves shall include the maximum-rate trim turn.

b. Velocity Magnitude. Either total velocity magnitude or incremental change in velocity magnitude from time of malfunction can be presented, although the incremental change in the velocity is desired. For each thrust vector offset angle (or other parameter), the point on the velocity graph

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corresponding to the point of tangency on the tumble turn-angle envelope shall be indicated. For tumble turns, velocity magnitudes are required in graphical form as a function of time for each thrust vector offset (or other parameter) used to define the tumble turn envelope.

c. Vehicle Orientation. If the vehicle has thrust augmenting rocket motors, then the vehicle attitude (in the form of the angular orientation of the vehicle longitudinal axis) as a function of time into the turn is required for each turn initiation time.

d. Onset Conditions. The vehicle state at the beginning of the turn, including the thrust, weight, and state vector (including velocity magnitude) shall be provided for each set of curves.

e. Breakup Information. The Range User must specify if the vehicle will remain intact throughout the turn. If the vehicle will breakup during a turn, then the point (time) for which vehicle breakup is expected to occur must be indicated. The time into the turn at which vehicle breakup would occur can be a specific value or a probability distribution for time to breakup.

f. Probability of Occurrence. The distribution for the probability of occurrence for the value of the parameter defining the turns (thrust vector offset, etc.) must be defined for each parameter (as a function of turn initiation time if the distribution varies with time). Also, information defining how the probability distribution was determined must be provided.

2B.9 VELOCITY VECTOR TURN DATA FOR CRUISE MISSILES AND REMOTELY PILOTED VEHICLES

a. From launch or drop until cruise altitude is reached, this information is required to provide a means of determining the maximum angle through which the missile velocity vector can turn in the event of a malfunction. The maximum angles turned for time intervals up to about 30** sec in duration are required. (The actual times will depend on the delays included in the FTS as well as

other factors). Both pitch and yaw turns should be investigated and the larger presented. It should be assumed that the missile has followed the nominal trajectory up to the point of malfunction that produces the maximum-rate trim turn. Thereafter, it should be assumed that the missile is trimmed to the maximum air load that the structure can stand, or that the missile is flying out of control in an attitude that produces maximum lateral acceleration (for example, a near ninety degree bank with a maximum pitch turn). During the launch phase, the missile may not be able to fly for 30** sec under these extreme conditions. In this event, it should be assumed that the missile is turning at the maximum rate for which these flight conditions can be maintained for required time duration. A complete discussion of the methods used in the calculations must be provided. This discussion should include assumptions made, types of malfunctions considered, forces producing turns, equations used, and sample computations.

b. During the cruise phase, the maximum turn capability of the velocity vector as a function of altitude is required. Rates should be based on normal missile weights and the expected cruising speeds at each altitude. For this phase of flight, the data may be expressed in the form of maximum lateral accelerations, if desired. A complete discussion similar to that requested for paragraph 2B.9.a is required. Also required are the maximum turn capability that the guidance system and the autopilot can command during the cruise phase.

c. A cruise missile may be boosted from the launch pad by separable rockets or by a booster motor that is an integral part of the missile. While the booster motor is thrusting, the missile may perform more as a ballistic missile or space vehicle than as a cruise missile. In such cases, maximum turning capability data during the boost phase will be required as specified in paragraph 2B.5 rather than as specified in paragraph 2B.9.a. For each missile program Range Safety will indicate which procedures are to be used in computing malfunction turn data during the boost phase.

APPENDIX 2C FRAGMENT DATA

2C.1 INTRODUCTION

Fragment listings and characteristics for all potential modes of vehicle breakup are required. At a minimum, the following modes of vehicle breakup shall be considered: (1) breakup due to FTS activation, (2) breakup due to an explosion, and (3) breakup due to aerodynamic loads, inertial loads, and atmospheric reentry heating. Fragment data is required up to thrust termination of the last stage that carries a destruct system. All fragments shall be included; however, similar fragments can be accounted for in fragment groups.

2C.2 DESCRIBING FRAGMENT GROUPS

A fragment group is one or more fragments whose characteristics are similar enough to allow all the fragments to be described by a single "average" set of characteristics. The following information is provided to aid in determining fragment groups:

a. Fragment type: All fragments must be of the same type (for example solid propellant, explosive, or inert), including whether or not propellant fragments are burning following breakup.

b. Ballistic coefficient (beta): The maximum beta in the group should be no more than about a factor of three times the minimum (except for very low beta fragments where betas ranging from near zero to about 3 psf can be grouped together).

c. Weight: If the fragments contain propellant that is burning during free fall the maximum weight of propellant in a fragment group should be no more than a factor of 1.2 times the minimum weight of propellant. The fragments included in a group should be such that the kinetic energies (KE) based on terminal velocity ($KE = 13 \times W \times \text{beta}$, ft-lbf) are within the following guidelines:

- Fragments having $KE < 35$ are grouped.
- Fragments having $35 < KE < 100$ are grouped.
- Fragments having $100 < KE < 6,200$ should be grouped so that the maximum fragment KE is no more than about three times the minimum.
- Fragments having $6,200 < KE < 33,670$ should be grouped so that the maximum fragment KE is no more than about three times the minimum.
- Fragments having $33,670 < KE < 74,000$ should be grouped so that the maximum fragment KE is no more than about three times the minimum.
- Fragments having $74,000 < KE < 1,616,000$ should be grouped so that the maximum fragment

KE is no more than about three times the minimum.

- Fragments having $KE > 1,616,000$ are grouped.

d. Velocity perturbation: The maximum expected destruct explosion or pressure rupture induced velocity in the group should be no more than a factor of 1.2 times the minimum induced velocity.

e. Projected area: For explosive fragments, the range of projected areas should be controlled by requiring that the maximum value of the weight of propellant at impact is no more than a factor of two times the minimum (however, if the propellant is burning during free fall the factor is 1.2). There is no limit on the range of projected areas for inert fragments.

2C.3 FRAGMENT DATA ITEMS

This paragraph provides a description of the data items required for each fragment or fragment group for each potential mode of vehicle breakup. The variation of the fragment characteristics with flight time shall be defined. Normally this is accomplished by specifying multiple fragment lists, each of which is applicable over a specified period of flight.

a. That fragment that, in the absence of winds, is expected to travel a maximum distance, and that fragment(s) that, in the absence of winds, is expected to travel a minimum distance shall be included.

b. Fragment group name

c. Number of fragments

d. General description(s) of fragments such as part/component, shape, dimensions, figure

e. Breakup Altitude. For breakup due to atmospheric reentry, the altitude at which breakup is expected to occur shall be provided.

f. Ballistic Coefficient (beta). Nominal, plus three-sigma, and minus three-sigma values (psf) for each fragment or group; including graphs of the coefficient of drag (C_d) versus Mach number for the nominal and three-sigma beta variations for each fragment or group. Each graph shall be labeled with the shape represented by the curve and reference area used to develop the curve. A C_d vs Mach curve for axial, transverse, and tumble orientations (when applicable) shall be provided for fragments not expected to stabilize during free-fall

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conditions. For fragments that may stabilize during free-fall, C_d vs Mach curves should be provided for the stability angle of attack. If the angle of attack where the fragment stabilizes is other than zero degrees, both the coefficient of lift (C_L) vs Mach number and the C_d vs Mach number curves should be provided. If available, equations for C_d vs Mach curves should be provided. The difficulty of estimating drag coefficient curves and weights for vehicle pieces is fully realized. If this cannot be done satisfactorily, an estimate of the subsonic and supersonic $W/C_d A$ for each major piece may be provided instead. In either case, three-sigma tolerance limits shall be included for the drag coefficients for the maximum and minimum-distance pieces.

g. Weight per fragment. Include the possible three-sigma weight (lb) variation for the fragment or group. NOTE: The fragment data must approximately add up to the total weight of inert material in the vehicle plus the weight of contained liquid propellants and solid propellant that is not consumed in the initial breakup and/or conflagration.

h. Projected area per fragment (ft^2). Include the axial, transverse, and tumbling area for the fragment or group. This information is not required for those fragment groups classed as uncontained propellant fragments (as described below).

i. Estimates of the maximum incremental velocities (ft/sec) imparted to the vehicle pieces due to FTS activation, explosive and/or overpressure loads at breakup. The velocity is normally assumed to be Maxwellian distributed with the specified maximum value equal to the 97th percentile. If the distribution is known to be significantly different than the Maxwellian, the correct distribution is required (including if the specified value should be interpreted as a fixed value with no uncertainty).

j. Fragment group type:

Type 1 = inert fragments; for example, no volatile type material that could be burning or could explode

Type 2 = uncontained solid propellant fragments; for example, solid propellant exposed directly to the atmosphere and will not explode upon impact

Type 3 = contained propellant fragments; for

example, propellant that is enclosed in a container, such as a motor case or pressure vessel, and will not explode upon impact

Type 4 = contained explosive propellant fragments; for example, propellant that is enclosed in a container, such as motor case or pressure vessel, and will explode upon impact

Type 5 = uncontained explosive solid propellant fragments; for example, solid propellant exposed directly to the atmosphere and will explode upon impact

k. Casualty area per fragment (ft^2). The casualty area per fragment shall be based on a fragment falling vertically at impact, and should reflect the credible fragment orientation giving the maximum projected area.

l. Vehicle stage where fragment group originated

m For those fragment groups defined as uncontained propellant fragments, contained propellant fragments, and explosive fragments, an indication as to whether or not the propellant fragments are burning during free fall.

n. For those fragment groups defined as contained propellant fragments, explosive or non-explosive, the initial weight of contained propellant (lb) and the consumption rate during free fall (lb per sec). The initial weight of the propellant in a contained propellant fragment is the weight of the propellant before any of the propellant is consumed by normal vehicle operation.

o. Diffusion and dispersion of any fragments containing toxic or radioactive materials and the radiation and exposure characteristics

2C.4 RESIDUAL THRUST DISPERSION

If an upper stage can be ignited as a result of FTS activation on a lower stage, sufficient information is required to evaluate the effects and duration of thrust, and the maximum deviation of the impact point that can be brought about by this thrust. The explosion effects on remaining fuels, pressurized tanks, and remaining stages are required, particularly with respect to ignition or detonation of upper stages if destruct action is taken during the burning period of a lower stage. For each thrusting or non-thrusting stage having residual thrust capability following FTS activation provide either the total residual impulse (lb-sec) imparted after

APPENDIX 2C FRAGMENT DATA

"arm" and "destruct," or the full-residual thrust (lb-f) versus time (s). Otherwise, a detailed analysis that clearly shows the stages are not capable of thrusting after FTS activation is required.

APPENDIX 2D

JETTISONED BODY DATA

2D.1 GENERAL DATA REQUIREMENTS

The following data shall be provided for each jettisoned body:

a. The nominal impact point. The nominal impact point (or aiming point) for each jettisoned body shall be given in terms of geodetic latitude and longitude in decimal degrees, and range (nm) from the pad. Computations shall be made for an ellipsoidal rotating earth taking into account drag and, if applicable, lift.

b. The number of fragments resulting from a specific scheduled jettison. If the jettisoned body is expected to break up during reentry, an estimate of the number of pieces, their approximate weights, cross-sectional areas, ballistic coefficients and their impact ranges are required.

c. Jettison flight time (sec), total weight (lbs) jettisoned and weight per fragment (lbs), reference area per fragment (ft^2), and the best estimate of C_d vs Mach number (preferred) or subsonic and supersonic W/C_dA for each stage or piece. The C_d vs Mach number data are to be provided in graphical and tabular format for the nominal, minus three-sigma and plus three-sigma drag coefficients and shall cover the range of possible Mach numbers from zero to the maximum values expected during free fall. Also indicate whether bodies are stable and, if so, at what angles of attack. For pieces that can possibly stabilize during free flight, drag coefficient curves shall be provided for the stability angle of attack. If the stability angle of attack is other than zero degrees, both coefficient of lift (C_L) vs Mach number and C_d vs Mach number curves shall be provided. State briefly how drag curves were determined.

d. The three-sigma uprange-downrange (nm) and crossrange (nm) impact dispersions and the azimuth orientation of the dispersion major axis (degrees clockwise from true north), assuming a normally functioning vehicle. Three-sigma wind effects acting upon the descending body or pieces must be included in the dispersion area. A brief discussion of the method used to determine dispersions is also required. The magnitude of the wind contribution in the total dispersions is required.

e. Impact ballistic coefficient (psf).

f. Maximum possible impact range of each im-

pacting stage or reentry vehicle for a missile burning to fuel exhaustion.

2D.2 REENTRY VEHICLE DATA

The items below are required either in records 23, 24, and 25 of the trajectory or with general vehicle data:

a. Type of reentry vehicle (RV) (ablation or heat sink) and ablation tables when applicable. The ablation table is a listing of Mach number or altitude vs the ratio W/W_0 , where W equals the instantaneous RV weight during reentry and W_0 equals the vehicle weight before ablation.

b. The RV weight before ablation

c. A table of RV drag coefficient versus Mach number of altitude

d. RV aerodynamic reference area associated with the drag coefficients

2D.3 SMALL UNGUIDED ROCKETS OR PROBE VEHICLES

Three-sigma range and cross-range dispersions are required for each stage, separable fragment or component, and payload. Since the magnitude of these dispersions may determine whether a destruct system deviation or waiver will be granted or the extent to which shipping must be clear of impact areas, a careful analysis is essential. The following factors should be considered in determining three-sigma impact dispersions about predicted impact points: Variation in thrust, error in drag estimates, thrust misalignment, fin and body misalignment, variation in weight, variation in ignition times of stages, impulse errors, tip-off and separation perturbations, errors in wind velocity measurements, error in launcher setting, and other significant perturbing influences. The three-sigma variation in each factor shall be provided in tabular format in addition to the extent to which each factor displaces the impact point of each stage in the downrange and crossrange directions. The total impact dispersion is then computed by a statistical combination of the individual displacements. A brief discussion of the assumptions made, method of analysis, and method of computation is required. The extent to which the three-sigma impact dispersion areas change with quadrant elevation angle is also required.

3CHAPTER 3

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GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

30 AMDS/SGPB - 30th Medical Group, Bioenvironmental Engineering, including the Radiation Protection Officer

30 CEG - 30th Civil Engineer Group

30 CEG/CEF - 30th Civil Engineer Group, Fire Protection

45 ADOS/SGGB - 45th Medical Group, Health Physics and Bioenvironmental Engineering

45 CES - 45th Civil Engineer Squadron

45 CES/CEF - 45th Civil Engineer Squadron, Fire Protection

45 MDG - 45th Medical Group

45 and 30 SW/SE - 45th and 30 Space Wing, Office of the Chief of Safety

45 and 30 SW/SES - 45th and 30 Space Wing, Systems Safety

A-50 - Aerozine 50, a 50-50 blend of hydrazine and unsymmetrical dimethyl hydrazine

“A” Basis Allowables - the minimum mechanical strength values guaranteed by the material producers or suppliers such that at least 99 percent of the material they produce or supply will meet or exceed the specified values with a 95 percent confidence level

AC - alternating current

acceptance tests - the required formal tests conducted on flight hardware to ascertain that the materials, manufacturing processes, and workmanship meet specifications and that the hardware is acceptable for intended usage

ACO - Aeronautical Control Officer

AF - Air Force

AFB - Air Force Base

AFI - Air Force Instruction

AFM - Air Force Manual

AFMC - Air Force Material Command

AFML - Air Force Material Lab

AFOSH - Air Force Occupational Safety and Health

AFR - Air Force Regulation

AFSC - Air Force Systems Command, now Air Force Material Command

AFSPC - Air Force Space Command

AFTO - Air Force Technical Order; *see also T.O.*

AGE - aerospace ground equipment

AISC - American Institute of Steel Construction

all-fire level - the minimum direct current or radio frequency energy that causes initiation of an electroexplosive initiator with a reliability of 0.999 at a confidence level of 95 percent as determined by a Bruceton test. Recommended operating level is all-fire current, as determined by test, at ambient temperature plus 150 percent of the minimum all-fire current

allowable load (stress) - the maximum load (stress) that can be allowed in a material for a given operating environment to prevent rupture or collapse or detrimental deformation; allowable load (stress) in these cases are ultimate load (stress), buckling load (stress), or yield load (stress), respectively

ANSI - American National Standards Institute

applied load (stress) - the actual load (stress) imposed on the structure in the service environment

ARAR - Accident Risk Assessment Report

Arm/Disarm device - an electrically or mechanically actuated switch that can make or break one or more electroexplosive firing circuits; operate in a manner similar to Safe and Arm devices except they do not physically interrupt the explosive train

arming plug - a removable device that provides electrical continuity when inserted in a firing circuit

ASCE - American Society of Civil Engineers

ASME - American Society of Mechanical Engineers

ASTM - American Society for Testing Materials

ATC - Applied Technology Council

AVE - Airborne Vehicle Equipment

AWS - American Welding Society

“B” Basis Allowables - the mechanical strength values specified by material producers and suppliers

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

ers such that at least 90 percent of the materials they produce or supply will meet or exceed the specified values with a 95 percent confidence level

BBL - burst before leak

BRCC - Blue Ribbon Crane Committee (Western Range)

brittle fracture - (1) a type of failure mode in structural materials that usually occurs without prior plastic deformation and at extremely high speed, (2) a type of failure mode such that burst of the vessel is possible during cycling [normally this mode of failure is a concern when cycling to the maximum expected operating pressure (MEOP) or when the vessel is under sustained load at MEOP], and (3) a type of fracture that is characterized by a flat fracture surface with little or no shear lips (slant fracture surface) and at average stress levels below those of general yielding

Bruceton test method - a statistical method for determining the all-fire and no-fire characteristics of an electroexplosive device using a small sample size, but with high reliability

burst factor - a multiplying factor applied to the MEOP to obtain the design burst pressure. Synonymous with *ultimate pressure factor*

CAD - computer-aided design

CAL-OSHA - California Occupational Safety and Health Act

Category A EED/Ordnance - electroexplosive devices or ordnance that, by the expenditure of their own energy or because they initiate a chain of events, may cause serious injury or death to personnel or damage to property

Category B EED/Ordnance - electroexplosive devices or ordnance that, by the expenditure of their own energy or because they initiate a chain of events, will not cause serious injury or death to personnel or damage to property

cc - cubic centimeter

CCAS - Cape Canaveral Air Station

CCB - Configuration Control Board

cDR - Conceptual Design Review

CDR - Critical Design Review

certified inspector - a person qualified and certified in nondestructive examination inspection techniques according to the American Society for Nondestructive Testing, recommended practices (SNT-TC-1A)

CFR - Code of Federal Regulations

CGA - Compressed Gas Association

CMAA - Crane Manufacturers Association of America

compatibility - the ability of two or more materials or substances to come in contact without altering their structure or causing an unwanted reaction in terms such as permeability, flammability, ignition, combustion, functional or material degradation, contamination, toxicity, pressure, temperature, shock, oxidation, or corrosion

composite material - the combinations of materials differing in composition or form on a macro-scale. The constituents retain their identities in the composite. Normally, the constituents can be physically identified, and there is an interface between them

COPV - Composite Overwrap Pressure Vessel

COTS - in reference to software, commercial off the shelf

CPIA - Chemical Propulsion Information Agency

cps - cycles per second

CPU - Central Processing Unit

CRCs - Cyclic Redundancy Checks

critical hardware - any hazardous or safety critical equipment or system; non-hazardous DoD high value items such as spacecraft, missiles, or any unique item identified by DoD as critical; non-hazardous, high value hardware owned by Range Users other than the DoD may be identified as critical or non-critical by the Range User

critical condition - the most severe environmental condition in terms of loads, pressures, and temperatures, or combination thereof imposed on structures, systems, subsystems, and components during service life

critical flaw - a specific shape of flaw with sufficient size that unstable growth will occur under the specific operating load and environment

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

critical load - a load consisting of critical hardware and/or any personnel

critical stress intensity factor - the stress intensity factor at which an unstable fracture occurs

cryogen - a super cold liquid such as liquid nitrogen or oxygen

CW - continuous wave

damage tolerance - a measure of the ability of structures to retain load carrying capability after exposure to sudden loads (for example, ballistic impact).

dB - decibel; a unit of relative power; the decibel ratio between two power levels, P1 and P2, is defined by the relation $dB = 10\log(P1/P2)$

dBA - decibels referenced to the "A" scale

DC - direct current

DDESB - Department of Defense Explosive Safety Board

dedicated - serving a single function, such as a power source serving a single load

design burst pressure - the calculated pressure (the analytical value that was calculated using an acceptable industry and/or government practice to determine its design pressure) that components must withstand without rupture and/or burst to demonstrate its design adequacy in a qualification test. During qualification testing, the actual burst pressure for a tested component must demonstrate that the design burst pressure is less than the actual burst pressure. Safety factors are based on design burst pressure, not actual burst pressure of a particular component.

design safety factor - a factor used to account for uncertainties in material properties and analysis procedures; often called *design factor of safety* or simply *safety factor*

destabilizing pressure - a pressure that produces comprehensive stresses in a pressurized structure or pressure component

detent - a releasable element used to restrain a part before or after its motion; detents are common arming mechanisms. Safe and Arm device safing pins use a spring-loaded detent to secure the pin in the device.

detonating cord - a flexible fabric tube containing a filler of high explosive material intended to be initiated by an electroexplosive device; often used in destruct and separation functions

detonation - an exothermic chemical reaction that propagates with such rapidity that the rate of advance of the reaction zone into the unreacted material exceeds the velocity of sound. The rate of advance of the reaction zone is termed *detonation velocity*. When this rate of advance attains such a value that it will continue without diminution through the unreacted material, it is termed the *stable detonation velocity*. When the detonation velocity is equal to or greater than the stable detonation velocity of the explosive, the reaction is termed a *high-order detonation*; when it is lower, the reaction is termed a *low-order detonation*.

detonator - an explosive device (usually an electroexplosive device) that is the first device in an explosive train and is designed to transform an input (usually electrical) into an explosive reaction

detrimental deformation - includes all structural deformations, deflections, or displacements that prevent any portion of the structure from performing its intended function or that reduces the probability of successful completion of the mission

development test - a test to provide design information that may be used to check the validity of analytic technique and assumed design parameters, to uncover unexpected system response characteristics, to evaluate design changes, to determine interface compatibility, to prove qualification and acceptance procedures and techniques, or to establish accept and reject criteria

deviation - a term used when a noncompliance is known to exist prior to hardware production or an operational noncompliance is known to exist prior to operations at CCAS or Vandenberg Air Force Base

DH - Design Handbook from AFSC

DoD - Department of Defense

DOT - Department of Transportation

ductile fracture - a type of failure mode in structural materials generally preceded by large amounts of plastic deformation and in which the

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

fracture surface is inclined to the direction of the applied stress

dudding - the process of permanently degrading an electroexplosive initiator to a state where it cannot perform its designed function

EBW - high voltage exploding bridgewire initiator; an initiator in which the bridgewire is designed to be exploded (disintegrated) by a high energy electrical discharge that causes the explosive charge to be initiated

EBW-FU - high voltage exploding bridgewire firing unit

EED - low voltage electroexplosive device

EEPROM - Electrically Erasable Programmable Read-Only Memory

EFP - explosively formed projectile

EGSE - electrical ground support equipment

electrical component - a component such as a switch, fuse, resistor, wire, capacitor, or diode in an electrical system

EMC - electromagnetic compatibility

e-N - (Low Cycle Fatigue) strain-life fatigue curve, normally plotted in terms of cyclic strain amplitude versus the number of cycles to failure

EPA - Environmental Protection Agency

EPC - emergency power cutoff

ER - Eastern Range

ESD - electrostatic discharge

ESMC - Eastern Space & Missile Center (Now 45 SW)

ETA - explosive transfer assembly; explosive train; an arrangement of explosive or combustible elements used to perform or transfer energy to an end function

ETS - explosive transfer system

explosion proof apparatus - an enclosure that will withstand an internal explosion of gases or vapors and prevent those gases or vapors from igniting the flammable atmosphere surrounding the enclosure, and whose external temperature will not ignite the surrounding flammable atmosphere

explosives - all ammunition, demolition material, solid rocket motors, liquid propellants, pyrotechnics, and ordnance as defined in AFMAN 91-201 and DoD-STD 6055.9

explosives quantity distance site plan - a formal plan for explosives facilities and areas required per AFMAN 91-201 and DoD 6055.9-STD detailing explosives quantity operating and storage limits and restrictions, and resultant distance clearance requirements

FAC - Florida Administrative Code

factor of safety (ultimate) - the ratio of the ultimate stress to the maximum calculated stress based on limit loads; Ultimate Factor of Safety = Ultimate Strength/Limit Load Stress

factor of safety (yield) - the ratio of the yield stress to the maximum calculated stress based on limit loads. Yield Factor of Safety = Yield Strength/Limit Load Stress

fail safe - a design feature in which a system reacts to a failure by switching to or maintaining a safe operating mode that may include system shut down

failure - the inability of a component or system to perform its designed function within specified limits

fatigue - the progressive localized permanent structural change that occurs in a material subjected to constant or variable amplitude loads at stresses having a maximum value less than the ultimate strength of the material

fatigue life - the number of cycles of stress or strain of a specified character that a given material sustains before failure of a specified nature occurs

fault - a manifestation of an error in software

fault tolerance - the built-in ability of a system to provide continued correct operation in the presence of a specified number of faults or failures

FCDC - flexible confined detonating cord

FDEP - Florida Department of Environmental Protection; FDEP requirements are available at <http://www2.dep.state.fl.us>

FED-STD - Federal Standard

FEMA - Federal Emergency Management Asso-

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

ciation

firing circuit - the current path between the power source and the initiating device

firmware - computer programs and data loaded in a class of memory that cannot be dynamically modified by the computer during processing. For Systems Safety purposes, firmware is to be treated as software.

fittings - pressure components of a pressurized system initialized to connect lines, other pressure components, and/or pressure vessels within the system

flaw - an imperfection or unintentional discontinuity that is detectable by nondestructive examination

FLSC - flexible linear shaped charge

FM - frequency modulation; Factory Mutual Corporation

FMECA - Failure Mode Effects and Criticality Analysis

FOC - fiber optic cable

FOCA - fiber optical cable assembly

fracture control - the application of design philosophy, analysis method, manufacturing technology, quality assurance, and operating procedures to prevent premature structural failure due to the propagation of cracks or crack-like flaws during fabrication, testing, transportation and handling, and service

fracture mechanics - an engineering concept used to predict flaw growth of materials and structures containing cracks or crack-like flaws; an essential part of a fracture control plan to prevent structure failure due to flaw propagation

fracture toughness - a generic term for measures of resistance to extension of a crack

ft - foot, feet

FTS - Flight Termination System

FU - firing unit

fuse - a system used to initiate an explosive train

G - gravity

GH₂ - Gaseous Hydrogen

GHe - Gaseous Helium

GHz - Gigahertz

GN₂ - Gaseous Nitrogen

GOX - Gaseous Oxygen

gr/ep - graphite epoxy

GSE - ground support equipment

h - hour, hours

handling structures - structures such as beams, plates, channels, angles, and rods assembled with bolts, pins, and/or welds; includes lifting, supporting and manipulating equipment such as lifting beams, support stands, spin tables, rotating devices, and fixed and portable launch support frames

hardware (computer) - physical equipment used in processing

hazard - equipment, system, operation, or condition with an existing or potential condition that may result in a mishap

hazard analysis - the analysis of systems to determine potential hazards and recommended actions to eliminate or control the hazards

hazard proof - a method of making electrical equipment safe for use in hazardous locations; these methods include explosion proofing, intrinsically safe, purged, pressurized, and nonincendive and must be rated for the degree of hazard present

hazardous LBB - a pressure vessel that exhibits a leak before burst failure mode and contains a hazardous material

hazardous materials - liquids, gases, or solids that may be toxic, reactive, or flammable or that may cause oxygen deficiency either by themselves or in combination with other materials

hazardous pressure systems - systems used to store and transfer hazardous fluids such as cryogenics, flammables, combustibles, hypergols; systems with operating pressures that exceed 250 psig; systems with stored energy levels exceeding 14,240 ft lb; systems that are identified by Range Safety as safety critical; *see also safety critical*

HDBK - handbook

Hg - mercury

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

HMX - cyclotetramethylmetetranitramine

HNS - 2,2,4,4,6,6 hexanitrostilbene

hoist angle - an angle at which the load line is pulled during hoisting

holdfire - an interruption of the ignition circuit of a launch vehicle

hot flow - a flow of live commodity in a newly assembled system to normally passivate system walls and components and to remove residual nonactive contaminants or flushing fluid. The hot flow is not intended for leak checks because of the potential hazards due to leaks.

HVDS - hypergolic vapor detection system

Hydraset - the trade name for a closed circuit hydraulically operated instrument installed between a crane hook and load that allows precise control of lifting operations and provides an indication of applied load; precision load positioning device

hydraulic - operated by water or any other liquid under pressure; includes all hazardous fluids as well as typical hydraulic fluids that are normally petroleum-based

hydrogen embrittlement - a mechanical-environmental failure process that results from the initial presence or absorption of excessive amounts of hydrogen in metals, usually in combination with residual or applied tensile stresses

hygroscopic - absorbs moisture from the air

hypergolic - ignites spontaneously upon contact, such as certain rocket fuels and oxidizers

Hz - hertz

IEEE - Institute of Electrical and Electronic Engineers

igniter - a device containing a specifically arranged charge of ready burning composition, usually black powder, used to amplify the initiation of a primer

in.- inch, inches

independent - not capable of being influenced by other systems

indication - the response or evidence from the application of a nondestructive examination including visual inspection

inhibit - an independent and verifiable mechanical and/or electrical device that prevents a hazardous event from occurring; device has direct control and is not the monitor of such a device

initial crack size - a crack dimension determined by nondestructive examination methods or proof test logic

initial flaw - a flaw in a structural material before the application of load and/or environment

initiator - includes low voltage electroexplosive devices and high voltage exploding bridgewire devices

interrupter - a mechanical barrier in a fuse that prevents transmission of an explosive effect to some elements beyond the interrupter

intrinsically safe - incapable of producing sufficient energy to ignite an explosive atmosphere and two-fault tolerant against failure with single fault tolerance at 1.5 times the maximum voltage or energy

ionizing radiation - gamma and X-rays, alpha and beta particles and neutrons

ISI - In-Service Inspection

INSRP - Interagency Nuclear Safety Review Panel

JP - jet propellant

KIc - critical stress intensity factor under Mode 1 conditions (opening mode)

KIe - surface-crack tension specimen fracture toughness; it is a nominal fracture toughness value based on residual strength and original crack dimensions

Kc - critical stress intensity factor under Mode 1 (for example, opening mode) conditions

KHB - Kennedy Handbook

KHz - kilohertz

KISCC - stress-corrosion, cracking threshold; a level of sustained loading as defined by linear elastic fracture mechanics, below which stress-corrosion cracking does not occur in a specified combination of material and environment

KMAX - maximum stress intensity factor

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

KSC - Kennedy Space Center

kV - kilovolts

launch vehicle - a vehicle that carries and/or delivers a payload to a desired location; this is the generic term that applies to all vehicles that may be launched from the Ranges; includes, but is not limited to, airplanes, all types of space launch vehicles, manned launch vehicles, missiles and rockets and their stages, probes, aerostats and balloons, drones, remotely piloted vehicles, projectiles, torpedoes, and air-dropped bodies

lb - pound, pounds

LBB - leak before burst; a failure mode in which it can be shown that any initial flaw will grow through the wall of a pressure vessel or pressurized structure and cause leakage rather than brittle fracture/burst before leak; normally determined at or below maximum expected operating pressure

lead angle - an angle in which the load line is pulled during hoisting. Commonly used to refer to an angle in line with the grooves in the drum or sheaves

LEL - lower explosive limit

LFU - laser firing unit

LH₂ - liquid hydrogen

LHe - liquid helium

LID - laser initiated device

limit load (design load) - the maximum load or combination of loads a part or structure is expected to experience at any time during its intended operation and expected environment; $\text{limit load} = (\text{load factor}) \times (\text{rated load})$

lines - tubular pressure components of a pressurized system provided as a means for transferring fluids between components of the system

LIO - laser initiated ordnance

LIOS - laser initiated ordnance system

LN₂ - liquid nitrogen

load factor - a factor that accounts for unavoidable deviations of the actual load from the nominal value. Examples of load factors include wind, shock, seismic, and dynamic load factors

loading spectrum - a representation of the cumulation loadings anticipated for the structure under all expected operating environments; significant transportation and handling loads are included

LOCC - Launch Operations Control Center

LOX - liquid oxygen (also LO₂)

LSC - Linear Shaped Charge

LV - launch vehicle

mA - milliamperes

MA - managing activity

MAC - maximum allowable concentration

major mishap - an event or incident that has the potential of resulting in a fatality or major damage such as the loss of a processing facility, launch complex, launch vehicle, or payload

margin of safety - the percentage by which the allowable load (stress) exceeds the limit load (stress) for specific design conditions; $\text{Yield Margin of Safety} = [(\text{Yield Strength/Limit Load Stress}) \times (\text{Yield Factor of Safety})] - 1$; $\text{Ultimate Margin of Safety} = [(\text{Ultimate Strength/Limit Load Strength}) \times (\text{Ultimate Factor of Safety})] - 1$

MAWP - maximum allowable working pressure

MDC - mild detonating cord

MDF - mild detonating fuse

meets intent certification - a certification used to indicate an equivalent level of safety is maintained despite not meeting the exact requirements stated in the document

megger - high voltage resistance meter

MEOP - maximum expected operating pressure; the highest pressure that a pressure vessel, pressurized structure, or pressure component is expected to experience during its service life and retain its functionality, in association with its applicable operating environments; synonymous with maximum operating pressure (MOP) or maximum design pressure (MDP); includes the effect of temperature, pressure transients and oscillations, vehicle quasi-steady, and dynamic accelerations and relief valve operating variability

MFCO - Mission Flight Control Officer

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

MHE - material handling equipment used to handle lift, support, or manipulate critical or non-critical hardware. MHE includes, but is not limited to, cranes, hoists, sling assemblies, hydrasets and load cells, handling structures, and personnel work platforms.

MHI - Materials Handling Institute

MHz - megahertz

MIC - meets intent certification

MIL - military

MIL-HDBK - Military Handbook

MIL-Spec - Military Specification

MIL-STD - Military Standard

min - minute, minutes

mismatching - the improper installation and/or connection of connectors

MMH - monomethylhydrazine

monitor circuit - a circuit used to verify the status of a system, such as an inhibit directly; control circuits can be monitored but they can not serve as a monitor circuit

MOP - maximum operating pressure; the maximum operating pressure a system will be subjected to during planned static and dynamic conditions

MSDS - Material Safety Data Sheet

MSFC - Marshal Space Flight Center

MSPSP - Missile System Prelaunch Safety Package; a data package that demonstrates compliance with Chapter 3 of this document and serves as a baseline for safety-related information for a system throughout its life cycle

N₂H₄ - Hydrazine

N₂O₄ - Nitrogen Tetroxide

NACE - National Association of Corrosion Engineers

NASA - National Aeronautical and Space Administration

NASC - National Aeronautics and Space Council

NDE - non-destructive examination; any testing, inspection, or evaluation that does not cause harm

to or impair the usefulness of an object satisfies the meaning of the word *non-destructive*. In common usage, *testing* (NDT) often refers just to test methods and test equipment with only a general reference to materials and/or parts. *Inspection* (NDI) relates to specific written requirements, procedures, personnel, standards, and controls for the testing of a particular material of a specific part. *Evaluation* is concerned with the decision making process, the determination of the meanings of the results, of the final acceptance or rejection of the material of part, and may be qualitative or quantitative.

NEC - National Electrical Code

NEI - nonexplosive initiators

NFPA - National Fire Protection Association

NIOSH - National Institute of Occupational Safety and Health

no-fire level - the maximum direct current or RF energy at which an electroexplosive initiator shall not fire with a reliability of 0.999 at a confidence level of 95 percent as determined by a Bruceton test and shall be capable of subsequent firing within the requirements of performance specifications

noise margin - the margin between the worst case noise level and logic circuitry threshold

noncritical hardware - equipment and systems employed for standard industry use; equipment and systems that are determined not to be hazardous, safety critical, or of high value

non-incendive - will not ignite group of gases or vapors for which it is rated; similar to *intrinsically safe*, but does not include failure tolerance ratings; used in rating electrical products for Class I, Division 2 locations only

NPT - National Pipe Thread

NRC - Nuclear Regulatory Commission

NSC - National Security Council

OIS - operational intercommunication system; operational information system

operating life - the period of time in which prime power is applied to electrical or electronic components without maintenance or rework

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

ordnance - all ammunition, demolition material, solid rocket motors, liquid propellants, pyrotechnics, and explosives as defined in AFMAN 91-201 and DoD 6055.9-STD

ordnance component - a component such as a squib, LOS, detonator, initiator, ignitor, or linear shape charge in an ordnance system

OSC - Operations Safety Console

OSHA - Occupational Safety and Health Act

O&SHA - Operating and Support Hazard Analysis

OSTP - Office of Science Technology Policy

PA - Public Address

PAD - percussion activated device

passive device - a device that permits signals to transient through it without modifying the signals

payload - the object(s) within a payload fairing carried or delivered by a launch vehicle to a desired location. This is a generic term that applies to all payloads that may be delivered from the ER or WR and includes, but is not limited to, satellites, other spacecraft, experimental packages, bomb loads, warheads, reentry vehicles, dummy loads, cargo, and any motors attached to them in the payload fairing

PD - Presidential Directive

PDR - Preliminary Design Review

personnel work platforms - platforms used to provide personnel access to flight hardware at off-pad processing facilities as well as at the launch pad; they may be removable, extendible, or hinged.

PETN - pentaerythritoltetranitrate

PHE - Propellant Handler's Ensemble

PL - Public Law

PLC - programmable logic controller

pneumatic - operated by air or other gases under pressure

POL - paints, oils, lubricants

PPE - personal protective equipment

ppm - parts per million

pressure component - a component such as lines, fittings, valves, regulators, and transducers in a pressurized system. Normally pressure vessels or pressurized structures are excluded, because of the potential energy contained, they generally require additional analysis, test and inspection.

pressure system - any system above 0 psig that is classified as follows: low pressure, 0 to 500 psi; medium pressure, 501 to 3000 psi; high pressure, 3001 to 10,000 psi; ultra-high pressure, above 10,000 psi. **NOTE:** The degree of hazard of a pressure system is proportional to the amount of energy stored, not the amount of pressure it contains; therefore, low pressure, high volume systems can be as hazardous to personnel as high pressure systems.

pressure vessel - a container that stores pressurized fluids and (1) contains stored energy of 14,240 foot pounds (19,130 joules) or greater based on adiabatic expansion of a perfect gas; or (2) contains gas or liquid which will create a mishap (accident) if released; or (3) will experience a MEOP greater than 100 psia. Excluded are special equipment including batteries, cryostats (or dewars), heat pipes, and sealed containers; or (4) per the ASME definition, summarized briefly; pressure containers that are integral pumps or compressors, hot water heaters and boilers, vessels pressurized in excess of 15 psi (regardless of size), and vessels with a cross-sectional dimension greater than 6 in. (regardless of length of the vessel or pressure).

pressurized system - a system that consists of pressure vessels or pressurized structures, or both, and other pressure components such as lines, fittings, valves, and bellows that are exposed to and structurally designed largely by the acting pressure; electrical or other control devices required for system operation are not included; a pressurized system is often called a *pressure system*

pressurized structure - a structure designed to carry both internal pressure and vehicle structural loads; the main propellant tank of a launch vehicle is a typical example

primacord - a detonating fuse used in destruct or separation functions

program - the coordinated group of tasks associated with the concept, design, manufacture, prepa-

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

ration, checkout and launch of a launch vehicle and/or payload to or from, or otherwise supported by the Eastern or Western Ranges and the associated ground support equipment and facilities

proof factor - a multiplying factor applied to the limit load or MEOP to obtain proof load or proof pressure for use in the acceptance testing

proof pressure - (1) the product of MEOP and a proof factor accounting for the difference in material properties between test and service environment (such as temperature); used to give evidence of satisfactory workmanship and material quality; for example, demonstrating that the component and/or system will not deform, leak or fail; (2) may be used to establish maximum initial flaw sizes for safe-life demonstration.

propellant storage tank - any container of propellants greater than one gallon. application of requirements of this document shall normally vary with the size of the tank and associated hazards. Containers less than one gallon shall also be subject to operational controls as a container of flammable liquid

psig - pounds per square inch gauge

PTFE - Polytetrafluoroethylene

QD - quick disconnect

qualification tests - the required tests used to demonstrate that the design, manufacturing, and assembly have resulted in hardware conforming to specification requirements

radiation source - materials, equipment, or devices that generate or are capable of generating ionizing radiation including naturally occurring radioactive materials, by-product, source materials, special nuclear materials, fission products, materials containing induced or deposited radioactivity, nuclear reactors, radiographic and fluoroscopic equipment, particle generators and accelerators, radio frequency generators such as certain klystrons and magnetrons that produce X-rays, and high voltage devices that produce X-rays

radioactive material - materials that generate, or are capable of generating, ionizing radiation including naturally occurring radioactive materials, by-product materials, source materials, special nuclear materials, fission products, materials con-

taining induced or deposited radioactivity, and nuclear reactors

radioactive equipment or device - equipment or devices that generate, or are capable of generating, ionizing radiation including radiographic and fluoroscopic equipment, particle generators and accelerators, radio frequency generators such as certain klystrons and magnetrons that produce X-rays, and high voltage devices that produce X-rays

RADSAFCOM - Radiation Safety Committee, Western Range

RAM - random access memory

Range Users - clients of CCAS and VAFB such as Department of Defense, non-Department of Defense government agencies, civilian commercial companies, and foreign government agencies that use Range facilities and test equipment, conduct prelaunch, launch, and impact operations, or require on-orbit support

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

rated load - the maximum static load or force that can be imposed on the part or structure at any time during its intended operation and expected environment

RCO - Range Control Officer

RDX - cyclotrimethylenetrinitramine

Recertification File - a file that contains data showing that a specific piece of MHE/MGSE meets the periodic test and inspection requirements of this document

redundant - a situation in which two or more independent means exist to perform a function

referee fluid - a compatible fluid, other than that used during normal system operations, that is used for test purposes because it is safer due to characteristics such as less (or non-) explosive, flammable, or toxic and/or easier to detect

remote control - control of a system from a remote and safe location

residual strength - the maximum value of nominal stress, neglecting the area of the crack, that a cracked body is capable of sustaining

residual stress - the stress that remains in a structure after processing, fabrication, assembly, testing, or operation; for example, welding induced residual stress

RF - radio frequency; electromagnetic energy from 30 kHz to 300 GHz

rms - root mean square

ROM - read only memory

RP - rocket propellant

RPIE - Real Property Installed Equipment

RPO - Radiation Protection Officer; the responsible agent to ensure enforcement of 45 SWI 40-201 and AFI 91-110 30 SW1

RSOR - Range Safety Operations Requirements

RT - Radiographic Testing

RV - reentry vehicle

S & A - safe and arm device; a device that provides mechanical interruption (safe) or alignment (arm) of the explosive train and electrical interruption (safe) or continuity (arm) of the firing circuit

cuit

Safe/Arm plug - normally two plugs; the ARM plug is inserted in the firing circuit to provide continuity. The ARM plug is removed and the SAFE plug inserted that shorts the electroexplosive device (EED) leads and provides static bleed capability, although some circuits have this protection inherent in their design. Shorting plugs and connectors that are placed on EED leads after disconnecting the cable are not the same as safing plugs, although they may perform similar functions.

SAE - Society of Automotive Engineers

safety critical - an operation, process, system, or component that controls or monitors equipment, operations, systems, or components to ensure personnel, launch area, and public safety; may be hazardous or non-hazardous

safety critical computer system function - a computer function containing operations that, if not performed, if performed out of sequence, or if performed incorrectly, may result in improper or lack of required control functions that may directly or indirectly cause a hazard to exist

safety factor - the ratio of design burst pressure over the maximum allowable working pressure or design pressure; it can also be expressed as the ratio of tensile or yield strength over the maximum allowable stress of the material

safety kernel - an independent computer program that monitors the state of a system to determine when potentially hazardous system states occur or when transitions to potentially hazardous system states may occur. The safety kernel is designed to prevent the system from entering the hazardous state and return it to a known safe state.

SAS - Safety Analysis Summary

SCAPE - Self-Contained Atmospheric Protective Ensemble

SCBB - Software Configuration Control Board

scc - standard cubic centimeter

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

SCCSF - Safety Critical Computing System Functions

SDD - Software Design Description; a representation of a software system created to facilitate analysis, planning, implementation, and decision-making; a blueprint or model of the software system; used as the primary medium for communicating software design information

SDP - Software Development Plan

SEAOC - Structural Engineers Association of California

serious mishap - an event or incident that has the potential of resulting in injury to personnel and damage to high value property or that might require the use of contingency or emergency procedures

service life - (1) the total life expectancy of a part or structure; service life starts with the manufacture of the structure and continues through all acceptance testing, handling, storage, transportation, operations, refurbishment, retesting, and retirement; (2) the period of time between the initial lot acceptance testing and the subsequent age surveillance testing for ordnance

SEU - Single Event Upset

SFP - single failure point; in general, a component that, if failed, could lead to the overall failure of the system; for example in a mechanical system, a component such as a lug, link, shackle, pin, bolt, or rivet, or a weld that, if failed, could cause a system inability to support a load using load path analysis

SHA - software hazard analysis

shall - mandatory action

shelf life, battery - the specified period of time a battery may be stored in a logistical environment and still perform to all required specifications when placed in service

shelf life, explosive - the period of time between explosive loading and end use

shield (RF) - a metallic barrier that completely encloses a device for the purpose of preventing or reducing induced energy

should - recommended action

single failure point analysis - in general, an analysis to identify single failure points; for mechanical systems, a load path analysis. A stress analysis of the resultant system after the first load path failure (of a single failure point). Twice the resultant dead weight shall be used in the analysis to account for the sudden redistribution of the load and an allowable stress of 90 percent of the ultimate material stress shall be used.

sling - a lifting assembly and associated hardware used between the load and the hoisting device hook

S-N - stress versus cycles; normally plotted in the form of a curve/diagram and is cyclic stress amplitude versus the number of cycles to failure

soft goods - the nonmetal materials in a pressure system that are used to form a seal or seat for metal-to-metal contact or between other hard surfaces

SPEC - specification

SRR - System Requirements Review

SSCF - software safety critical function

SSED - safe skin exposure distance

STP - Software Test Plan

STS - Space Transportation System

stress-corrosion cracking - a mechanical-environmental induced failure process in which sustained tensile stress and chemical attack combine to initiate and propagate a crack or a crack-like flow in a metal part

stress intensity factor - a parameter that characterizes the stress-strain behavior at the tip of a crack contained in a linear elastic, homogeneous, and isotropic body

structural component - a component such as a bolt, lug, hook, shackle, pin, rivet, or weld in a MHE

surface inspection - a nondestructive examination method, other than visual, used for detection of surface and near surface discontinuities

TLV - threshold limit value

TNSE - Technical Nuclear Safety Evaluation

T.O. - Technical Order

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

TOPS - transistorized operational phone system

UDMH - unsymmetrical dimethyl hydrazine

UL - Underwriter's Laboratories

ultimate load - the product of the limit load and the design ultimate load factor. It is the load that the structure must withstand without rupture or collapse in the expected operating environment

ultimate strength - the stress at which a material exhibits failure (i.e., fracture/break)

UN - United Nations

USAF - United States Air Force

UT - ultrasonic testing

Vac - voltage, alternating current

VAFB - Vandenberg Air Force Base

Vdc - voltage, direct current

VHF - very high frequency

volumetric inspection - a nondestructive testing method to determine the presence of discontinuities throughout the volume of a material

Vrms - voltage, root mean square

waiver - a designation used when, through an error in the manufacturing process or for other reasons, a hardware noncompliance is discovered after hardware production or an operational noncompliance is discovered after operations have begun at CCAS or VAFB

WR - Western Range

WP-S - A classification for a fitting(s) that is manufactured from seamless product by a seamless method of manufacturer (marked with class symbol, WP-S)

WP-WX - A classification for a fitting(s) that contains welds where all welds have been radiographed (marked with class symbol, WP-WX)

yield strength - the stress at which a material exhibits a specified permanent deformation or set

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- ANSI/ASME B30.8, *Floating Cranes and Floating Derricks*
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- AWS D14.2, *Metal Cutting Machine Tool Weldments*
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CHAPTER 3

LAUNCH VEHICLE, PAYLOAD, AND GROUND SUPPORT EQUIPMENT DOCUMENTATION, DESIGN, AND TEST REQUIREMENTS

3.1 INTRODUCTION

3.1.1 Purpose of the Chapter

Chapter 3 establishes minimum design, test, inspection, and data requirements for hazardous and safety critical launch vehicles, payloads, and ground support equipment, systems, and materials. The following topics are addressed:

- 3.2 Responsibilities and Authorities
- 3.3 General Design Policy
- 3.4 Documentation Requirements
- 3.5 Operations Safety Console
- 3.6 Material Handling Equipment
- 3.7 Acoustic Hazards
- 3.8 Non-Ionizing Radiation Sources
- 3.9 Radioactive (Ionizing Radiation) Sources
- 3.10 Hazardous Materials
- 3.11 Ground Support Pressure Systems
- 3.12 Flight Hardware Pressure Systems
- 3.13 Ordnance Systems
- 3.14 Electrical and Electronic Equipment
- 3.15 Motor Vehicles
- 3.16 Computer Systems and Software
- 3.17 Seismic Design Criteria (WR only)

3.1.2 Applicability

a. All Range Users operating on the Eastern Range (ER) and Western Range (WR) are subject to the requirements of this Chapter to ensure safety by design, testing, and inspection.

b. The Space Transportation System (STS) *Payload Ground Safety Handbook* (KHB 1700.7) design requirements may be used in lieu of the requirements of this Chapter only for payloads in-

tended to fly on STS. Those systems without design requirements in KHB 1700.7 shall meet the requirements of this Chapter.

3.2 RESPONSIBILITIES AND AUTHORITIES

3.2.1 Systems Safety, 45th and 30th Space Wings

Systems Safety, 45th Space Wing (45 SW/SES) and 30th Space Wing (30 SW/SES) are responsible for the review and approval of the design, inspection, and testing of all hazardous and safety critical launch vehicles, payloads, and ground support equipment, systems, subsystems, and material to be used at Cape Canaveral Air Station (CCAS) and Vandenberg Air Force Base (VAFB) in accordance with the requirements of this Chapter. **NOTE 1:** Unless otherwise noted, all references to *Range Safety* in this Chapter refer to the Systems Safety of the 30th and 45th Space Wings. The responsibilities of Range Safety are as follows:

- a.* Reviewing and approving all required Missile System Prelaunch Data Packages (MSPSPs)
- b.* Reviewing and approving all required MSP-SP associated Test Plans and Test Reports

3.2.2 Medical Groups, 45th and 30th Space Wings

3.2.2.1 Health Physics

Health Physics, 45th Medical Group (45 ADOS/SGGB) and 30th Medical Group (30 AMDS/SGPB) Radiation Protection Officer

REFERENCED DOCUMENTS

(RPO) are responsible for reviewing and approving the design, test, and inspection of non-ionizing

and ionizing radiation sources in conjunction with Range Safety. **NOTE:** Unless otherwise noted, these agencies will be referred to as the *RPO* in this Chapter.

3.2.2.2 Bioenvironmental Engineering

Bioenvironmental Engineering, 45th Medical Group (45 ADOS/SGGB) and 30th Medical Group (30 AMDS/SGPB) are responsible for reviewing and approving the design, test, and inspection of systems with acoustic and radiation hazards. **NOTE:** Unless otherwise noted, these agencies will be referred to as *Bioenvironmental Engineering* in this Chapter.

3.2.3 Civil Engineering, 45th and 30th Space Wings

a. The 45th Civil Engineering Squadron (45 CES) and 30th Civil Engineering Group (30 CEG) Environmental Planning Sections are responsible for reviewing and approving regulated hazardous waste plans and procedures. **NOTE:** Unless otherwise noted, these agencies will be referred to as *Environmental Planning* in this Chapter.

b. The 45th and 30th Fire Marshals (45 CES/CEF) and (30 CEG/CEF) are responsible for establishing hazardous atmosphere classification and other duties. **NOTE:** Unless otherwise noted, these positions will be referred to as *Fire Marshal* in this Chapter.

3.2.4 Range Users

Range Users are responsible for the design, inspection, and testing of all hazardous and safety critical launch vehicle, payload, and ground support equipment, systems, subsystems, and materials to be used at the Ranges in accordance with the requirements of this Chapter. These responsibilities include the following:

- a.* Timely submission of all required MSPSPs
- b.* Timely submission of all MSPSP associated Test Plans and Test Reports

3.3 GENERAL DESIGN POLICY

All systems shall be designed to tolerate a minimum number of credible failures. The number of design inhibits required to prevent an overall system failure or mishap is based on the failure or mishap result. Specific inhibit requirements are addressed in the design criteria for each of the systems addressed in this Chapter. Those systems that do not have specific design criteria or systems not addressed in this

Chapter shall be designed to the following general criteria:

a. If a system failure may lead to a catastrophic hazard, the system shall have three inhibits (dual fault tolerant).

b. If a system failure may lead to a critical hazard, the system shall have two inhibits (single fault tolerant).

c. If a system failure may lead to a marginal hazard, the system shall have a single inhibit (no fault tolerant).

d. Probabilities of hazard occurrence shall be taken into consideration when determining the number of required inhibits. (See Chapter 1, Table 1-1, "Acceptability Guidelines for Prelaunch Launch Area/Launch Complex Hazard Consequences and Probability Categories.")

e. Systems shall be able to be brought to a safe state with the loss of an inhibit.

f. All inhibits shall be independent and verifiable.

g. Design inhibits shall consist of electrical and mechanical hardware.

h. Operator controls shall not be considered a design inhibit. **NOTE:** Operator controls are considered a control of an inhibit.

3.4 DOCUMENTATION REQUIREMENTS

3.4.1 MSPSP

3.4.1.1 MSPSP Submittal, Review, and Approval Process

a. Range Users shall submit an MSPSP for each new program such as launch vehicle, payload, or stand-alone ground support equipment.

b. Range Safety shall review and provide comments to each of the MSPSP submittals at or prior to the appropriate cDR, PDR, and CDR.

c. A final MSPSP that satisfies all Range Safety concerns addressed at the CDR shall be submitted to Range Safety at least 45 calendar days prior to the intended shipment of hardware to the Ranges.

d. Range Safety shall review the MSPSP and, if the MSPSP is found to be satisfactory, approve it within 10 calendar days of receipt. **NOTE:** The final MSPSP shall be approved prior to shipment of associated hardware to the Ranges.

3.4.1.2 MSPSP Content

a. Guidelines for preparing an MSPSP can be found in Appendix 3A.

b. Specific MSPSP data requirements, including analyses, drawings, plans, specification, and other

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data are identified in each of the major sections of this Chapter.

3.4.2 MSPSP Associated Test Plans and Test Results

a. All MSPSP associated test plans shall be submitted at least 45 calendar days prior to the intended test plan use.

b. Range Safety shall review and comment on or approve test plans within 45 calendar days of receipt. Disapproved test plans shall be resubmitted. **NOTE:** An approved test plan is required prior to test performance.

c. Test reports shall be submitted within 45 calendar days of intended system use.

d. Range Safety shall review and comment and approve test reports within 10 calendar days of receipt. Disapproved test reports shall be resubmitted. **NOTE:** An approved test report is required prior to system use.

3.5 OPERATIONS SAFETY CONSOLE

3.5.1 Operations Safety Console General Design Requirements

a. Each launch control center, blockhouse, and firing room, as applicable, shall provide for an Operations Safety Console (OSC).

b. An ER/WR OSC shall be provided by the Range User (normally the launch vehicle provider) unless otherwise agreed to by Range Safety. **NOTE:** The ER normally provides an OSC.

c. The Range User shall provide ample and satisfactory space to install and operate the console.

d. No single failure point components shall be in the ground support equipment (GSE) or firing room/launch control center/blockhouse system that will cause the loss of a safety critical system control or monitor (as determined by Range Safety) at the OSC.

e. MIL-STD-1472 should be used as guidance in designing the OSC.

3.5.2 ER OSC Controls, Monitors, and Communication Lines

The OSC shall be in a dedicated position to provide the Operations Safety Manager sufficient information and communications capability to convey safety status and conditions to the appropriate authority (the launch complex control authority for day-to-day operations and the MFCO during a

launch operation). At a minimum, the controls, monitors, and communication lines listed below are required at the launch complex OSC. These items are general in nature and may vary depending on the launch vehicle configuration. The monitor circuit shall be designed so that the actual status of the critical parameters can be monitored rather than the command transmittal. **NOTE:** It is important that this console does not have any Flight Termination System (FTS) command transmittal functions.

a. FTS status (Refer to Chapter 4 for requirements)

b. Ignition SAFE and ARM status for all solid rocket motor safe and arm devices

c. An ENABLE control switch and status for all solid rocket motor arming devices

d. Launch vehicle liquid propulsion system inhibits and propellant tank pressure status (psig)

e. Water System (pump station)

1. 18 in. main pressure status

2. 36 in. main pressure status

3. Status for each main pump on-line or off-line

f. Master Communications Control Panel

1. Two administrative telephones with HOLD function

2. Audio-selector push buttons for intercom net and green phones (direct line)

3. Green phones with a minimum of 30 channels

4. Intercom capability via the Operational Information System (OIS) or Transistorized Operational Phone System (TOPS) in which four channels can be accessed simultaneously

5. Paging capabilities

6. Very High Frequency/Frequency Modulation (VHF/FM) radio phone

7. Particular communication requirements will be specified in applicable Range Safety Operations Requirements (RSORs) in accordance with Chapter 7 of this document.

g. Master Countdown status

h. HOLD-FIRE (stop launch sequencer) control switch and status active through T-0

i. Ignition firing line ENABLE and DISABLE control switch and status

j. Mission Flight Control Officer (MFCO), Range Control Officer (RCO), and Range User HOLD-FIRE status

k. Emergency Panel

1. Launch complex warning beacon and horn

control switch and status

Alert (S&A) lights to MFCO

2. Emergency and normal electrical power status for critical locations such as the firing room and launch complex

3.5.3 WR OSC Controls, Monitors, and Communication Lines

The OSC shall be in a dedicated position to provide the Operations Safety Manager sufficient information and communications capability to convey safety status and conditions to the appropriate authority (the launch complex control authority for day-to-day operations and the MFCO during a launch operation). At a minimum, the controls, monitors, and communication needs listed below are required at the launch complex OSC. These items are general in nature and may vary depending on the launch vehicle configuration. The monitor circuit shall be designed so that the actual status of the critical parameters can be monitored rather than the command transmittal. **NOTE:** It is important that this console does not have any Flight Termination System (FTS) command transmittal functions.

- a. FTS SAFE and ARM status for all FTS safe and arm devices
- b. Ignition SAFE and ARM status for all solid rocket motor safe and arm devices
- c. Launch vehicle liquid propulsion system inhibits and propellant tank pressure status (psig)
- d. Communications
 1. Countdown net capable of monitoring and transmitting (redundant)
 2. Direct line to MFCO
 3. Direct line to RCO
 4. Direct line to Building 7000 Launch Operations Control Center (LOCC)
 5. Direct lines to Test Conductor and Launch Control Officer
 6. Direct line to primary access control point for safety control areas
 7. Direct line to facility safety net
 8. Direct line to Launch Support Team Chief and fallback area
 9. Access to facility Public Address (PA) system with emergency override capability
 10. At least one Class A dial line
 11. Radio Frequency (RF) nets, as required
 12. Direct line to Launch Director
 13. Direct line to ACO
- e. MFCO and Range User HOLDFIRE status
- f. Wind speed and direction readouts
- g. Complex and Range Clearance Status and

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h. Launch complex warning lights and klaxon/horn switch and status indicators

3.5.4 OSC Color Television System

a. An OSC color television system shall be provided to ensure the coverage necessary to view all hazardous operations in the launch complex.

b. Control of the television system shall be available at the OSC.

3.5.5 OSC Communication and Video Recording

a. The OSC shall be capable of recording and playback of hazardous operations.

b. Communication and video recording requirements shall be coordinated with the launch controller and test conductor prior to the start of an operation.

c. Designated recordings shall remain on file for 180 days.

3.5.6 OSC Validation and Test Requirements

a. At a minimum, an OSC validation and check-out test shall be performed to demonstrate the following:

1. The correct and reliable operation of OSC functions
2. The validity of OSC outside interfaces
3. The operating limits of the OSC

b. Test Plans, procedures, and results shall be reviewed and approved by Range Safety.

3.5.7 OSC Data Requirements

The following OSC data shall be submitted in the MSPSP:

a. An overall schematic of the OSC and outside interfaces

b. A narrative of each of the features of the OSC, including the following:

1. Function
2. Operation
3. Outside interface
4. Operating limits

c. Test Plan and Maps

3.6 MATERIAL HANDLING EQUIPMENT

This section provides design, initial and periodic test, and initial and recurring data requirements

for material handling equipment (MHE) used at the Ranges for handling (lifting, supporting, or manipulating) critical and non-critical hardware. These requirements are applicable for new or modified MHE. The requirements are also applicable for permanent or short-term use MHE and apply whether the equipment is owned, rented, or leased by either government, contractor, or commercial operators.

3.6.1 MHE General Requirements

a. As part of the MSPSP, a list of all MHE equipment to be used on the Ranges shall be submitted to Range Safety for review and approval as soon as possible, preferably during the cDR.

b. The list shall include a detailed description of each handling device, its intended use, and whether it handles critical and/or non-critical hardware.

3.6.2 MHE Used to Handle Critical Hardware

3.6.2.1 MHE Used to Handle Critical Hardware General Requirements

3.6.2.1.1 MHE Used to Handle Critical Hardware Single Fault Tolerance. MHE used to handle critical hardware should have connector (pin, bolt, lug, rivet) and weld designs that are single fault tolerant against catastrophic failure. Reducing and/or eliminating the number of single failure point (SFP) connectors and SFP welds results in a significant reduction in the probability of a catastrophic event such as fatalities and the loss of national assets and a significant reduction in the cost of initial and periodic nondestructive examination.

3.6.2.1.2 MHE Used to Handle Critical Hardware Stress Analysis. A stress analysis shall be performed on all MHE used to handle critical hardware and the results reported in the MSPSP.

3.6.2.1.3 MHE Used to Handle Critical Hardware Single Failure Point Analyses.

a. All MHE used to handle critical hardware shall be analyzed for SFPs and the results reported in the MSPSP, ARAR, or other Range Safety approved documentation format.

b. The use of SFP welds shall be avoided.

c. If the use of SFP welds cannot be avoided, they shall be designed to be easily inspected and shall be identified as SFP welds in the drawings.

d. A list of SFPs for each piece of equipment

shall be submitted to Range Safety for review and approval as part of the MSPSP.

3.6.2.1.4 MHE Used to Handle Critical Hardware Nondestructive Examination Plans.

a. Non-destructive examination (NDE) plans shall be developed for each piece of MHE with SFP components or SFP welds. **NOTE:** NDE applies to all hooks and all MHE used to lift and support critical hardware.

b. The NDE plan for each applicable MHE shall include the following:

1. NDE technique and acceptance criteria to be used on each SFP component or SFP weld after initial and periodic proof load tests

2. Detailed engineering rationale for each technique and acceptance criteria

3. A determination of whether the MHE is a dedicated piece of equipment used for only one function or whether it is multi-purpose

4. The environment and/or conditions under which MHE will be used and stored

5. The existence of any SFP component and SFP weld materials susceptible to stress corrosion.

6. Corrosion protection and maintenance plans

c. The NDE plan shall be submitted to Range Safety for review and approval as soon as it is developed, but no later than the MHE PDR and shall be included as part of the MSPSP.

d. The following are acceptable NDE techniques and standards:

1. Surface inspection in accordance with MIL-STD-6866 or ASTM-E1444

2. Volumetric inspection in accordance with MIL-STD-453 or MIL-STD-2154

3. Visual inspections performed by persons trained and qualified. **NOTE:** Visual inspector qualification criteria and training shall be documented in a written procedure.

e. A non-inclusive list of standards that may be used to develop NDE acceptance criteria is provided below:

- 1.* AWS D1.1, D1.2, D14.1, D14.2
- 2.* MIL-STD-278
- 3.* MIL-STD-2154
- 4.* MIL-STD-1265
- 5.* MIL-HDBK-1890
- 6.* MIL-STD-2175
- 7.* NAVSHIP 250-692-2
- 8.* MSFC-STD-100
- 9.* MSFC-STD-1249

3.6.2.1.5 MHE Accessibility for Initial and Periodic NDE. SFP components and welds shall be designed to be accessible for initial and periodic NDE.

3.6.2.1.6 MHE Used to Handle Critical Hardware Identification.

a. Marking Requirements. All MHE shall be permanently marked with the following information:

- 1.* Serial number
- 2.* Part number
- 3.* Rated load
- 4.* Weight of major component

b. Tagging Requirements

1. Following the proof load test, a non-sparking metal tag shall be securely attached to the MHE and shall be accessible for inspection.

2. The load test tags shall be marked (stamped or etched) with the following minimum information:

- (a)* Part number, serial number, or other unique identifier
- (b)* Date of most recent load test
- (c)* Weight of test load
- (d)* Date of next load test
- (e)* Date of most recent NDE
- (f)* Date of next NDE
- (g)* A quality assurance or quality control indication certifying data on the tag

c. In addition, certification that all components have been proof load tested as an assembly shall be provided. **NOTE:** If the assembly is to be disassembled after proof testing, each component and subassembly shall be individually tagged.

3.6.2.1.7 MHE Used to Handle Critical Hardware Load Test Devices. Load tests shall be conducted with certified weights.

a. Load test weights shall be accurately identified and tagged with total weight (lb) and owner or agency identification number. **NOTE:** Calibrated load devices such as dynamometers may be used to test slings and other lifting devices except cranes.

b. Reinforcing steel (rebar) shall not be used for lift points.

c. The test weight shall be applied a minimum of 3 min.

3.6.2.1.8 MHE Used to Handle Critical Hardware Data Requirements. Specific data requirements for each type of MHE are identified throughout this section. These requirements fall into two categories: initial data requirements and recurring

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data requirements. The definition and processing requirements for initial and recurring data are described below:

a. Initial Data Requirements

1. All MHE shall have data that shows that the equipment meets the applicable design and initial test requirements.

2. These data requirements are identified in the **Initial Data Requirements** section for each type of MHE.

3. These data shall be submitted to Range Safety for review and approval prior to the first operational use of the equipment at the Ranges.

4. MHE design and initial test data shall be consolidated and included in the MSPSP as an appendix.

5. MHE design and initial test data shall be updated as required to reflect changes in design and testing.

b. Recurring Data Requirements

1. All MHE shall have data that shows that the equipment meets the applicable periodic testing requirements.

2. These data requirements are identified in the **Recurring Data Requirements** section for each type of MHE.

3. The periodic test plans shall be included in the MSPSP as an appendix.

4. In addition, periodic test plans and test results and MHE design and initial test data shall be maintained by the Range User in the MHE Recurring Test Data File.

5. MHE Recurring Test Data Files shall be made available to Range Safety upon request.

3.6.2.1.9 Major Item MHE Designs. All major MHE items, such as cranes, shall incorporate the requirements of Chapter 5, paragraph 5.4.2 a.

3.6.2.2 Cranes and Hoists Used to Handle Critical Hardware

3.6.2.2.1 Cranes and Hoists Used to Handle Critical Hardware Analyses.

a. An Operating and Support Hazard Analysis (O&SHA) shall be performed in accordance with a Range User and Range Safety jointly tailored System Safety Program. (See Appendix 1B.)

b. A Failure Mode Effects and Criticality Analysis (FMECA) shall be performed in accordance with a jointly tailored MIL-STD-1543 and MIL-STD-1629.

1. The FMECA shall identify failure condi-

tions that could result in personnel injury, loss of load, or damage to critical hardware.

2. The FMECA shall encompass the complete power and control circuitry as well as the load path from hook to structure.

3. SFP components, SFP welds, and SFP modes shall be documented for tracking to elimination or acceptance.

3.6.2.2.2 Cranes and Hoists Used to Handle Critical Hardware Design Standards. All cranes and hoists shall comply with the following standards:

a. 29 CFR 1910

b. Crane Manufacturers Association of America (CMAA) 70 and 74 for Overhead Cranes and Hoists

c. ANSI B30 series for all Cranes and Hoists

d. Software control programs for cranes and hoists shall be designed and tested in accordance with a jointly tailored MIL-STD-2167 and MIL-STD-2168 and the **Computing Systems and Software** sections of this Chapter.

e. *National Electrical Code* (NEC) for all electrically powered cranes and hoists

f. *Material Handling Institute Standards*, as applicable

3.6.2.2.3 Additional WR Design Standards for Cranes and Hoists Used to Handle Critical Hardware.

a. All crane analyses, specifications, test plans, and test results shall be reviewed and approved by the Blue Ribbon Crane Committee (BRCC).

b. At VAFB, cranes not on VAFB exclusive Federal jurisdiction property also require inspection, testing, and certification in accordance with California Occupational Safety and Health (CAL-OSHA) requirements. **NOTE:** These requirements can be found in Title 8 of the *Administrative Code* and Chapter 4, *General Industry Safety Orders of CAL-OSHA* and the *BRCC Design Requirements Handbook for Electrically Powered Top Running Overhead and Underhung Traveling Cranes*

3.6.2.2.4 Cranes and Hoists Used to Handle Critical Hardware Selection Criteria.

a. The service classifications found in CMAA 70 and 74 shall be used as the basis for selecting cranes and hoists to be used on the Ranges.

b. Classification less than D shall be approved by Range Safety.

3.6.2.2.5 Cranes and Hoists Used in Hazard-

ous Environments.

a. All cranes and hoists used in hazardous environments shall be designed to meet the hazard proofing requirements in the **Electrical Systems and Equipment Hazard Proofing** section of this Chapter.

b. Runway systems for overhead cranes and hoists shall be provided with non-sparking cable feed systems (festoon cable or double shoe sliding contractors) for supplying power to the bridge cranes.

c. Structural and mechanical parts shall not cause sparks during normal operation and sparks caused by emergency braking shall be prevented from falling into the work areas below.

3.6.2.2.6 Cranes and Hoists Component Accessibility.

a. Safe and adequate access to components to inspect, service, repair, or replace equipment shall be provided for during design. Consideration shall be given to the use of fixed platforms with guard rails in lieu of extensive use of personnel tie-offs.

b. The design shall provide for visual and physical accessibility of all safety critical SFP components and SFP welds.

3.6.2.2.7 Use of Rotation Resistant Wire Rope.

a. Rotation resistant wire rope shall not be used without specific permission from Range Safety.

b. Rotation resistant ropes shall not be used for any purposes with swivel links installed.

3.6.2.2.8 Use of Cast Iron. Cast iron and other similar brittle materials shall not be used in load bearing parts.

3.6.2.2.9 Hook Design.

a. All hooks shall be equipped with a positive latching mechanism to prevent accidental load disengagement.

b. All hooks used to lift loads containing propellants or ordnance shall have a grounding lug.

c. The initial throat opening of a hook shall be measured and permanent reference marks placed on each side of the hook. The distance between the marks shall be measured and recorded during periodic inspections for determination of the hook throat opening.

d. All hooks used to lift critical loads shall be insulated to allow not more than 70 microamperes of current flow per 1000 volts applied.

1. Hooks used for indoor cranes shall be rated for 10,000 volts.

2. Hooks used for outdoor cranes shall be rated for 50,000 volts.

3. Manufacturer test data shall show testing at two times the rated voltage.

4. Hook insulation shall be rated for RF attenuation of 50 to 1 at 50 megahertz.

e. Attachments such as handles and latch supports shall not be welded to a finished hook in field applications. If welding of an attachment such as these is required, it shall be done in manufacturing or fabrication prior to any required final heat treatment.

f. ANSI 30.10 requirements shall apply to hook design, testing, and repair.

3.6.2.2.10 Overhead Crane and Hoist Design Requirements.

a. Reeving

1. Overhead cranes and hoists shall be capable of operating with a 5° hoist angle without the load line contacting any structural member or obstructions and without the rope being pulled out of the drum or sheave grooves.

2. Cranes shall be double reeved with all load lines terminated at the equalizer and drum(s). **NOTE:** The equalizer system shall have the means to allow movement of the system to level the block.

(a) Cranes shall be reeved with one right lay rope and one left lay rope to cancel the block rotation tendency.

(b) The equalizer system shall have sufficient damping to sustain one load line breaking without shock loading the other rope enough to cause failure.

(c) The equalizer system shall be self-aligning with the load line.

(d) Vertical load displacement following a rope failure shall be minimized. This vertical load displacement shall be calculated and the analysis submitted.

(e) The effects of a broken rope on the entire system, including the load block and the equalizer assembly, shall be analyzed and reported.

(f) In the event of one broken rope, the remaining intact reeving system shall not be loaded to more than 40 percent of the breaking strength of the remaining intact wire rope, including the dynamic loading effects of the load transfer.

3. All overhead cranes and hoists shall be equipped with a means (such as a level-wind device) for preventing the load line from coming out of the drum groove and overwrapping itself on the drum. **NOTE:** As an alternative, a warning device

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such as a spooling monitor that will activate an aural/visual warning and shutdown the crane when the load line comes out of the drum groove may be used.

4. Load lines shall be attached to the crane by a rope termination method that develops 100 percent of the rope strength.

5. Ropes shall be attached to the drum with a minimum of two clamps each. Clamp bolts shall be properly torqued.

6. Provisions shall be made to support the drum, to prevent disengagement of the drum gearing, and to prevent disengagement of the drum from its emergency brake in the event of drum shaft, drum hub, shaft bearing, or bearing support failure.

b. Overhead Crane and Hoist Controls

1. Movement controls shall be of the "dead man" type.

2. Cab-operated cranes shall have a lever control, spring-loaded to the NEUTRAL position, and a RELEASE button that, if released, shall stop motion and require the control to be brought back to the NEUTRAL position to restart.

3. Cranes shall be provided with spring-loaded push button or lever-type control switches for bridge, trolley, and hoist controls. Rotary or toggle switches can be used for other functions such as operation of accessory lights and microdrive mode selection.

4. Lever type switches shall be provided with a positive latch, that, in the OFF position, prevents the handle from being inadvertently moved to the ON position. **NOTE:** An OFF detent or spring return arrangement is not sufficient.

5. Movement controls shall have an inching (jog) capability only when the SPEED selector switch is in the slowest speed position. The slow speed shall be no greater than 2 ft per min.

6. All control panels shall have a lock-out feature such as a keyed switch to prevent unauthorized operation.

7. Crane controls shall permit the use of reversing or plugging as a means of controlling or stopping hoist, trolley, or bridge motion. **NOTE:** This capability should not be used during normal crane operations.

8. Pendant control stations shall be suspended by a strain relief chain or cable connected to protect the electrical conductors from strain.

9. The control station shall be located so the

crane operator has direct line of sight to the load at all times. **NOTE:** If this is not possible, spotters or assistant operators shall have emergency stop capability at their location if inadvertent crane movement could result in personnel injury or death.

10. Control stations shall have the built-in capability to test the integrity of all indicator lamps and aural/visual warning devices.

11. Automatic cranes shall be designed so that all motion shall fail-safe if any malfunction of operation occurs.

12. Remotely-operated cranes shall function so that if the control signal for any crane motion becomes ineffective, the crane motion shall stop.

13. For systems where concurrent commands can be made, priority shall be provided for superior command or the control station shall be provided with a disconnect or key lockout feature. **NOTE:** The key lockout feature shall not preclude the emergency stop capability.

14. MIL-STD-1472 shall be used as guidance in designing the crane and hoist controls.

c. Overhead Crane and Hoist Limit Switches

1. All overhead cranes and hoists shall be equipped with 2 limit switches in the UP direction to prevent "two blocking" and 1 limit switch in the DOWN direction to prevent a slack rope condition.

(a) The first UP limit switch shall interrupt the movement control circuit and shall be reset by reversing the movement control.

(b) The second UP limit switch shall be a mechanical fail-safe switch that will interrupt power to the hoist mechanism and require maintenance personnel to reset.

2. Each bridge and trolley shall be equipped with limit switches that will first slow the bridge or trolley to "creep" speed and a second limit switch that will remove power and apply the brake before it engages the bumper or other mechanical stop.

d. Overhead Crane and Hoist Overload Indicators. All hoists shall be provided with an adjustable hoist overload detection device set to operate at 110 percent of rated load. When triggered, the device shall activate an overload indicator light and overload indicator horn

e. Overhead Crane and Hoist Brakes. Powered hoists shall have three independent brake systems: a control brake system, a holding brake system, and an emergency brake system on the hoist drum. Due to the difficulty of proper adjustment and the potential for contamination, band-type

emergency brakes are not recommended. Caliper-type brakes are preferred.

1. The emergency brake system shall automatically stop the drum if drum overspeed (110 percent of maximum rated lowering speed) is sensed.

2. All brake systems shall be capable of braking and holding at least 150 percent of torque exerted by full rated load on the hook.

3. Both the holding brake and the emergency brake shall be activated by the EMERGENCY STOP button.

4. Each brake system shall be designed to allow controlled lowering of the load.

5. Each brake system shall be capable of being tested independently in place. **NOTE:** A torque wrench fitting for purposes of testing the brakes shall be provided.

6. The application of multiple brake systems shall be synchronized to prevent overstressing or shock loading.

7. The holding and emergency brake systems shall be fail-safe; in other words, the brakes shall be applied automatically when power is removed.

f. Overhead Crane Bridge and Trolley Brakes. All overhead crane bridge and trolleys shall be equipped with fail-safe brakes in both directions. For specific requirements, see CMAA 70 and 74 and the ANSI B30 series.

8. For pneumatic emergency brake fail-safe systems, redundant solenoid dump valves are required. An electrical switch that enables independent testing of these dump valves shall be provided. No lubricants such as oil shall be introduced into the pneumatic system without first performing a chemical compatibility analysis. **NOTE:** Valve softgoods and o-rings may swell up when in contact with some lubricants.

g. Overhead Crane and Hoist Grounding and Bonding.

1. All cranes and hoists shall be grounded and bonded to provide critical hardware and personnel protection against electrical failures or lightning strikes.

2. Grounding and bonding between trolley, bridge, and runway shall use separate bonding conductors that may be run with electrical circuit conductors.

3. The contact between the wheels and frame shall not be considered a low resistance path to ground.

h. Overhead Crane Bridge and Trolley Move-

ment Marking

1. Each overhead crane shall have the directions of its bridge and trolley movements displayed on the underside of the crane. These directions (North, East, South, and West) shall correspond to the directions on the operator station.

2. These markings shall be visible from the floor and any operator station.

i. Overhead Crane and Hoist Emergency Lowering System. All hoisting mechanisms used for lifting critical loads shall have a fail-safe capability for emergency lowering of the load in the event of a power failure or credible hoist mechanism malfunction.

j. Overhead Crane and Hoist Torque Proving System. A torque proving system shall be provided for all hoist drives and motors to ensure that the hoist holding brakes are not released until the motor has been verified for its ability to energize. If microdrive systems with non-fail safe clutches are used, this torque proving system shall be designed not to release the hoist brakes until the system has verified positive clutch engagement. The torque proving system shall be designed to eliminate any undesirable hook jump.

k. Overhead Cranes and Hoists With Microdrives Using Non-Fail Safe Clutches. If microdrives with non-fail safe electrical clutches are used, current monitoring systems shall be provided to immediately shut down the hoist and apply all hoist brakes in case of the loss of the clutch coil supply current. A load drop detection system shall also be provided to allow no perceptible load drop to occur in case of clutch failure. **NOTE:** Use of separate microdrives with non-fail safe electrical clutches is not recommended. Use of single drives capable of low hook speeds is preferred.

l. Motion Stops for Outside Tower Cranes. In the case of outside tower cranes with runway terminations that are clear of any walls or structural member to stop the crane motion, bridge and trolley stops shall be capable of withstanding 110 percent maximum speed impact of the bridge or trolley and stop all motion without failure.

trolley and stop all motion without failure.

m. Unique Cranes.

1. All unique cranes such as TORUS, straddle, and winches used as hoists not covered in this document shall be justified to and approved by Range Safety on a case-by-case basis.

2. For those bridge cranes designed for intentional side pulls or for bridge cranes used in

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tandem crane operations where horizontal forces will be exerted on the crane because of angular pulls, special features shall be incorporated to prevent sliding of the crane bridge/trolley as a result of the horizontal forces applied and to shut down the hoist if the maximum side pull angle has been exceeded. (**NOTE:** To prevent stressing the bridge/trolley brakes, rail clamps can be used to hold the bridge/trolley in place during these operations. Also, limit switches can be used to shut-down the hoist if the maximum allowable side pull angle on the crane ropes has been exceeded.) Additionally, the design shall ensure the trolley remains stable (no potential danger of tipover due to the horizontal component of the resulting force) under worst-case loading conditions.

3.6.2.2.11 Mobile Cranes. The use of mobile cranes to lift critical hardware shall be justified to and approved by Range Safety on a case-by-case basis. At a minimum, mobile cranes used to lift critical hardware shall comply with the following:

- a. ANSI B30.5, ANSI B30.15, OSHA 1926, and OSHA 1910.180
- b. Load charts shall be used as the primary means for determining safe loads for various boom angles. Crane computers shall not be used as a sole means for this determination.
- c. The following man-rated crane criteria shall be used for cranes used to lift critical hardware
 1. A minimum of one upper limit switch
 2. Deadman levers and controls on fixed control panels
 3. The ability to deactivate free fall features
 4. Be derated to 50 percent of capacity as determined by the load chart or 70 percent of capacity when a specific lift plan is approved by Range Safety
 5. Evolutions that actually involve man-rated lifts shall also comply with the operational requirements of Section 6.6.10.2.4.
- d. Reeving diagrams shall be provided for each crane.

3.6.2.2.12 Portal Cranes. Portal cranes used to handle critical hardware shall be designed to incorporate the following items:

- a. A load indicating device with the readout located in the cab
- b. An upper limit switch at the boom point to

prevent "two blocking"

- c. A boom angle indicating device readable from the operator seat in the cab

3.6.2.2.13 Initial Test Requirements for Cranes and Hoists Used to Handle Critical Hardware.

a. General Test Requirements

1. Initial shop and field test plans and test results for cranes and hoists shall be submitted to Range Safety for review and approval as part of the crane and hoist Design and Initial Test Data in the MSPSP.

2. Any test anomaly discovered shall be evaluated by Range Safety as a cause for rejection.

3. Inspections and tests shall be performed by appointed or authorized persons. At the WR, these persons shall identify the federal or state office issuing certification authority and the expiration date of the certification authority.

4. At a minimum, the following tests shall be performed on cranes and hoists prior to their first operational use at the Ranges. Unless otherwise agreed to by Range Safety, all or part of these tests shall also be performed after a crane or hoist has been modified or repaired.

b. Testing Hooks Prior to Assembly on the Crane. The following tests shall be performed on the hook prior to assembly on the crane:

1. A proof load test shall be performed in accordance with ANSI B30.10.

2. After the proof load test, volumetric and surface NDE shall be performed on the hook and its shank, shank threads, nut (including nut threads); or for pinned shank hooks, the attachment pin.

c. Overhead Crane and Hoist Initial Functional Test (No-Load). Prior to and after any load testing, the following no-load tests shall be performed:

1. A complete functional test of all control systems, safety devices, and warning indicators shall be performed after the crane is assembled on the Range.

2. The hook insulator shall be tested, as installed, to verify that the insulator complies with the design specification.

3. If a spooling monitor is installed, a test shall be performed to verify that the monitor sounds an alarm and shuts down the hoist when the load line comes out of the drum grooves or overwinds.

4. A test shall be performed to verify that the crane can operate with a 5° degree hoist angle without the load line contacting any structural member or obstruction and without the rope being pulled out of the drum or sheave grooves.

5. A test shall be performed to verify that all crane control levers (joysticks) are deadman-type controls. This test shall also verify that the neutral detent feature on the control levers is operational. If push buttons are used to control the crane movements, they shall also be tested to ensure that they perform as deadman-type controls (return to the OFF position when released).

6. A test shall be performed to verify that the crane operator station or stations are capable of performing an integrity check of all indicator lamps and aural/visual warning devices.

d. Overhead Crane and Hoist Load Tests.

The following tests shall be performed by the manufacturer or a designated representative on site at the Ranges after complete installation of the crane:

1. Overhead cranes and hoists shall be proof load tested to 125 percent of the rated load. The test shall be performed in the following sequence:

(a) The test weight shall be hoisted approximately 2 ft and suspended for a minimum of 3 min to verify that drum rotation and test weight drift, as measured, are within acceptable limits.

(b) The test weight shall be raised to sufficient height and at least one emergency stop shall be made at the 110 percent lowering speed to verify that brake application meets specification requirements..

(c) Electrical power shall be removed from the crane so that the holding and emergency drum brakes are engaged. The brakes shall be manually released in such a manner that each individual brake demonstrates its ability to hold the entire test weight without slipping. Electrical power shall be reapplied.

(d) The test weight shall be raised to the maximum height and then lowered in three increments, stopping each time to verify there is no uncommanded drum rotation or test weight lowering.

(e) The test weight shall be transported by the trolley for the full length of the bridge.

(f) The test weight shall be transported the full length of the runway in one direction with the trolley as close to the extreme right hand of the bridge as practical and in the other direction with the trolley as close to the extreme left hand of the bridge as practical.

2. Overhead cranes and hoists shall be subjected to the following tests at 100 percent of rated load:

(a) The test weight shall be hoisted approximately 2 ft and suspended for a minimum of 3 min to verify that drum rotation and test weight drift, as measured, are within acceptable limits.

(b) The test weight shall be raised to sufficient height and at least one emergency stop shall be made at the fastest lowering speed to verify that brake application meets specification requirements.

(c) The test weight shall be moved throughout the complete operating envelope of the overhead crane and hoist, stopping and starting at various locations to verify smooth operation.

(d) Crane controls shall be tested to verify that the use of reversing or plugging can control or stop the hoist, trolley, and bridge motion.

(e) Bridge and trolley brakes shall be tested to verify that they function in accordance with CMAA 70 and 74 and ANSI B30 Series requirements.

(f) The hoist emergency load lowering system shall be tested to verify that it is fail-safe and functions properly.

(g) Bridge, trolley, and hoists shall be tested at each specified speed, including bumping and jogging.

(h) The load slippage detection system shall be tested for proper activation to ensure that the load stops within the specified distance. If the crane is equipped with a non-fail safe microdrive electrically operated clutch, a test that simulates clutch failure to engage (mechanical failure with coil energized) and clutch electrical failure during hoisting shall be performed. Maximum load drop shall be measured to ensure that it is within specifications and the detection system performs properly.

(i) For special purpose cranes designed for side angle pulls, the bridge brakes, trolley brakes, and special devices, such as the rail clamps and side angle pull limit switches, shall be tested at the maximum side pull angle to ensure proper function. The trolley should remain stable (no danger of tipover due to the horizontal component of the resulting force).

e. Crane and Hoist No-Load Test Requirements. The following tests shall be performed after load testing:

1. Hoist brake overspeed sensing devices shall be tested to verify they function properly.

2. Bridge, trolley, and hoist limit switches

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shall be tested in each direction.

3. The fail-safe design of the bridge and trolley brakes shall be tested by turning the power off while moving the bridge and trolley in each direction.

f. Crane and Hoist NDE Requirements. The following NDE tests shall be performed as indicated:

1. All SFP components and SFP welds on the crane and hoist and support structures shall be volumetrically and surface inspected prior to the proof load test.

2. After the 125 percent proof load test, volumetric and surface NDE testing shall be performed on all crane and hoist SFP components and SFP welds including those located on support structures. **NOTE:** SFP welds that cannot be inspected after the crane proof load test shall be identified and a risk assessment submitted to Range Safety for review and approval.

3. Volumetric and surface NDE testing shall be performed on 4 in. or 10 percent, whichever is less, of every continuous non-SFP weld on support structures for overhead cranes and hoists in accordance with AWS D14.1, paragraphs 8.9.5, 8.10, and 8.11.

4. After completion of the 125 percent proof load test, surface NDE testing shall be performed on the exposed portions of hooks.

g. Crane and Hoist Inspection Requirements. Cranes and hoists shall be visually inspected per ANSI and Range Safety inspection criteria.

3.6.2.2.14 Cranes and Hoists Used to Handle Critical Hardware Periodic Test Requirements.

a. General Periodic Test Requirements.

1. Periodic test plans and test results for cranes and hoists shall be submitted to Range Safety for review and approval as part of the MSPSP.

2. At a minimum, the following tests shall be performed on cranes and hoists annually. These tests shall be accomplished within the calendar month in which they are due.

b. Overhead Crane and Hoist Annual No-Load Functional Test. A complete functional test of all control systems, safety devices, and warning indicators shall be performed after the annual load test.

c. Overhead Crane and Hoist Annual 100 Percent Rated Load Tests. Overhead cranes and hoists shall be load tested to 100 percent of the rated load. The test shall be performed in the following sequence:

1. The test weight shall be hoisted approximately 2 ft and suspended for a minimum of 3 min to verify hoist drum rotation and test weight drift, as measured, are within acceptable limits.

2. The hoist overload detection devices shall be tested to verify that they activate when the test weight is greater than 110 percent of rated load.

3. Electrical power shall be removed from the crane so that the holding and emergency drum brakes are engaged. The brakes shall be manually released in such a manner that each individual brake demonstrates its ability to hold the entire test weight within acceptable drift. Electrical power shall be reapplied.

4. The test weight shall be raised to the maximum height and then lowered in three increments, stopping each time to verify there is no uncommanded drum rotation or test weight lowering.

5. The test weight shall be transported by the trolley for the full length of the bridge.

6. The test weight shall be transported the full length of the runway in one direction with the trolley as close to the extreme right hand of the bridge as practical and in the other direction with the trolley as close to the extreme left hand of the bridge as practical.

7. The test weight shall be moved throughout the complete operating envelope of the overhead crane and hoist, stopping and starting at various locations to verify smooth operation.

8. Crane controls shall be tested to verify that the use of reversing or plugging can control or stop the hoist, trolley, and bridge motion.

9. Bridge and trolley brakes shall be tested to verify that they function in accordance with CMAA 70 and 74 and ANSI B30 Series requirements.

10. The hoist emergency load lowering system shall be tested to verify that it is fail-safe and functions properly. The load shall not be lowered more than a few feet. The brakes shall be inspected and adjusted afterwards.

11. Bridge, trolley, and hoists shall be tested at each available specified speed, including bumping and jogging.

12. A load slippage detection system test shall be performed to demonstrate that the measured load drop is within acceptable limits. For cranes equipped with non-fail safe electrical microdrive clutches, this test shall be performed by simulating a mechanical and electrical clutch failure.

d. Crane and Hoist Annual NDE Requirements. The following NDE tests shall be performed as indicated:

1. After completion of the 100 percent load test, surface NDE testing shall be performed on the exposed portions of hooks.

2. After completion of the 100 percent load test, volumetric and surface NDE testing shall be performed on all modified and repaired SFP components and SFP welds located on overhead crane and hoist support structures.

3. NDE shall be performed in accordance with the Range Safety approved NDE plan on all SFP components and SFP welds located on overhead and hoist support structures.

e. Crane and Hoist Annual Inspection Requirements. Cranes and hoists shall be visually inspected per ANSI and Range Safety inspection criteria.

3.6.2.2.15 Cranes and Hoists Used to Handle Critical Hardware Initial Data Requirements. At a minimum, the following data is required as part of the Crane and Hoist Design and Initial Test Data File:

- a. SFP Analysis
- b. O&SHA
- c. FMECA
- d. NDE plans and test results for crane hooks

and SFP components and SFP welds on overhead crane and hoist support structures and 10 percent of non-SFP welds on overhead crane and hoist support structures

- e. Software test plans and results if applicable
- f. Initial crane and hoist test plans and test results
- g. Stress analysis for crane and hoist support structures
- h. Crane specifications
- i. Certificate of conformance to specifications
- j. Computer-aided design (CAD) output data, if available

3.6.2.2.16 Cranes and Hoists Used to Handle Critical Hardware Recurring Data Requirements. At a minimum, the following recurring data is required as part of the Crane and Hoist Recurring Test Data File:

- a. Crane and hoist design and initial test data
- b. NDE test results for crane hook and SFP components and SFP welds on crane support structures
- c. Periodic crane and hoist test plans and tests results
- d. Crane design and test data updates

3.6.2.3 Sling Assemblies Used to Handle Critical Hardware

3.6.2.3.1 Sling Assemblies Used to Handle Critical Hardware Design Standards. All slings shall be designed and fabricated in accordance with ANSI B30.9 and 29 CFR 1910.184.

3.6.2.3.2 Sling Assemblies Used to Handle Critical Hardware Design Requirements.

- a. All slings shall be designed with an ultimate factor of safety of 5 or higher.
- b. All synthetic slings shall be designed with an ultimate factor of safety of 10 or higher.
- c. Natural fiber rope or natural fiber web slings shall not be used.
- d. Carbon steel or wrought iron chain slings shall not be used.
- e. Wire rope slings shall be formed with swaged or zinc poured sockets or spliced eyes.
- f. Wire rope clips or knots may not be used to form slings.
- g. Rotation resistant rope shall not be used for fabricating slings.

3.6.2.3.3 Sling Assemblies Used to Handle Critical Hardware Marking. Sling assemblies used to handle critical hardware shall be marked in ac-

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cordance with the **MHE Used to Handle Critical Hardware Identification** section of this Chapter.

3.6.2.3.4 Sling Assemblies Used to Handle Critical Hardware Initial Test Requirements. At a minimum, the following tests shall be performed on sling assemblies prior to first operational use at the Ranges:

a. The proof load for single-leg slings and endless slings shall be two times the vertical orientation rated capacity.

b. The proof load for multiple leg bridle slings shall be applied to the individual legs and shall be two times the vertical orientation rated capacity of a single-leg sling of the same size, grade, and construction of rope.

c. Chain falls shall be proof load tested to 125 percent of rated load in accordance with ANSI/ASME B30.16.

d. After the proof load test, volumetric and surface NDE testing shall be performed on all sling assembly SFP components such as pins, bolts, shackles, and links.

e. Sling assemblies shall be visually inspected in accordance with ANSI and Range Safety inspection criteria.

3.6.2.3.5 Sling Assemblies Used To Handle Critical Hardware Periodic Tests. At a minimum, the following tests shall be performed on sling assemblies annually. Unless otherwise agreed to by Range Safety, these tests shall also be performed after a sling assembly has been modified or repaired:

a. Sling assemblies shall be proof load tested to 200 percent of rated load.

b. Chain falls shall be proof load tested to 100 percent of rated load.

c. After the proof load test, NDE testing shall be performed on all sling assembly SFP components in accordance with the Range Safety approved NDE plan.

d. After the proof load test, volumetric and surface NDE testing shall be performed on all modified and repaired sling assembly SFP components.

e. Sling assemblies shall be visually inspected in accordance with ANSI and Range Safety inspection criteria.

3.6.2.3.6 Sling Assemblies Used to Handle Critical Hardware Initial Data Requirements. At a minimum, the following data is required as part of the Sling Design and Initial Test Data:

a. SFP analysis

b. NDE plan and test results for SFP components

c. Initial proof load test plan and test results

d. Stress analysis

3.6.2.3.7 Sling Assemblies Used to Handle Critical Hardware Recurring Data Requirements. At a minimum, the following data is required as part of the Sling Assembly Recurring Test Data File:

a. Sling assembly design and initial test data

b. NDE test results for SFP components

c. Periodic proof load test plan and test results

d. Sling design and test data updates

3.6.2.4 Hydrasets and Load Cells Used to Handle Critical Hardware

3.6.2.4.1 Hydrasets and Load Cells Used to Handle Critical Hardware Design Requirements.

a. All hydrasets and load cells shall be designed with an ultimate factor of safety of 5.

b. If pneumatically controlled hydrasets are used, the following items are required:

1. Installation of a fail-safe check valve in the hydraset control line to prevent a drop of the load due to loss of pneumatic control pressure

2. Installation of a fast acting safety shutoff valve downstream of the load regulator to provide positive control of the hydraset when no motion is desired

c. Hydrasets shall be designed to mechanically support the rated load if the hydraset hydraulics fail.

d. Load cells shall be designed to support the rated load if the load measuring device fails.

e. Hydrasets and load cells shall not be used to lift loads in excess of 50 percent rated load if the device can not be proof load tested to 200 percent of rated load. **NOTE:** If the hydraset or load cell is derated, the identification tag shall be marked with the derated load.

f. For cranes and hoists with load cells designed into the load path, location of the load cell shall be approved by Range Safety.

3.6.2.4.2 Hydrasets and Load Cells Used to Handle Critical Hardware Initial Test Requirements. At a minimum, the following tests shall be performed on all hydrasets and load cells prior to first operational use at the Ranges:

a. Hydrasets and load cells shall be proof load tested to 200 percent of rated load.

b. After the proof load test, volumetric and surface NDE testing shall be performed on all SFP components and SFP welds.

3.6.2.4.3 Hydrasets and Load Cells Used to Handle Critical Hardware Periodic Test Requirements. At a minimum, the following tests shall be performed on all hydrasets and load cells annually. Unless otherwise agreed to by Range Safety, these tests shall also be performed after a hydraset and load cell has been modified or repaired:

a. Hydrasets and load cells shall be proof load tested to 125 percent of rated load and calibrated.

b. After the proof load test, volumetric and surface NDE testing shall be performed on all modified and repaired SFP components and SFP welds.

c. After the proof load test, NDE shall be performed on all hydraset and load cell SFP components and SFP welds in accordance with the Range Safety approved NDE plan.

d. If volumetric and surface NDE of critical lifting device components is not feasible, an alternate program of inspection and evaluation shall be identified in the Range Safety approved NDE plan.

3.6.2.4.4 Hydrasets and Load Cells Used to Handle Critical Hardware Initial Data Requirements. At a minimum, the following data is required as part of the Hydraset and Load Cell Design and Initial Test Data:

a. SFP analysis

b. NDE plan and test results for SFP components and SFP welds

c. Initial proof load test plan and test results

d. Stress analysis

3.6.2.4.5 Hydrasets and Load Cells Used to Handle Critical Hardware Recurring Data Requirements. At a minimum, the following data is required as part of the Hydraset and Load Cell Recurring Test Data File:

a. Hydraset and load cell design and initial test data

b. NDE test results for SFP components and SFP welds

c. Periodic proof load test plan and test results

d. Design and test data updates

3.6.2.5 Handling Structures Used to Handle Critical Hardware

3.6.2.5.1 Handling Structures Used to Handle Critical Hardware Design Standards.

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a. Structural mechanisms such as spin tables, rotating devices, and portable launch platforms shall be subjected to a hazard analysis in accordance with a Range User and Range Safety jointly tailored System Safety Program Plan (see Appendix 1B.)

b. All structural lifting beams shall meet ANSI B30.20.

3.6.2.5.2 Handling Structures Used to Handle Critical Hardware Design Requirements.

a. All handling structures, except portable launch support frames, shall be designed with a yield factor of safety of 3.

b. Material used in the construction of handling structures shall have a yield strength less than or equal to 85 percent of ultimate strength. **NOTE:** If this criteria cannot be met, the structure shall be designed with an ultimate factor of safety of 5.

c. Portable and movable launch support frames may be designed with a yield factor of safety of 2 if weight is a consideration; however, NDE requirements may increase.

3.6.2.5.3 Handling Structures Used to Handle Critical Hardware Marking Requirements. Handling structures used to handle critical hardware shall be marked in accordance with the **MHE Used to Handle Critical Hardware Identification** section of this Chapter.

3.6.2.5.4 Handling Structures Used to Handle Critical Hardware Initial and Periodic Test Requirements.

a. Handling structures shall be tested in accordance with either Option 1 or Option 2 of Appendix 3B or an alternate method approved by Range Safety based on such criteria as the type of material, weld characteristics, factors of safety, lack of single failure points, and storage conditions. *EXCEPTION: For portable launch support frames with a yield factor of safety of less than 3, Step 17 in Option 2 is changed to read "Proof test to 150 percent times rated load" and Step 16 is eliminated.*

b. Initial tests shall be performed following modification and repair or prior to first operational use at the Ranges.

3.6.2.5.5 Handling Structures Used to Handle Critical Hardware Initial Data Requirements. At a minimum, the following data is required as part of the Handling Structure Design and Initial Test Data:

a. SFP analysis

b. NDE plan and test results for SFP and non-

SFP components and welds.

c. Initial proof load test plan and test results

- d. Stress analysis for structures
- e. Safe-life analysis if Option 2 of Appendix B is chosen

f. O&SHA and FMECA analyses for structural mechanisms such as spin tables, rotating structures, and portable launch support frames

3.6.2.5.6 Handling Structures Used to Handle Critical Hardware Recurring Data Requirements. At a minimum, the following recurring data is required as part of the Handling Structure Recurring Test Data File:

- a. Handling structure design and initial test data
- b. NDE test results for SFP components and SFP welds
- c. Periodic test plans and test results
- d. Design and test data updates

3.6.2.6 Flight Hardware Used to Lift Critical Loads

3.6.2.6.1 Flight Hardware Used to Lift Critical Loads Design Requirements. Lift fittings such as lugs and plates permanently attached to flight hardware shall be designed so that the loss of one fitting and/or structure will not result in the dropping of the load. **NOTE:** If this requirement can not be met, the minimum ultimate factor of safety shall be 1.5.

3.6.2.6.2 Flight Hardware Used to Lift Critical Loads Initial Test Requirements. At a minimum, the following tests shall be performed on permanently attached flight hardware lift fittings prior to their first operational use at the Ranges:

- a. Lift fittings shall be load tested to 100 percent of rated load as an integral part of structural flight load testing.
- b. After the load test, volumetric and surface NDE testing shall be performed on all lift fitting SFP components and SFP welds.

3.6.2.6.3 Flight Hardware Used to Lift Critical Loads Initial Data Requirements. At a minimum, the following data is required as part of the Flight Hardware Lifting Equipment Design and Initial Test Data:

- a. SFP analysis
- b. NDE plan and test results for SFP components and SFP welds
- c. Initial proof load test plan and test results
- d. Stress analysis

3.6.2.7 Removable, Extendible, and Hinged Personnel Work Platforms

3.6.2.7.1 Removable, Extendible, and Hinged Personnel Work Platform Design Requirements.

a. Safety factors for the design of platforms shall be consistent with those of the overall structures on which they are permanently mounted. In no case shall the safety factors be less than that of the overall structure, the applicable national consensus standard American Institute of Steel Construction (AISC), Aluminum Association, or yield factor of safety of 2, whichever is greater.

b. Hinges, attaching points, and other high stress or abuse prone components and their interface hardware shall be designed with a yield factor of safety of at least 3. Yield strength shall be less than or equal to 85 percent of ultimate strength or the ultimate factor of safety shall be 5.

c. A minimum of 60 lb per ft² shall be used for the uniformly distributed live load.

d. A minimum of 2000 lb shall be used for point loading.

e. A minimum load of 300 lb per occupant shall be used.

f. Guardrail systems and toe boards shall be provided and designed in accordance with OSHA 1910.23.

g. Man-rated baskets used with cranes shall be certified and load test in accordance with OSHA 1926.550.

h. Personnel platforms shall have a means of positive mechanical restraint when in the open, raised, folded back, or use position to prevent unintentional movement. **NOTE:** Bolting is not acceptable; latches, levers, or pins with lanyards shall be used.

3.6.2.7.2 Removable, Extendible, and Hinged Personnel Work Platforms Marking Requirements.

a. All platforms shall be clearly marked with 2-in. letters minimum indicating maximum load capacity.

b. In addition, the following information shall be imprinted on a metal tag attached to the platform:

- 1. Maximum distributed load
- 2. Maximum concentrated load (point load)
- c. A load test tag accessible for inspection shall be provided on the platform.

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3.6.2.7.3 Removable, Extendible, and Hinged Personnel Work Platform Initial Test Requirements. At a minimum, the following tests shall be performed on all personnel work platforms prior to their first operational use at the Ranges:

a. Platforms shall be proof load tested to 125 percent of rated load.

b. After the proof load test, volumetric and surface NDE testing shall be performed on all personnel work platform SFP components and SFP welds.

3.6.2.7.4 Removable, Extendible, and Hinged Personnel Work Platform Periodic Test Requirements. At a minimum, the following tests shall be performed on all personnel work platforms annually:

a. Visual inspection shall be performed on all hinges, attaching points, and other high stress or abuse prone components.

b. NDE shall be performed on all personnel work platform SFP components and SFP welds in accordance with the Range Safety approved NDE plan.

c. After the proof load test, volumetric NDE testing shall be performed on all modified and repaired SFP components and SFP welds.

d. Unless otherwise agreed to by Range Safety, personnel work platforms that have been modified and/or repaired shall be proof load tested to 125 percent of rated load.

3.6.2.7.5 Removable, Extendible, and Hinged Personnel Work Platform Initial Data Requirements. At a minimum, the following data is required as part of the Personnel Work Platform Design and Initial Test Data:

a. SFP analysis

b. NDE plan and test results for SFP and non-SFP components and welds

c. Initial proof load test plan and test results

d. Stress analysis

3.6.2.7.6 Removable, Extendible, and Hinged Personnel Work Platform Recurring Data Requirements. At a minimum, the following recurring data is required as part of the Personnel Work Platform Recurring Test Data:

a. Platform design and initial test data

b. NDE test results for SFP components and SFP welds

c. Periodic proof test plans and results

d. Design and test data updates

3.6.3 MHE Used to Handle Non-Critical Hardware

3.6.3.1 Material Handling Equipment Used to Handle Non-Critical Hardware General Requirements

3.6.3.1.1 MHE Used to Handle Non-Critical Hardware Identification.

a. Marking Requirements. All MHE shall be permanently marked with the following information:

1. Serial number

2. Part number

3. Rated load

b. Tagging Requirements

1. Following the rated load test, a durable tag shall be securely attached to the MHE and shall be accessible for inspection.

2. The load test tags shall be marked (stamped or etched) with the following minimum information:

(a) Part Number, Serial Number, or other unique identifier

(b) Date of most recent load test

(c) Weight of test load

(d) Date of next load test

(e) Date of most recent NDE

(f) Date of next NDE

c. In addition, certification that all components have been proof load tested as an assembly shall be provided. **NOTE:** If the assembly is to be disassembled after proof testing, each component and subassembly shall be individually tagged.

3.6.3.1.2 MHE Used to Handle Non-Critical Hardware Load Test Devices.

a. Load tests shall be conducted with certified weights. **NOTE:** Calibrated load devices such as dynamometers may be used to test slings and other lifting devices except cranes.

b. These weights shall be accurately identified and tagged with total weight (lb) and owner or agency identification number.

c. Reinforcing steel (rebar) shall not be used for lift points.

d. The test weight shall be applied for a minimum of 3 min.

3.6.3.1.3 MHE Used to Handle Non-Critical Hardware Data Requirements. Specific data re-

quirements for each type of MHE are identified throughout this section. These requirements fall into two categories: initial data requirements and recurring data requirements. The definition and processing requirements for initial and recurring data are described below:

a. Initial Data Requirements

1. All MHE shall have data that shows that the equipment meets the applicable design and initial test requirements.

2. These data requirements are identified in the **Initial Data Requirements** section for each type of MHE.

3. These data shall be consolidated into an MHE Design and Initial Test Data Package and maintained by the Range User.

4. The MHE Design and Initial Test Data Package shall be updated as required to reflect changes in design and tests.

5. The MHE Design and Initial Test Data Package shall be submitted to Range Safety for review and approval prior to the first operational use of the equipment at the Ranges.

b. Recurring Data Requirements

1. All MHE shall have data that shows that the equipment meets the applicable periodic testing requirements.

2. These data requirements are identified in the **Recurring Data Requirements** section for each type of MHE.

3. The periodic test plans shall be included in the MHE Design and Initial Test Data Package. In addition, the periodic test plans and test results and the MHE Design and Initial Test Data Package shall be maintained by the Range User in the MHE Recurring Test Data File.

4. MHE Recurring Test Data Files shall be made available to Range Safety upon request.

3.6.3.2 Cranes and Hoists Used to Handle Non-Critical Hardware

3.6.3.2.1 Cranes and Hoists Used to Handle Non-Critical Hardware Design Standards. All cranes and hoists shall comply with the following industry standards:

- a. 29 CFR 1910
- b. CMAA 70 and 74 for overhead cranes and hoists
- c. ANSI B30 series for all cranes and hoists
- d. NEC for all electrically powered cranes and hoists
- e. *Material Handling Institute Standards*, as

applicable.

3.6.3.2.2 Additional WR Design Standards for Cranes and Hoists Used to Handle Non-Critical Hardware.

a. All crane specifications, test plans, and test results shall be reviewed and approved by the BRCC.

b. At VAFB, cranes not on VAFB Exclusive Federal Jurisdiction property also require inspections, testing, and certification in accordance with CAL-OSHA requirements. **NOTE:** These requirements can be found in Title 8 of the *Administrative Code* and Chapter 4, *General Industry Safety Orders* of CAL-OSHA and the *BRCC Design Requirements Handbook for Electrically Powered Top Running Overhead and Underhung Traveling Cranes*.

3.6.3.2.3 Cranes and Hoists Used to Handle Non-Critical Hardware Selection Criteria. The service classifications found in CMAA 70 and 74, Chapter 2 shall be used as the basis for selecting cranes and hoists to be used on the Ranges.

3.6.3.2.4 Cranes and Hoists Component Accessibility.

a. Safe and adequate access to components to inspect, service, repair, or replace equipment shall be provided for during design. Consideration shall be given to the use of fixed platforms with guard rails in lieu of the extensive use of personnel tie-offs.

b. The design shall provide for visual and physical accessibility of all SFP components and SFP welds safety critical parts.

3.6.3.2.5 Use of Rotation Resistant Wire Rope.

a. Rotation resistant wire rope shall not be used without specific permission from Range Safety.

b. Rotation resistant ropes shall not be used for any purposes with swivel links installed.

3.6.3.2.6. Use of Cast Iron. Cast iron and other similar brittle materials shall not be used in load bearing parts.

3.6.3.2.7 Hooks.

a. All hooks shall be equipped with a positive latching mechanism to prevent accidental load disengagement.

b. The initial throat opening of a hook shall be measured and permanent reference marks placed on each side of the hook. The distance between the marks shall be measured and recorded during peri-

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odic inspections for determination of the hook throat opening.

c. Attachments such as handles and latch supports shall not be welded to a finished hook in a field application. **NOTE:** If welding of an attachment such as these is required, it shall be done in manufacturing or fabrication prior to any required final heat treatment.

3.6.3.2.8 Overhead Cranes and Hoists Used to Handle Non-Critical Hardware Design Requirements.

a. Reeving

1. For double reeved overhead cranes, equalizer sheaves shall be self-aligning with the load line.

2. Load lines shall be attached to the crane by a rope termination method that develops 100 percent of the rope strength.

b. Overhead Crane and Hoist Controls

1. Movement controls shall be of the “dead man” type.

2. Cranes shall be provided with push button or lever type control switches.

3. Movement controls shall have an inching (jog) capability only when the SPEED selector switch is in the slowest speed position.

4. Pendant control stations shall be suspended by a strain relief chain or cable to protect the electrical conductors from strain.

5. The control station shall be located so that the crane operator has direct line of sight to the load at all times.

c. Overhead Crane and Hoist Limit Switches. All overhead cranes and hoists shall be equipped with 2 limit switches in the UP direction to prevent “two blocking” and 1 limit switch in the DOWN direction to prevent a slack rope condition.

1. The first UP limit switch shall interrupt the movement control circuit and shall be reset by reversing the movement control.

2. The second UP limit switch shall be a mechanical fail-safe switch that will interrupt power to the hoist mechanism and require maintenance personnel to reset.

d. Overhead Crane Bridge and Trolley Brakes. All overhead crane bridge and trolleys shall be equipped with fail-safe brakes in both directions. For specific requirements, see CMAA 70 and 74 and the ANSI B30 series.

e. Overhead Crane and Hoist Grounding and Bonding

1. All cranes and hoists shall be grounded and bonded to provide critical hardware and personnel protection against electrical failures or lightning strikes.

2. Grounding and bonding between trolley, bridge, and runway shall use separate bonding conductors that may be run with electrical circuit conductors.

3. The contact between the wheels and frame shall not be considered a low resistance path to ground.

f. Overhead Crane Bridge and Trolley Movement Marking

1. Each overhead crane shall have the directions of its bridge and trolley movements displayed on the underside of the crane. These directions (North, East, South, and West) shall correspond to the directions on the operator station.

2. These markings shall be visible from the floor and any operator station.

3.6.3.2.9 Cranes and Hoists Used to Handle Non-Critical Hardware Initial Test Requirements.

a. General Initial Shop and Field Test Requirements

1. Initial test plans and test results for cranes and hoists shall be submitted to Range Safety for review and approval as part of the Crane and Hoist Design and Initial Test Data Package in the MSPSP.

2. Any test anomaly discovered shall be evaluated by Range Safety as a cause for rejection.

3. Inspections and tests shall be performed by appointed or authorized persons. At the WR, these persons shall identify the federal or state office issuing certification authority and the expiration date of the certification authority.

4. At a minimum, the following tests shall be performed on cranes and hoists prior to their first operational use at the Ranges. **NOTE:** Unless otherwise agreed to by Range Safety, all or part of these tests shall also be performed after a crane and hoist has been modified or repaired.

b. Testing Hooks Prior to Assembly on the Crane. The following tests shall be performed on the hook prior to assembly on the crane:

1. A proof load test shall be performed in accordance with ANSI B30.10.

2. After the proof load test, a surface NDE shall be performed on the hook and its shank, bolt, and nut.

c. Portal Crane Proof Load Test. Portal cranes

shall be proof load tested to 125 percent of the rated load.

d. Mobile Crane Proof Load Test. Mobile cranes shall be proof load tested to 110 percent of the rated load.

e. Overhead Crane and Hoist Initial Functional Test (No-Load). A complete functional test of all control systems, safety devices, and warning indicators shall be performed after the crane is assembled at the Ranges and after load testing.

f. Overhead Crane and Hoist Load Tests. The following tests shall be performed by the manufacturer or a designated representative on site at the Ranges after complete installation of the crane:

1. Overhead cranes and hoists shall be proof load tested to 125 percent of the rated load. The test shall be performed in the following sequence:

(a) The test weight shall be hoisted approximately 2 ft and suspended for a minimum of 3 min to verify hoist drum rotation and test weight drift are within acceptable limits.

(b) The test weight shall be raised to the maximum height and then lowered in three increments, stopping each time to verify there is no uncommanded drum rotation or test weight lowering.

(c) The test weight shall be transported by the trolley for the full length of the bridge.

(d) The test weight shall be transported the full length of the runway in one direction with the trolley as close to the extreme right hand of the bridge as practical and in the other direction with the trolley as close to the extreme left hand of the bridge as practical.

2. Overhead cranes and hoists shall be subjected to the following tests at 100 percent of rated load. The test shall be performed in the following sequence:

(a) The test weight shall be hoisted approximately 2 ft and suspended for a minimum of 3 min to verify hoist drum rotation and test weight drift are within acceptable limits.

(b) The test weight shall be moved throughout the complete operating envelope of the overhead crane and hoist, stopping and starting at various locations to verify smooth operation.

(c) Bridge and trolley brakes shall be tested to verify that they function in accordance with CMAA 70 and 74 and ANSI B30 Series requirements.

(d) The test weight shall be raised to sufficient height and at least one emergency stop shall be made at the fastest lowering speed to verify that

brake application is positive and effective.

(e) Bridge, trolley, and hoists shall be tested at each specified speed, including bumping and jogging.

g. Crane and Hoist NDE Requirements. After completion of the 125 percent proof load test, surface NDE shall be performed on the exposed portions of overhead, portal, and mobile crane hooks.

h. Crane and Hoist Inspection Requirements. Cranes and hoists shall be visually inspected in accordance with ANSI and Range Safety inspection criteria.

3.6.3.2.10 Cranes and Hoists Used to Handle Non-Critical Hardware Periodic Test Requirements.

a. General Periodic Test Requirements

1. Periodic test plans for cranes and hoists shall be submitted to Range Safety for review and approval as part of the MSPSP.

2. At a minimum, the following tests shall be performed on cranes and hoists every four years unless as otherwise approved by Range Safety.

b. Overhead Crane and Hoist Functional Test (No-Load). A complete functional test of all control systems, safety devices, and warning indicators shall be performed after load testing.

c. Portal and Mobile Crane Load Tests. Portal and mobile cranes shall be load tested to 100 percent of rated load.

d. Overhead Crane and Hoist 100 Percent Rated Load Tests. Overhead cranes and hoists shall be load tested to 100 percent of the rated load. The test shall be performed in the following sequence:

1. The test weight shall be hoisted approximately 2 ft and suspended for a minimum of 3 min to verify hoist drum rotation and test weight drift are within acceptable limits.

2. The test weight shall be raised to the maximum height and then lowered in three increments, stopping each time to verify there is no uncommanded drum rotation or test weight lowering.

3. The test weight shall be transported the full length of the runway in one direction with the trolley as close to the extreme right hand of the bridge as practical and in the other direction with the trolley as close to the extreme left hand of the bridge as practical.

4. The test weight shall be raised to sufficient height and at least one emergency stop shall be made at the fastest lowering speed to verify that brake application is positive and effective.

REFERENCED DOCUMENTS

5. The test weight shall be moved throughout the complete operating envelope of the overhead crane and hoist, stopping and starting at various locations to verify smooth operation.

6. Bridge and trolley brakes shall be tested to verify that they function in accordance with CMAA 70 and 74 and ANSI B30 Series requirements.

7. Bridge, trolley, and hoists shall be tested at each specified speed, including bumping and jogging.

e. Crane and Hoist NDE Requirements. After completion of the proof load test, surface NDE shall be performed on the exposed portions of overhead, portal, and mobile crane hooks.

f. Crane and Hoist Inspection Requirements. Cranes and hoists shall be visually inspected at required intervals in accordance with ANSI and 30/45 SW inspection criteria.

3.6.3.2.11 Cranes and Hoists Used to Handle Non-Critical Hardware Initial Data Requirements. At a minimum, the following data is required as part of the Crane and Hoist Design and Initial Test Data Package:

- a.* NDE plan and test results for crane hooks
- b.* Initial crane and hoist test plans and test results
- c.* Crane specifications
- d.* Certification of conformance to specifications

3.6.3.2.12 Cranes and Hoists Used to Handle Non-Critical Hardware Recurring Data Requirements. At a minimum, the following recurring data is required as part of the Crane and Hoist Recurring Test Data File:

- a.* Crane and hoist design and initial test data
- b.* NDE test results for crane hooks
- c.* Periodic crane and hoist test plans and test results
- d.* Crane and Hoist Design and test data updates

3.6.3.3 Sling Assemblies Used to Handle Non-Critical Hardware

3.6.3.3.1 Sling Assemblies Used to Handle Non-Critical Hardware Design Standards. All slings shall be designed and fabricated in accordance with ANSI B30.9 and 29 CFR 1910.184.

3.6.3.3.2 Sling Assemblies Used to Handle Non-Critical Hardware Design Requirements.

- a.* All slings shall be designed with an ultimate

factor of safety of 5 or higher.

b. Carbon steel or wrought iron chain slings shall not be used.

c. Wire rope slings shall be formed with swaged or zinc poured sockets or spliced eyes.

d. Wire rope clips or knots may not be used to form slings.

e. Rotation resistant rope shall not be used for fabricating slings.

3.6.3.3.3 Sling Assemblies Used to Handle Non-Critical Hardware Marking Requirements. Sling assemblies used to handle non-critical hardware shall be marked in accordance with the **MHE Used to Handle Non-Critical Hardware Identification** section of this Chapter.

3.6.3.3.4 Sling Assemblies Used to Handle Non-Critical Hardware Initial Test Requirements. At a minimum, the following tests shall be performed on sling assemblies prior to their first operational use at the Ranges:

- a.* The proof load for single leg slings and endless slings shall be two times the vertical orientation rated capacity.
- b.* The proof load for multiple leg bridle slings will be applied to the individual legs and shall be two times the vertical orientation rated capacity of a single leg sling of the same size, grade, and construction of rope.
- c.* Chain falls shall be proof load tested to 125 percent of rated load (per ANSI B30.16).
- d.* Sling assemblies shall be visually inspected in accordance with ANSI inspection criteria.

3.6.3.3.5 Sling Assemblies Used To Handle Non-Critical Hardware Periodic Test Requirements. At a minimum, the following tests shall be performed on sling assemblies every four years. Unless otherwise agreed to by Range Safety, these tests shall also be performed after a sling assembly has been modified or repaired:

- a.* Sling assemblies shall be proof load tested to 200 percent of rated load.
- b.* Chain falls shall be proof load tested to 100 percent of rated load.
- c.* Sling assemblies shall be visually inspected in accordance with ANSI inspection criteria.

3.6.3.3.6 Sling Assemblies Used to Handle Non-Critical Hardware Initial Data Requirements. At a minimum, the initial proof load test plan and results shall be maintained in the Sling Assembly Design and Initial Test Data Package.

3.6.3.3.7 Sling Assemblies Used to Handle Non-Critical Hardware Recurring Data Requirements. At a minimum, periodic proof load test and inspection results are required as part of the Sling Recurring Test Data File.

3.6.3.4 Handling Structures Used to Handle Non-Critical Hardware

3.6.3.4.1 Handling Structures Used to Handle Non-Critical Hardware Design Requirements.

a. All structural lifting beams shall meet the requirements of ANSI B30.20.

b. All handling structures shall be designed with a yield factor of safety of 3.

3.6.3.4.2 Handling Structures Used to Handle Non-Critical Hardware Marking Requirements. Handling structures used to handle critical hardware shall be marked in accordance with the **MHE Used to Handle Non-Critical Hardware Identification** section of this Chapter.

3.6.3.4.3 Handling Structures Used to Handle Non-Critical Hardware Initial Test Requirements. At a minimum, handling structures shall be proof load tested to 200 percent of rated load prior to their first operational use at the Ranges.

3.6.3.4.4 Handling Structures Used to Handle Non-Critical Hardware Periodic Test Requirements. At a minimum, handling structures shall be proof load tested to 200 percent of rated load every four years. Unless otherwise agreed to by Range Safety, this test shall also be performed after handling structure modification and/or repair.

3.6.3.4.5 Handling Structures Used to Handle Non-Critical Hardware Initial Data Requirements. At a minimum, initial proof load test plan and test results are required as part of the Handling Structure Design and Initial Test Data Package.

3.6.3.4.6 Handling Structures Used to Handle Non-Critical Hardware Recurring Data Requirements. At a minimum, periodic proof load test results are required as part of the Handling Structure Recurring Test Data File.

3.7 ACOUSTIC HAZARDS

3.7.1 Acoustic Design Standards

a. Systems shall be designed to ensure that personnel are not exposed to hazardous noise levels in accordance with MIL-STD-1472 and AFOSH 48-19. In all cases, noise shall be reduced to the lowest practical levels.

b. Where total protection is not possible through the design process, a hearing conservation program incorporating hearing protection and/or access controls shall be used.

c. Workspace noise shall be reduced to levels that permit necessary direct person-to-person and telephone communication.

d. Bioenvironmental Engineering shall evaluate noise levels and determine the hazard potential

3.7.2 Acoustic Data Requirements

The following data requirements shall be submitted as part of the MSPSP: (See Appendix 3A for guidance.)

a. The location of all sources generating noise levels that may result in hazardous noise exposure for personnel and the sound level (in decibels on the "A" scale [dBA]) for that noise

b. The anticipated operating schedules of these noise sources

c. Methods of protection for personnel who may be exposed to sound pressure levels above 85 dBA (8-hr time weighted average)

d. A copy of the Bioenvironmental Engineering approval stating the equipment and controls used are satisfactory

3.8 NON-IONIZING RADIATION SOURCES

3.8.1 Radio Frequency Emitters

3.8.1.1 Radio Frequency Emitter Design Standards

a. Radio frequency (RF) emitters shall be designed to ensure that personnel are not exposed to hazard levels in excess of those specified AFOSH 161-9.

b. Where total protection is not possible through the design process, clearance areas and access controls shall be established.

c. The RPO shall determine design requirements, evaluate RF levels, and determine the hazard potential for personnel.

REFERENCED DOCUMENTS

3.8.1.2 Radio Frequency Emitter Design

3.8.1.2.1 Radio Frequency Emitter General Design Requirements.

a. RF emitters shall be designed and located to allow test and checkout without presenting a hazard to personnel, ordnance, or other electronic equipment.

b. Where necessary, interlocks, interrupts, or other safety devices shall be provided to protect operating personnel and exposed initiators during ground operations.

c. No ground based RF system shall be installed, erected, or relocated without site plan approval from Range Safety and the RPO. **NOTE:** This includes modifications to change transmitting characteristics.

d. Fail-safe systems shall be incorporated so that inadvertent operation of an RF emitting system is prevented.

3.8.1.2.2 Special Considerations for Electroexplosive Subsystem Exposure to RF Radiation

a. Electroexplosive subsystems shall not be exposed to RF radiation that is capable of firing the electroexplosive device (EED) by pin-to-pin bridgewire heating or pin-to-case arcing.

b. RF power at the EED shall not exceed 20 dB below the pin-to-pin direct current (DC) no-fire power of EED.

c. The siting of ground based RF emitters in proximity to electroexplosive subsystems shall be in accordance with Table 5-1, "Recommended EED Safe Separation Distances and Power Densities" in AFMAN 91-201 and DoD 6055.9-STD.

d. The effect of payload and launch vehicle system emitters on their own electroexplosive subsystem shall be evaluated by analysis or electromagnetic compatibility (EMC) testing.

3.8.1.3 RF Emitter Initial Test Requirements

a. All hazardous RF emitters shall have their RF hazard area verified by the RPO or a designated representative prior to the first operation and/or test.

b. Interlocks and other safety features shall be tested and verified by the Range User prior to coming to the Ranges.

1. Test plans shall be submitted to Range Safety for review and approval.

2. Test results shall be submitted to Range Safety.

3.8.1.4 RF Emitter Data Requirements

3.8.1.4.1 RF Site Plans. Site plans shall be submitted to Range Safety and the RPO for all ground based RF transmitters. The site plan shall include the following information:

- a.* Location of generating equipment
- b.* RF hazard areas
- c.* Description and use of nearby facilities and operating areas

3.8.1.4.2 RF Emitter Design and Test Data.

The following RF emitter design and test data requirements shall be submitted as part of the MSPSP: (See Appendix 3A for guidance.)

- a.* Emitter peak and average power
- b.* Pulse widths
- c.* Pulse repetition frequencies
- d.* Pulse codes
- e.* Maximum rated duty cycle
- f.* Type and size of antenna
- g.* Antenna gain and illumination
- h.* Beam width and beam skew
- i.* Operating frequency (MHz)
- j.* Insertion loss between transmitter and antenna
- k.* Polarization of transmitted wave
- l.* An analysis of the RF hazard area with and without antenna hats/dummy load and results of any testing
- m.* A table that lists all of the RF emitters aboard a launch vehicle, payload, and ground support equipment and their hazard areas (distances)
- n.* A description of interlocks, inhibits, and other safety features that prevent inadvertent exposures
- o.* A copy of the RPO approved Radiation Protection Program RF User Request Authorization
- p.* A copy of the Range Safety and RPO approved site plan for all ground based RF emitters

3.8.2 Laser Systems

3.8.2.1 Laser System Design Standards

a. Laser systems shall be designed to ensure that personnel are not exposed to hazardous laser emissions in accordance with the requirements of AFOSH 161-10 and 45 SW 40-201. Where total protection against exposure is not possible through the design process, clearance areas and access controls shall be established.

b. The RPO evaluates laser system design and operations and determines the hazard potential for personnel.

3.8.2.2 Laser System General Design Requirements

3.8.2.2.1 Radiation Hazards.

a. Interlocks, interrupts, or other safety devices shall be provided when necessary to protect personnel.

b. Fail-safe systems shall be incorporated so that inadvertent operation of the laser system is prevented.

c. Mechanical stops shall be provided to limit azimuth and elevation of tracking lasers.

d. Mechanical stops shall be used as backup for electrical inhibits to prevent laser radiation outside desired areas and to prevent mechanical damage to equipment.

e. Electrical inhibits shall be provided to inhibit laser radiation outside desired areas and to inhibit the azimuth and/or elevation drive motors before they reach the mechanical stops.

f. Emergency laser shutdown or shuttering capability shall be provided.

g. Emergency shutdown or shuttering shall be fail-safe or redundant.

3.8.2.2.2 Hazardous Materials. Hazardous materials used in laser systems shall meet the requirements of the **Hazardous Materials** section of this Chapter.

3.8.2.2.3 Cryogenic Systems Hazards. Cryogenic systems used in laser systems shall meet the requirements of the **Cryogenic Systems** sections of this Chapter.

3.8.2.2.4 Electrical Hazards. Electrical ground support equipment used for laser systems shall meet the requirements of the **Electrical and Electronic Equipment** section of this Chapter.

3.8.2.2.5 Mechanical Hazards.

a. Laser platforms shall comply with the requirements for mechanical ground support equipment used to handle critical hardware as described in the **Handling Structures Used to Handle Critical Hardware** section of this Chapter.

b. Moving mounts shall be stabilized to compensate for the motion of the vehicle.

c. Heating effects on unprotected laser platforms shall be considered when siting and setting elevation and azimuth stops.

3.8.2.3 Laser System Test Requirements

a. All hazardous laser systems and installations activated on the Ranges shall have their hazard area verified by the RPO or a designated representative prior to first operation and test.

b. Interlocks and other safety features shall be verified prior to coming to the Ranges.

c. Test Plans and test results shall be submitted to Range Safety for review and approval.

3.8.2.4 Laser System Data Requirements

The following laser system data requirements shall be submitted as part of the MSPSP: (See Appendix 3A for guidance.)

3.8.2.4.1 General Laser System Data Requirements.

a. A general description of the systems and its operation including how, where, why, and by whom the laser will be used. **NOTE:** The laser system also includes calibration equipment.

b. Drawings of the system that identify and show the location and operation of all components, interfaces, safety interlocks, and stops

c. For lasers that generate or use hazardous or corrosive materials, the data required for hazardous materials described in the **Hazardous Material Data Requirements** section of this Chapter

d. For lasers that use cryogenic fluids for cooling or operational enhancement, the data required for cryogenic systems and hazardous materials as described in the **Ground Support Pressure System Data Requirements** or the **Flight Hardware Pressure Systems Data Requirements** as applicable, and the **Hazardous Materials Data Requirements** sections of this Chapter

e. For laser systems using high voltages and/or high capacitance, the data required for electrical ground support equipment as described in the **Electrical and Electronics Equipment Data Requirements** section of this Chapter

3.8.2.4.2 Laser System Performance Data.

a. Type, class, nomenclature, manufacturer model number, general identification, and other pertinent information

REFERENCED DOCUMENTS

b. General description of the test, pertinent drawing of the operation site, and associated equipment

c. Lasing material

d. Continuous Wave (CW) or pulse identification

e. Wave length

f. Bandwidth

g. Average power/energy per pulse/maximum output energy

h. Pulse duration and pulse rate

i. Beam width at 1/e point for both axes

j. A sketch of the beam pattern and location and energy density of hot spots and effects of weather and reflectivity

k. Beam divergence at 1/e point for both axes

l. Emergent beam diameter

m. Coolant

n. Amount of energy reflected back through the eyepiece or pointing device

o. Electrical voltage applied to the system

p. Any other pertinent laser parameter such as distribution of energy on beam and scanrate as determined by the Range User or Range Safety

q. Composition, color, and specularly or diffusely reflected surface characteristics of intended targets

r. Maximum incident energy on targets

s. Target characteristics including secondary hazards that may be affected by the laser, including fuels and other flammables, sensitive electronic components, flight termination systems, and others

t. Intended method such as binoculars or spotter scope for viewing the beam and/or its reflections

u. Safety devices such as interlocks, filters, shutters, and aiming devices

v. Azimuth and/or electrical and mechanical elevation stops

3.8.2.4.3 Hazard Evaluation Data. Analysis and supporting data outlining possible laser system failures for all phases of laser system uses shall be submitted. Such data includes the following:

a. All critical failure modes, failure mode effects, and failure probabilities including possible effects on secondary hazards. The results shall be included as part of a FMECA in accordance with MIL-STD-1543 and MIL-STD-1629.

b. Routine occupational hazard exposure that has been experienced in the past with the system or similar systems along with recommended meth-

ods for reducing or eliminating the hazards shall be included in an O&SHA in accordance with a jointly tailored System Safety Program (See Appendix 1B of this document).

3.8.2.4.4 Biophysiological Data.

a. Safe eye and skin distances based on permissible exposure limits

b. Safety clearance and hazard zones

c. Personal protective equipment (PPE) required for personnel remaining inside clearance zones

d. A copy of the RPO approved Radiation Protection Plan Laser Use Request Authorization

3.8.2.4.5 Test Plans and Test Results. Test plans and test results shall be submitted to Range Safety for review and approval.

3.9 RADIOACTIVE (IONIZING RADIATION) SOURCES

3.9.1 Radioactive Source Design Standards and Controls

3.9.1.1 Radioactive Sources Design Standards

a. Radioactive sources shall be designed to minimize the possibility of release of radioactive contamination.

b. Radioactive sources shall incorporate shielding in the design to ensure minimum exposure to personnel. Where total protection from radiation exposure by use of shielding is not feasible, access controls shall be employed.

c. Radioactive systems shall conform to the requirements specified in 10 CFR and 49 CFR

3.9.1.2 Additional ER Design Controls

Additional ER controls include compliance with 45 SWI 40-201 and approval by the RPO.

3.9.1.3 Additional WR Design Controls

Additional WR controls include the following:

a. Written approval from the 30 SW Radiation Safety Committee (RADSAFCOM) for processing and launch of radioactive sources. **NOTE:** 30 SW/SE is a voting member of the RADSAFCOM.

b. Range Users shall brief the RADSAFCOM on the hazards and procedures concerning the handling of radioactive sources and other information as required by AFI 91-110 30 SW1.

c. Range Users shall submit an approved environmental impact statement to the RADSAFCOM.

d. Radioactive sources shall be handled under the

supervision of a designated Range User or the RPO named on the Nuclear Regulatory Commission (NRC) license, state license, or USAF permit. **NOTE:** Licensing and permitting requirements and procedures are specified in AFI 40-201 and AFI 91-110 30 SW1, and 30 SWI 40-201.

e. The final Safety Analysis Summary (SAS) and AFI 91-110 30 SW1 Radiation Protection Plan shall be submitted 120 days prior to source arrival on Vandenberg Air Force Base (VAFB).

f. Application for USAF permits shall be submitted to the RPO and shall include a copy of the NRC license.

g. The NRC license holder or Range User shall submit three copies of the NRC license with the USAF permit to Range Safety at least 30 calendar days prior to planned entry to the WR.

3.9.2 Radioactive Sources General Design

a. Radioactive sources shall be designed to minimize the potential for release of radioactive material during normal ground handling and launch operations and in credible launch abort and accident environments.

b. Radiation hazard warning signs and/or labels shall be fixed to the container or housing as directed by the RPO.

c. High voltage sources shall be evaluated to determine their capability of producing X-rays.

1. High voltage sources shall be properly shielded and shall use interlocks on cabinet doors to interrupt power when a door is open.

2. Control measures for flight systems shall be handled on a case-by-case basis.

3.9.3 Radioactive Sources Carried on Launch Vehicles and Payloads

In addition to the design requirements noted in the **Radioactive Sources Design Standards** section of this Chapter, radioactive materials carried on launch vehicles and payloads shall meet the following requirements:

3.9.3.1 Radioactive Sources Carried on Launch Vehicles and Payloads General Design Requirements

a. Radioactive materials carried aboard launch vehicles and payloads shall be compatible with and have no adverse safety effects on ordnance items, propellants, high pressure systems, critical structural components, or flight termination systems.

b. Radioactive materials carried aboard launch vehicles and payloads shall be designed so that

they may be installed as late in the countdown as possible, particularly if personnel will be required to work within the system controlled radiation area (2 millirem per hr) while performing other tasks on the launch vehicle and/or payload.

3.9.3.2 Radioactive Sources Carried on Launch Vehicles and Payloads Test Requirements

a. For radioactive materials to be launched from the Ranges, adequate tests shall be performed to demonstrate the survival of the materials with minimal release of radioactive material within the launch vehicle, payload abort, and destruct environment. **NOTE:** Range Safety provides membership on the Interagency Nuclear Safety Review Panel (INSRP) on major sources to provide launch abort data and evaluation; therefore, some failure mode, breakup, and blast data may be obtained from the Program Office or Range Safety. In some situations, such as using a new launch vehicle, the data may not be available from the sources and shall be obtained by analysis and test following the requirements described in Chapter 2 of this document and through discussions with Range Safety.

b. Test Plans, Test Analyses, and Test Results

1. Test plans, analyses, and results shall be approved by Range Safety.

2. Range Users shall perform and document the results of radiation surveys of their radioactive sources prior to coming to the Ranges.

3. An initial radiation survey shall be performed by the RPO the first time the source is delivered to the Ranges.

4. Safeguards, such as interlocks and leak tests, shall be tested and verified by the Range User prior to bringing a radiation source to the Ranges.

3.9.3.3 Radioactive Sources Carried on Launch Vehicles and Payloads Launch Approval Requirements

a. Range Users contemplating launch of any radioactive source shall comply with AFI 91-110 and the National Aeronautics and Space Council document *Nuclear Safety Review and Approval Procedure for Minor Radioactive Sources in Space Operations*.

b. At the WR, Range Users shall also comply with AFI 91-110 30 SW1 and 30 SWI 40-201.

c. Non-Air Force users may use their own agencies' equivalent document if it meets the requirements of AFI 91-110 and the National Aeronautics

REFERENCED DOCUMENTS

and Space Council document *Nuclear Safety Review and Approval Procedure for Minor Radioactive Sources in Space Operations*.

d. Certification of compliance with an equivalent government agency safety review and launch approval process is required for all non-Air Force Range Users.

e. All Range Users proposing to use major radioactive sources shall comply with Presidential Directive/National Security Council (NSC) 25, dated 14 December 1977, *Scientific or Technological Experiments with possible Large-Scale Adverse Environmental Effects and Launch of Nuclear Systems into Space*.

3.9.3.4 Radioactive Sources Launch Approval Data Requirements

3.9.3.4.1 Letter of Certification. Range Users shall provide a letter of certification to the Range Commander with a copy provided to Range Safety stating that they have complied with the Office of Science Technology Policy NASC letter, AFI 91-110, or the Presidential Directive/NCS-25 as appropriate.

3.9.3.4.2 MSPSP Data. The following data shall be submitted to Range Safety as part of the MSPSP:

a. The final SAS as required by AFI 91-110 or equivalent document if non-Air Force Range User.
NOTE: The SAS shall be referenced in the MSPSP and submitted as an accompanying document.

1. Status reports on the SAS approval and copy of the Technical Nuclear Safety Evaluation (TNSE)

2. Verification of approval for launch by separate correspondence in accordance with the requirements of AFI 91-110 or the equivalent

b. Manufacturer of the source

c. Date of source preparation

d. Source identification number

e. Cross-sectional sketch showing dimensions of the source

f. Source container or holder construction material

g. Physical source form such as powder or plate

h. Chemical source form such as metal or oxide

i. Strength in curies

j. Type of protective cover material over the source

k. Date and result of last wipe test

l. Method of sealing against leakage

m. Radionuclide solubility in sea water

n. Description, including diagrams, showing exact placement of source in vehicle or payload

o. A brief description of intended use

p. Radiation levels in millirem per hour for all modes of operation and all radiation container surfaces accessible to personnel

q. Description of potential accidents that would cause release of radioactive material including potential personnel exposure and ground contamination

r. A summary of the possible consequences of a release of radioactive material at the Ranges including the maximum credible release and recommendations for methods to reduce or eliminate the resulting hazards

s. Description of recovery plans for land and sea launch abort scenarios

t. Location and name of responsible organization and licensed individual assigned to supervise handling of this material

u. Detailed nuclear system design

v. Normal and potentially abnormal environments and failure modes that can affect the processing, launch, and flight of a nuclear system

w. The predicted responses of the nuclear system to processing, launch, and flight environments and failures

x. The predicted resulting nuclear risk

y. Ground support equipment design data as required by the appropriate sections of this document

z. Detailed ground processing flow

aa. The final intended disposition of the radioactive source

ab. A copy of the RPO approved 45 SWI 40-201 Radiation Protection Program (ER only)

ac. A copy of the AFI 91-110 30 SW1 Radiation Protection Plan (WR only)

3.9.4 Radiation Producing Equipment and Devices Data Requirements

The MSPSP shall identify all flight and ground radiation producing devices. The following information shall be provided:

a. Manufacturer and model number

b. A description of the system and its operation

c. A description of the interlocks, inhibits and other safety features

d. If installed on a flight system, a diagram showing the location

e. Radiation levels in millirems per hour for all

modes of operation and all radiation container surfaces accessible to personnel. **NOTE:** Levels with doors and access panels removed shall be included.

f. A copy of the RPO approved 45 SWI 40-201 Radiation Protection Program Radiation Use Request Authorization to use these sources during ground processing.

g. A copy of the AFI 91-110 30 SW1 Radiation Protection Plan (WR only)

3.10 HAZARDOUS MATERIALS

3.10.1 Hazardous Materials Selection Criteria

3.10.1.1 Hazardous Materials Flammability and Combustibility

a. The least flammable liquid or material shall be used where feasible.

b. Materials that will not burn readily upon ignition shall be used.

3.10.1.2 Hazardous Materials Toxicity

NOTE: National Aeronautics and Space Administration (NASA), Kennedy Space Center (KSC), and Range Safety have data on materials that have already been tested.

a. The least toxic liquid or material shall be used where feasible.

b. Materials that will not give off a toxic gas if ignited shall be used.

3.10.1.3 Hazardous Materials Compatibility

a. Materials, including leakage, shall not come in contact with a non-compatible material that can cause a hazard.

b. Compatibility shall be determined on a case-by-case basis.

3.10.1.4 Hazardous Materials Electrostatic Build-Up

Hazardous materials shall not retain a static charge that presents an ignition source to ordnance or propellants or a shock hazard to personnel.

3.10.2 Hazardous Materials Test Requirements

3.10.2.1 Plastic Materials Test Requirements

a. Plastic materials that may pose a hazard because of compatibility, flammability, or electrostatic build-up shall be tested in accordance with the requirements described in KSC Material Testing Laboratory report Material Testing Bulletin MTB-

402-85.

b. The results of the test shall be submitted to Range Safety for review and approval based on use.

3.10.2.2 Other Hazardous Material Test Requirements

a. Range Safety may require the testing of materials whose hazardous properties are not well defined.

b. Toxicity, reactivity, compatibility, flammability and/or combustibility testing requirements shall be determined by Range Safety on a case-by-case basis.

3.10.3 Hazardous Materials Environmental Requirements

a. The use of ozone depleting chemicals and hazardous materials that result in the generation of regulated hazardous waste shall be minimized to the greatest extent possible in accordance with federal and state regulations.

b. Hazardous waste management and disposal procedures and plans shall be reviewed and approved by Environmental Planning.

c. Range User business plans will comply with the Base Hazardous Materials (HAZMAT) Plan.

3.10.4 Hazardous Material Data Requirements

The following information shall be included in the MSPSP:

a. A list of all hazardous materials on the flight system and those used in ground processing

b. A description of how and under what conditions each of these materials and liquids is used and in what quantity

c. A description of flammability and, if applicable, explosive characteristics including test results provided or referenced

d. A description of toxicity including Threshold Limit Value (TLV) and other exposure limits, if available

e. A description of compatibility including a list of all materials that may come in contact with a hazardous liquid or vapor with test results provided or referenced

f. A description of electrostatic characteristics with test results provided or referenced including bleed-off capability of the as-used configuration

g. A description of PPE to be used with the hazardous material and liquid; including type, make, and location

REFERENCED DOCUMENTS

h. A summary of decontamination, neutralization, and disposal procedures

i. A Material Safety Data Sheet (MSDS) for each hazardous material and liquid on flight hardware or used in ground processing. **NOTE:** The MSDS shall be available for review at each location in which the material is stored or used.

j. Description of any detection equipment, location, and proposed use

k. Additional data required for plastic material includes:

1. Identification of the cleaning methods to be used to maintain surface cleanliness and conductivity, if applicable

2. Identification of the minimum acceptable voltage accumulation levels for the plastic materials or operations

3. Identification of the method for ensuring conductivity between adjoining pieces of the plastic materials

4. Assessment of the environmental effects on plastic materials such as humidity, ultraviolet light, and temperature that could cause degradation of conductivity, flammability, or electrostatic properties

3.10.5 Process Safety Management and Risk Management Program

a. Range Users shall comply with 29 CFR 1910.119, 40 CFR 68, and AFOSH 91-119 for Process Safety Management.

b. Additional ER Requirements: Range Users shall comply with the 45 SW Process Management Implementation Plan. **NOTE:** The point of contact is 45 SW/SES.

c. Additional WR Requirements: Range Users shall comply with 30 SW Plan 91-119. **NOTE:** The point of contact is 30 SW/SES.

3.11 GROUND SUPPORT PRESSURE SYSTEMS

3.11.1 Ground Support Pressure Systems Design Requirements

This section establishes minimum design, fabrication, installation, testing, inspection, recertification, and data requirements for fixed, portable, or mobile ground support hazardous pressure systems. Ground support systems include aerospace ground equipment (AGE), ground support equipment (GSE), missile support systems, real prop-

erty installed equipment (RPIE), and industrial property.

3.11.1.1 Definition of Ground Support Hazardous Pressure Systems

Ground support hazardous pressure systems are defined as follows: (1) systems used to store and transfer hazardous fluids such as cryogenics, flammables, combustibles, and hypergols; (2) systems with operating pressures that exceed 250 psig; (3) systems with stored energy levels exceeding 14,240 ft lb; (4) systems that are identified by Range Safety as safety critical

3.11.1.2 Non-Hazardous Pressure System Design

Non-hazardous pressure systems shall be designed in accordance with accepted national industry standards such as NFPA, UL, and API. For the ER, see also Florida Department of Environmental Protection (FDEP) requirements, especially Florida Administrative Code (FAC) Sec 62-761, *Above Ground Storage Tanks*, and Sec 62-762, *Underground Storage Tanks*.

3.11.1.3 Ground Support Vacuum System Design

a. Vacuum systems should be designed in accordance with T.O. 00-25-223.

b. Pressure systems used to store and transfer fuels such as kerosene, RP-1, and heating oils are not generally considered hazardous when designed and operated in accordance with the following requirements:

1. Pressure shall not exceed 15 psig

2. The system shall be designed, maintained and operated in accordance with API 620 and applicable EPA and OSHA requirements,

3. Vessels/tanks and systems shall be inventoried and records maintained in the Eastern Range Pressure System Database Management Program

3.11.1.4 Compliance Documents

Federal regulations such as those published by the Department of Transportation (DOT), the Environmental Protection Agency (EPA), and the Occupational Safety and Health Administration (OSHA) and industry standards are specified as compliance documents throughout this section. When there is a conflict between federal regulations, industry standards, or other requirements in

this section, the more stringent requirement shall be used unless otherwise agreed to by Range Safety.

3.11.1.5 Ground Support Pressure System Repairs and Modifications

Repairs and/or modifications to tankage, piping, and other components shall be performed to the same standards, codes, and requirements as for new systems and components.

3.11.1.6 Ground Support Pressure System Operation

The requirements for operating hazardous pressure systems found in Chapter 6 of this document shall be taken into consideration in the design and testing of these systems.

3.11.1.7 Ground Support Pressure System Fault Tolerance

a. Ground support hazardous pressure systems shall be designed to ensure that no single failure (component fails to function or human operator error) can result in serious injury and/or loss of life.

b. Single-fault tolerant systems shall have at least two, Range Safety approved, independent and verifiable inhibits in place during all periods when the potential for serious injury and/or death exists.

NOTE: Structural failure of tubing, piping, or pressure vessels are not to be considered single failures.

c. Range Safety may require that a pressure system be dual-fault tolerant if the failure of two components could result in a catastrophe (multiple injuries or deaths).

3.11.1.8 Ground Support Pressure System Hazard Analysis

a. As applicable, a hazard analysis, shall be performed on all hazardous systems hardware and software in accordance with a jointly tailored System Safety Program (Appendix IB). Tailoring shall be accomplished by Range Safety and the Range User.

b. At a minimum, the hazardous analysis shall include the analysis requirements in 29 CFR 1910.119 and AFI 32-4002 for toxic, reactive, flammable, and explosive fluids.

3.11.1.9 Ground Support Pressure System Safety Factor

a. Safety factor for pressure systems is defined as the ratio of design burst pressure over the maximum allowable working pressure or design pressure, whichever is greater. The safety factor can also be expressed as the ratio of tensile strength over the maximum allowable stress for the material.

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b. American Society of Mechanical Engineers (ASME) or DOT codes are specified as compliance documents for various components such as pressure vessels and piping throughout this section. Acceptable safety factors have already been incorporated into the specified code. If an ASME or DOT code is not specified in this section as a compliance document for a component (applicable code does not exist), the minimum safety factor for the component shall be 4.

3.11.1.10 Ground Support Pressure System Material Selection and Compatibility

a. Materials shall be compatible throughout their intended service life with the service fluids and the materials such as supports, anchors, and clamps used in construction and installation of tankage, piping, and components as well as nonmetallic items such as gaskets, seals, packing, seats, and lubricants.

b. At a minimum, material compatibility should be determined in regard to the following criteria: permeability, flammability, ignition and combustion, functional and material degradation, contamination, toxicity, pressure and temperature extremes, shock, oxidation, and corrosion.

c. Brittle materials shall not be used for pressure system components. The nil-ductility transition temperature of materials shall be below the service temperature. **NOTE:** Reliable sources such as MIL-HDBK-5, MIL-HDBK-17, American Society for Testing Materials (ASTM) Standards, AFML/-AFFOL Damage Tolerant Design Handbook shall be used to verify material is not crack sensitive.

d. Materials that could come in contact with fluid from a ruptured or leaky tank, pipe, or other components that store or transfer hazardous fluids shall be compatible with the fluid so that it does not create a flammable, combustible, or toxic hazard.

e. Compatible materials selection shall be obtained from one of the following sources:

1. T.O. 00-25-223
2. Chemical Propulsion Information Agency 394 (CPIA 394)
3. Marshall Space Flight Center Handbook 527 (MSFC-HDBK-527)

f. Compatibility Testing

1. Materials shall be tested for compatibility if data does not exist.

2. If compatibility testing is performed, the test plan shall be submitted to Range Safety for review

and approval.

g. Compatibility Analysis. A compatibility analysis containing the following information shall be prepared:

1. List of all materials used in system
2. Service fluid in contact with each material
3. Materials that may come in contact with leaking fluid
4. Source document or test results showing material compatibility in regard to permeability, flammability, ignition and combustion, functional and material degradation, contamination, toxicity, pressure and temperature extremes, shock, oxidation, and corrosion

3.11.1.11 Ground Support Pressure System Corrosion Control

NOTE: The atmosphere at the ER contains a high salt content that is readily deposited on exposed surfaces. Combined with acidic solid rocket booster effluent and substantial rainfall, steady winds, low land elevation, and generally high humidity and temperatures, this results in an ideal environment for extensive metal corrosion. These conditions induce both electrolytic action and chemical reactions depending on the metals involved and how they are used. The atmosphere at Vandenberg Air Force Base (VAFB) is similar to Cape Canaveral Air Station CCAS except that fog is the predominant moisture source. Although corrosion control is primarily the responsibility of the maintainer of the equipment, the designer is responsible for providing hardware that will not present safety problems caused by corrosion. KSC-STD-0001 or National Association of Corrosion Engineers (NACE) RP-2-85 shall be used as guidance for corrosion control.

3.11.1.11.1 Determining Hazardous Pressure System Location.

a. The location of hazardous pressure systems at the Ranges shall be identified including the types of corrosion that may be encountered (oxidation and reduction, galvanic, corrosion fatigue, stress corrosion cracking, and corrosive atmosphere).

b. Once these environments have been identified, the appropriate corrosion protection shall be provided.

3.11.1.11.2 Corrosion Protection Coatings. Corrosion protection coatings for fixed outdoor pressure systems including supports, anchors, and

clamps are as follows: **NOTE:** Alternate coatings that provide equal or better protection may be used.

a. Carbon steel surfaces should be protected from atmospheric corrosion through the application of zinc coatings (inorganic zinc coating and/or hot-dip galvanizing).

b. Stainless steel surfaces on piping and vessels that receive rocket engine exhaust impingement or acid deposits from solid rocket motor exhaust should be painted with a nitrile rubber-based aluminum pigmented coating.

c. Stainless steel surfaces on piping and vessels used in hypergolic propellant systems shall be painted with a nitrile rubber-based aluminum pigmented coating.

d. Underground vessels and piping should be coated with coal tar epoxy.

e. All hypergolic underground systems shall be protected against corrosion by cathodic protection. Cathodic protection systems (sacrificial or DC power) shall be designed so that a periodic check of the system can be obtained.

f. Dissimilar metals shall be protected against galvanic corrosion through mutual isolation.

3.11.1.11.3 Use of 17-4PH Stainless Steel.

a. The use of 17-4PH stainless steel shall be avoided where possible due to its susceptibility to stress corrosion cracking at low heat treatment levels.

b. Any 17-4PH stainless steel specified shall require heat treatment to condition H1025 or higher.

3.11.1.11.4 Avoidance of Type 303 Stainless Steel. Where 300-series stainless steels are specified, type 303 shall be avoided wherever possible due to susceptibility to stress corrosion cracking.

3.11.1.12 Ground Support Pressure System Contamination Control

Adequate levels of contamination control shall be established by relating the cleanliness requirements to the actual needs and nature of the system and components. KSC-C-123 or T.O. 42C-11 shall be used as guidance.

a. Materials and fluids used in the design shall be selected to reduce internally generated contamination caused by rate of wear, friction, and fluid decomposition.

b. Systems shall have acceptable contamination tolerance levels. **NOTE:** The tolerance level of the system and/or components shall be based on con-

siderations of the overall functional requirements and service life.

c. Components and systems shall be protected from contaminants by adequate filtration, sealed modules, clean fluids and clean environment during assembly, storage, installation and use.

d. The system shall be designed or marked to prevent incorrect installation of filters.

e. Accessibility shall be provided for inspection and testing of systems and components and for removal of contaminants and filters by allowing means of disassembly for cleaning, drainage, and post-assembly cleaning and maintenance.

f. The system shall be designed to verify through sampling that the lines and components are clean after flushing and purging of the system.

g. Each component or section of a system shall be cleaned to the appropriate level prior to installation. Immediately following cleaning, all components or sections of a system shall be protected to prevent contamination.

h. Filters shall be installed immediately upstream of all interfaces where control of particulate matter is critical and at other appropriate points as required to control particulate migration. **NOTE:** Filter design shall permit easy servicing and ready accessibility.

i. Equipment designed to be cleaned or recleaned in place without significant disassembly shall be provided with high point bleeds and low point drains to facilitate introduction and removal of cleaning fluid.

3.11.1.13 Ground Support Pressure System Service Life

All hazardous pressure system components shall operate safely and reliably during their intended period of service (service life). Components shall not fail at operating conditions in a time period that is 4 times the service life of the components. Minimum service life requirements are as follows:

a. Permanently installed pressure vessels shall be designed to have a service life of at least 20 years.

b. Other components shall be designed to have a service life of not less than 5000 cycles. Normal preventive maintenance or calibration may be performed to maintain the service life.

3.11.1.14 Inservice Operating, Maintenance, and Inspection Plan

The Range User responsible for the design of hazardous pressure systems shall prepare an inservice

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operating, maintenance, and inspection plan. This plan will be referred to as the Inservice Inspection (ISI) Plan. **NOTE:** Guidance for preparing the ISI Plan can be found in ESMC-TR-88-01, *A Guide for Recertification of Ground Based Pressure Vessels and Liquid Holding Tanks*.

a. The ISI Plan shall address and provide the following:

1. Credible failure mechanisms that may cause service related failures of the system during its service life shall be analyzed.

2. Methods such as “eliminated,” “controlled by design,” “controlled by procedure,” or “controlled by corrosion protection” used to eliminate and control these failure mechanisms shall be identified. **NOTE:** Failure mechanisms to be evaluated include corrosion, stress, fatigue, creep, design fabrication, installation, operation, and maintenance deficiencies.

3. Using the results of the above failure mechanism analysis, the following minimum requirements for an operating, maintenance, and inspection plan shall be defined:

(a) Operating plans shall address operating constraints such as maximum pressure, maximum allowable working pressure (MAWP), maximum operating pressure (MOP), minimum and maximum temperature, vibration, and maximum cycles.

(b) Maintenance plans shall address corrosion protection, maintenance schedule, soft-good replacement program, refurbishment, calibration, and other maintenance requirements.

(c) Inspection plans shall identify the type and frequency of inspections such as visual, surface and volumetric, NDE required for each vessel and system to detect the types of failure mechanisms identified in (1) above.

b. Hazardous pressure systems shall be maintained and periodically inspected in accordance with the ISI Plan.

c. Unacceptable findings from the performance of periodic inspections shall be resolved with Range Safety participation.

3.11.1.15 Physical Arrangement and Human Factors Requirements for Ground Support Pressure Systems

Pressure systems shall be designed to provide adequate accessibility, clearance, and operating safety.

3.11.1.15.1 Accessibility.

a. Components shall be located to provide ease of maintenance and calibration.

b. Access ladders and platforms shall be provided for components that cannot be located in normal work areas.

c. Hypergolic system design shall take into consideration the limitations imposed on individuals dressed in Self-Contained Atmospheric Protective Ensemble (SCAPE) suits or Propellant Handlers Ensemble (PHE).

d. Pressure systems shall be designed so that removal and replacement of tubing can be accomplished with minimal removal of other system components.

e. Pressure lines shall not be installed inside conduit, large pipe, or tubing for protective support. *EXCEPTION: Lines may be enclosed in protective conduit, pipes, or tubing when routed under roadways, obstructions, and through thick walls.*

f. All piping shall be located so that it is accessible for maintenance.

g. Systems shall be designed with accessibility to perform end-to-end static ground system checks.

h. Where possible, pipes containing hazardous liquids shall be routed in a gradual, direct, down-grade angle to prevent the accumulation of trapped liquid fluids and allow draining of the lines.

i. Where possible, pipes carrying hazardous liquids shall be mounted so that the liquid will not be trapped in internal cavities when it is drained.

3.11.1.15.2 Clearance.

a. Tubing shall be located and protected so that damage will not occur due to being stepped on, used as handholds, or by manipulation of tools during maintenance.

b. Pressure lines shall clear all structures, components, and other lines by not less than 1/4 in. under the most adverse conditions of service to ensure that abrasive chafing does not occur.

c. Piping, tubing, and other components shall be routed or located to provide protection from other operational hazards, including moveable equipment. **NOTE:** Where such exposure is unavoidable, safeguards that minimize the effects of such exposure shall be incorporated in the design.

d. Where feasible, high pressure lines and components shall be protected from damage due to leakage, servicing, or other operational hazards created by other systems.

e. All welded pipe fabricated in place shall be installed with a minimum 6-in. clearance from building structures.

f. The minimum spacing between fuel and oxidizer piping shall be 24-in. in any direction.

g. Pipes containing liquids shall not be attached or secured to electrical lines or conduit.

h. A minimum spacing of 2 in. shall be maintained between an electrical conduit and a pressure line.

i. Vent outlets shall be located far enough away from incompatible propellant systems and incompatible materials to ensure that no contact is made during vent operations.

j. System connections for incompatible propellants shall be keyed, sized, or located so that it is physically impossible to interconnect them. **NOTE:** Unless otherwise agreed to by Range Safety, breathing air quick disconnects (QDs) shall use 3/8 in. Hansen QDs (part numbers LL3-K21 (male) and LL-H21 (female)). In addition, the 3/8-in. Hansen QD will not be used for any other type system.

k. Redundant legs (i.e., branches) of a safety pressure system shall be physically separated and protected so that a single event (such as damage, fire, or an explosion) will not cause both redundant legs to fail.

l. Components shall be located and lines routed so that a leak or rupture will not cause ignition.

m. Safety relief valves and burst diaphragms shall be located so that their discharge is directed away from personnel or safety critical equipment to prevent injury to personnel or damage to safety critical equipment. **NOTE 1:** If this requirement cannot be met, safety valves and burst diaphragms shall be equipped with deflection devices. **NOTE 2:** Consideration shall be given to minimizing the noise hazard of high pressure venting.

n. Vent lines for flammable and combustible vapors shall be extended away from work areas to prevent accidental ignition of vapors and/or injury to personnel.

o. Pipe routing shall not block personnel egress routes.

3.11.1.15.3 Human Factors.

a. System components such as a hand regulator and gauge that are closely related shall be arranged to allow operation and surveillance from a common point.

b. Remotely controlled systems shall have emergency manual safing controls located inside and outside of the hazard area.

c. Pressure systems shall be designed so that the operator is not required to leave the operating control station to monitor the hazard level of that system.

d. For remotely controlled valves, positive indication of actual valve position shall be displayed at the control station. **NOTE:** Indication of valve stem position or flow measurement is an acceptable indication. Indication of a remote command being initiated is not a positive indication of valve position.

e. All piping shall be located so that it is not hazardous to working personnel.

f. All calibration adjustments shall be designed so that the setting, position, or adjustment cannot be inadvertently altered.

g. All valves that shall remain in a CLOSED or OPEN position during system operation shall be protected against inadvertent actuation by mechanical stops, lock wires, or access control.

h. Valves carrying hazardous liquids shall not be located overhead in the area of an operating station.

i. Manually operated liquid valves shall be located to permit operation from the side or above to prevent spillage of service fluid on the operator due to leak or failure of the valve seals.

j. MIL-STD-1472 or equivalent should be used as guidance in designing pressure system operating consoles.

3.11.1.16 Identification and Marking of Components and Control Panels/Consoles

3.11.1.16.1 Hazardous Pressure Systems Component Identification. All hazardous pressure system components shall be identified as to function, content, applicable hazard, and, if applicable, direction of flow. Minimum identification and marking requirements are as follows:

a. Fixed Pressure Vessels

1. Fixed pressure vessels shall be code stamped in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 or Division 2.

2. The maximum pressure at which fixed pressure vessels will be normally operated and the name of the working fluid shall be painted in a conspicuous location on the vessel facing the roadway approach, if possible. **NOTE:** This additional labeling shall be legible at a distance of 50 ft.

b. Portable and mobile pressure vessels shall be marked in accordance with the applicable DOT specifications.

c. Individual lengths or fabricated assemblies of

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pipe and tubing shall be identified with pipe and/or tube size, schedule number and wall thickness, test pressure, and the date of hydrostatic

and/or pneumatic test. Identification data shall be fixed to the pipe and tubing by means of an attached stainless steel tag.

d. Fixed ground support piping and tubing runs external to regulation and control panels and consoles shall be identified in accordance with MIL-STD-1247 or equivalent.

e. All RPIE shall be identified in accordance with MIL-STD-101 or equivalent.

f. Shutoff and metering valves, regulators, gauges, quick disconnect ground-half couplings and filters shall have the following information permanently attached to the body by stamping, engraving, tagging, or other means:

1. Manufacturer and/or contractor name
2. Manufacturer part number
3. Applicable design pressure rating
4. Service media
5. Month and year of most recent calibration for gauges and transducers
6. Flow direction arrow, if applicable
7. System reference designation for the component, such as CV1, CV2

g. Flex hoses shall be provided with an identification tag that is permanently and legibly marked with the following information:

1. Manufacturer name
2. Manufacturer and/or contractor part number
3. Hose size
4. MAWP or manufacturer rated working pressure
5. Service media
6. Month and year of most recent hydrostatic test and test pressure
7. System reference designation for the hose such as FH1, FH2

h. Pressure Relief Devices

1. Pressure relief devices shall be marked in accordance with ASME Code Section VIII, Division 1, Paragraphs UG-129, UG-130, UG-131, and UG-132 as applicable.

2. An identification tag that is permanently and legibly marked with the month and year of the most recent set pressure calibration shall be attached to the relief valve.

3.11.1.16.2 Pressure Vessels, Valves, and Other Component Identification. The marking and identification of pressure vessels, valves, and other components shall be accomplished by some

means that will not cause “stress concentration” or otherwise reduce the integrity of the system.

3.11.1.16.3 Manual Pressure System Regulation and Control Panel and Console Identification. All manual pressure system regulation and control panels and consoles shall be clearly marked with a flow schematic, operating parameters, and component identification.

3.11.1.17 Ground Support Pressure System Supports, Anchors, Clamps, and Other Restraints

a. All piping supports, anchors, hangers, and other restraints shall conform to the requirements of American National Standards Institute (ANSI/ASME) B31.3, paragraph 321.

b. Hazardous pressure system piping shall be installed with sufficient flexibility to prevent static or dynamic flow-induced loads and thermal expansion or contraction from causing excessive stresses to be induced in the system, excessive bending moments at joints, or undesirable forces or moments at points of connection to equipment or at anchorage or guide points.

c. Line Restraints

1. Where line restraint is required, anchors, guides, pivots or restraints shall be fabricated or purchased and assembled in such a form as to secure the desired points of piping in relatively fixed positions.

2. Line restraints shall permit the line to expand and contract freely in opposite directions away from the anchored or guided point.

3. Line restraints shall be designed to withstand the thrust, torsional forces, and load conditions of operation.

4. Line restraints shall contain the line in case of line failure.

5. The support shall be capable of withstanding no less than two times the available force as a result of thrust generated from component failure under pressure.

d. All relief valves and attached vent piping shall be designed to withstand any thrust caused by venting fluids.

e. All rigid tubing assemblies shall be supported by rigid structures using cushioned steel clamps or suitable multiple-tube block-type clamps.

f. Tubing supports within consoles or modules shall be spaced according to the maximum spacing listed below:

Nominal Tubing Diameter (in.)	Maximum Distance Between Tubing Support (in.)
1/8 through 3/8	18
1/2 through 3/4	25
1 and over	30

g. Tubing supports between consoles and modules shall be spaced according to the maximum spacing listed below:

Nominal Tubing Diameter (in.)	Maximum Distance Between Tubing Supports (ft)
1/8 through 3/8	4
1/2 through 7/8	6
1 through 2	9

h. Components within a system shall be supported by a firm structure and not the connecting tubing or piping unless it can be shown by analysis that the tubing or piping can safely support the component with a safety factor of 3 against yield.

3.11.1.18 Ground Support Pressure System Bonding and Grounding

3.11.1.18.1 Hazardous Pressure System Bonding and Grounding. All hazardous pressure systems shall be properly bonded and grounded to provide the following. **NOTE:** National Fire Protection Association (NFPA) 77 and KSC-STD-E-0012 shall be used as guidance.

a. A low-impedance path to earth for electrical currents resulting from lightning discharges or electrical power system faults to minimize abnormal voltage rises that might injure personnel or damage equipment

b. A discharge path between distribution piping and tubing and earth to prevent the buildup of static electricity

3.11.1.18.2 Combustible and Flammable Pressure System Piping and Tubing. Minimum metal pipe and tube bonding requirements for combustible and flammable pressure systems are as follows:

a. Piping and tubing shall be bonded to ground at the end termination and at intervals of not more than 100 ft.

b. Systems located outdoors shall have brazed or welded bonds. *EXCEPTION: Stainless steel clamps may be used to bond stainless steel pipe to ground if brazing or welding would cause dissimilar metal concerns.*

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c. Flanged joints are acceptable if the flanges are stainless steel or the flanged areas in contact with the bolt heads and washers are clean and bright. In addition, the bolts and nuts shall be equipped with serrated or spring washers to maintain tightness.

d. Tubing sections joined with fittings that seat metal-to-metal are considered adequately bonded.

3.11.1.18.3 Non-Flammable and Non-Combustible Pressure Piping and Tubing. Non-flammable and non-combustible pressure system piping and tubing shall be bonded to ground at the end terminations and at intervals of not more than 300 ft.

3.11.1.18.4 Fixed Facility Transfer Apron Bonding and Grounding Station. All fixed facility transfer apron areas shall be equipped with a bonding and grounding station for use with associated mobile equipment.

3.11.1.18.5 Use of Copper, Bronze, and Other Alloys in Hydrazine Areas.

a. Copper, bronze, or other alloys that might form copper oxides should not be used in hydrazine areas. If used, they shall be positively protected by distance, sealing in a compatible material, or use of a splash guard.

b. The use of interconnecting dissimilar ground metals that could lead to increased resistance due to galvanic corrosion over a relatively short time period shall be avoided.

3.11.1.18.6 Bonding and Grounding Resistance Values. The following resistance values are the maximum desired to achieve the intended bonding and grounding requirements:

a. Any single joint measurement shall exhibit a DC resistance of 10 milliohms or less.

b. DC resistance from any point in the piping and tubing system to the nearest earth electrode ground plate shall be 100 milliohms or less.

3.11.2 Ground Support Pneumatic Systems

This section contains minimum safety requirements for all fixed, portable, and mobile equipment used to handle gaseous nitrogen, helium, oxygen, hydrogen, breathing air, and any other gas or gas mixtures designated by Range Safety.

3.11.2.1 Compressed Air Systems

Compressed air systems operating at 250 lb/in² or less shall be designed in accordance with accepted industry standards such as OSHA 1910.169 and ANSI/ASME B19.

3.11.2.2 Ground Support Pressure Vessels

3.11.2.2.1 Permanently Installed Pressure Vessels.

a. All permanently installed pressure vessels shall be designed, constructed, tested, certified, and code stamped in accordance with the ASME Code, Section VIII, Division 1 or Division 2.

b. All ASME code stamped vessels shall be registered with the National Board of Boiler and Pressure Vessel inspectors.

c. The following additional design, fabrication, and inspection requirements shall also be met:

1. Pressure vessels shall be designed with an opening for inspection purposes.

2. Pressure retaining welds including all shell, head nozzle, and nozzle to head or shell welds shall be inspected using volumetric and surface NDE techniques.

3. At a minimum, all attachment welds such as supports, lugs, pads, and nameplates shall be inspected using surface NDE techniques.

4. Welded attachments such as stiffening rings or supports shall be welded with a continuous weld bead.

5. Welded and bolted attachments such as piping, gussets, ladders, and platforms to the pressure vessel shall be minimized.

6. External and internal surfaces of vessels shall be free of crevices and other areas that can trap moisture or contaminants.

7. All attachments shall be positioned so that no attachment weld will overlap any category A or B weld as defined by ASME Code, Section VIII, Division 1 or Division 2.

8. SA514, SA517, or other alloys with substantially the same properties as T-1 steel shall not be used for pressure vessels that are fabricated by welding.

9. All fixed pressure vessels exposed to the atmosphere and winds shall be designed with a minimum 2 psig external pressure load.

3.11.2.2.2 Portable and Mobile Pressure Vessels.

a. Portable and mobile pressure vessels used for

transportation of hazardous materials shall be designed, fabricated, inspected, and tested in accordance with 49 CFR.

b. A copy of any DOT approved exemptions shall be provided to Range Safety.

3.11.2.2.3 Permanently Installed Portable and Mobile Pressure Vessels.

a. Pressure vessels designed and fabricated according to DOT codes are not normally specified for permanent installation in high pressure systems.

b. If such vessels are installed on a permanent basis, the installation shall meet ASME design requirements or be installed to permit easy access to hydrostat the vessel periodically in compliance with DOT regulations.

c. If DOT vessels are used in portable GSE, maintenance and operating procedures for periodic hydrostatic tests shall be in accordance with DOT regulations.

3.11.2.3 Ground Support Pneumatic System Piping

All piping installations shall be designed, as a minimum, in accordance with ANSI/ASME B31.3 in addition to the following:

a. Recommended pipe material is seamless cold-drawn, type 304L or type 316L stainless steel in accordance with ASTM A312 and ANSI/ASME B36.10M.

b. Weld fittings such as tees, crosses, elbows, and reducers should be of the butt weld type in accordance with ANSI B16.9 and be constructed of ASTM A403, grade WP-316L or WP-304L material.

c. Mechanical joints should be made of ASTM A182 F316 butt weld hubs, ASTM A182 F304 clamp assemblies, and type 17-4PH teflon-coated seal rings. **NOTE:** Where system design dictates the use of industrial flanged type mechanical joints, they shall be in accordance with ANSI B16.5.

d. Threaded National Pipe Thread (NPT) connectors shall not be used in hazardous pressure system piping unless specifically approved by Range Safety.

e. Socket welded flanges shall not be used in hazardous pressure system piping.

f. All piping welds shall be of the full penetration butt weld type unless specifically approved by Range Safety.

g. All piping and fitting butt welds used to fabricate hazardous pressure systems shall be 100 percent visually and radiographically inspected. Accept

and reject criteria shall be in accordance with ANSI/ASME B31.3, Table 341.3.2A or Table K341.3.2A for pressure systems equal to or greater than 6000 psi.

3.11.2.4 Ground Support Pneumatic System Tubing

a. If welded, pneumatic distribution tubing should be annealed seamless, stainless steel Type 304/316 or 304L/316L. **NOTE:** Tubes may be joined by the use of precision 37° flared ends and threaded fittings or by the use of special purpose butt welded studs containing a precision machined 37° flare and threaded fittings.

b. 37° flared end fittings shall be designed in accordance with precision type AN, MS or KSC-GP-425 Standards. The material should be type 316.

c. If used to join tubing, butt weld fittings shall be designed in accordance with KSC-GP-425 or equivalent. Material should be 304L or 316L.

d. All tubing and butt weld fitting welds shall be 100 percent radiographically inspected. The accept and reject criteria shall be in accordance with Section 4.5.2 of KSC-SPEC-Z-0020. **NOTE:** If this criteria cannot be met, the Range User shall submit alternate accept and reject criteria to Range Safety for review and approval.

e. Since flared tubing is not designed for service above 6000 psig, Range Safety approved super pressure tubing shall be used for service above 6000 psig.

f. The number of mechanical joints shall be minimized to reduce the probability of leakage.

g. Tube fittings with NPT connectors shall not be used in hazardous pressure systems.

3.11.2.5 Ground Support Pneumatic System Regulators

a. Regulators shall be selected so their working pressure falls within the center 50 percent of the total pressure range if it is susceptible to inaccuracies or creep at either end of the pressure range.

b. Manually operated regulators shall be selected so that overtightening the regulator cannot damage soft seats to the extent that seat failure occurs.

c. Designs using uncontained seats are unacceptable.

d. Regulator functional failure shall not create a hazard to personnel.

e. Dome loaded pressure regulators shall withstand a differential pressure across the diaphragm and/or piston equal to the maximum rated inlet

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pressure without damage. A means of venting the dome loading circuit shall be provided.

f. For each stage of regulation, it is desirable that the ratio of upstream pressure to downstream pressure not exceed 5 for optimum control of pressure and flow and to minimize problems in sizing pressure relief devices.

g. Except for cylinder (K-bottle) regulators, pressure regulator bodies and other pressure containing parts should be constructed of 300 series stainless steel.

h. Pressure regulator actuators shall be capable of shutting off the fluid when the system is at the maximum possible flow and pressure.

i. The use of a sheathed flexible actuator such as push-pull wires and torque wires for regulator control is prohibited.

j. Remotely operated regulators shall be designed to be fail-safe if pneumatic or electric control power is lost.

k. All electrical control circuits for remotely actuated regulators shall be shielded or otherwise protected from hazardous stray energy.

l. A regulator shall not be used as a safety critical component or be required to function to prevent a failure that might injure personnel.

3.11.2.6 Ground Support Pneumatic System Valves

a. Valve actuators shall be operable under maximum design flow and pressure.

b. Remotely operated valves shall be designed to be fail-safe if pneumatic or electric control power is lost.

c. Balanced manual valves that use external balancing ports or vents open to the atmosphere shall not be used.

d. Valve bodies and other appropriate parts should be constructed of 300 series stainless steel.

e. Valve stem travel shall be limited by a positive stop at each extreme position.

f. The application or removal of force to the stem-positioning device shall not cause disassembly of the pressure containing structure of the valve.

g. Designs using uncontained seats are prohibited.

h. All electrical control circuits for remotely actuated valves shall be shielded or otherwise protected from hazardous stray energy.

i. Manually operated valves shall be designed so that overtorquing the valve stem cannot damage soft seats to the extent that seat failure occurs.

j. Inlet and outlet isolation valves shall be bi-directional valves capable of isolating the maximum allowable working pressure in both directions without seat failure.

k. Inlet and outlet isolation valves (shutoff valves) and appropriate intermediate vent valves shall be provided for shutdown and maintenance.

l. Local or remote stem-position indicators shall sense the position of the stem directly, not the position of the actuating device.

m. Valves used in flared tubing system applications shall be designed for panel or other rigid mounting.

n. Special care shall be taken in the design of oxygen systems to minimize the heating effect due to rapid increases in pressure.

o. Fast opening valves that can produce high velocity kinetic effects and rapid pressurization shall be avoided.

p. Valves that are not intended to be reversible shall be designed or marked so that they will not be connected in a reverse mode.

q. Systems shall have shutoff valves located as close to the supply vessel as practical and be readily accessible.

r. Check valves shall be provided where back flow of fluids would create a hazard.

s. The use of a sheathed flexible actuator such as push-pull wires and torque wires for valve control is prohibited.

t. All hazardous pressure system valves that shall remain in a CLOSED or OPEN position during system operation shall be protected against inadvertent actuation by mechanical stops or lock wires (access control may only be used if mechanical stops/lock wires are not feasible and Range safety concurs).

u. Remotely controlled valves shall provide for remote monitoring of OPEN and CLOSED positions.

3.11.2.7 Ground Support Pneumatic System Indicating Devices

a. A pressure indicating device shall be connected downstream of each pressure regulator on each storage system and on any section of the system where pressure can be trapped.

b. Remote readout pressure transducers are required when determined by Range Safety to monitor hazardous operations from a remote location.

c. All pressure gauges shall conform to the requirements of ANSI/ASME B40.1. *EXCEPTION:*

Pressure gauges that are part of a cylinder regulator assembly such as those used with cutting, welding, or other industrial equipment are exempt from these requirements as are gauges associated with pneumatic controllers, positioners, and other standard process control equipment.

1. Gauges shall be selected so that the normal operating pressure falls between 25 percent and 75 percent of the scale range, except for gauges used in applications that require a wide range of operating pressure.

2. For applications requiring a wide range of operating pressure, the pressure gauges shall be selected so that the maximum pressure that can be applied shall not exceed 95 percent of the scale range of the gauge.

3. Pressure gauges shall be of one piece, solid front, metal case construction, using an optically clear shatterproof window made of high-impact, non-cracking plastic, heat-treated glass, or laminated glass.

4. All pressure gauges shall be equipped with a full diameter pressure release back that shall be sized for maximum flow without case rupture. **NOTE:** The use of blowout plugs is not recommended.

5. Gauges shall be securely attached to a panel or other rigid mounting.

d. All pressure gauge material that normally contacts the service fluid should be type 316 stainless steel. *EXCEPTION: Bourdon-tube bleed screws may be constructed of any 300 series stainless steel.*

e. If pressure gauge isolation valves are used, they shall be designed so that they can be lock wired in the OPEN position.

f. At a minimum, gauge installations shall be designed to have a 1-in. clearance in the back to allow unrestricted venting in the event the gauge vents.

g. Personnel and critical equipment shall be protected from potential venting hazards.

3.11.2.8 Ground Support Pneumatic System Flexible Hoses

a. Flexible hoses shall be used only when required for hookup of portable equipment or to provide for movement between interconnecting fluid lines when no other feasible means is available.

b. Flexible hoses shall consist of a flexible inner pressure carrier tube (compatible with the service fluid) constructed of elastomeric (typically poly-

tetrafluoroethylene [PTFE]) or corrugated metal (typically 300 series stainless steel) material reinforced by one or more layers of 300 series stainless steel wire and/or fabric braid. **NOTE 1:** In applications where stringent permeability and leakage requirements apply, hoses with a metal inner pressure carrier tube should be used. **NOTE 2:** Where these hoses are used in a highly corrosive environment, consideration should be given to the use of Hastalloy C-22 in accordance with ASTM B575 for the inner pressure carrier tube and C-276 material for the reinforcing braid.

c. Hoses shall be provided with 300-series stainless steel end fittings of the coupling nut, 37° flared type or with fittings to mate with the appropriately sized ANSI/ASME B16.5 flange or KC159 hub. **NOTE:** Other end fittings may be used for unique applications, subject to Range Safety approval.

d. Hoses over 2 ft long, pressurized to 150 psig or greater, shall meet the following restraint requirements:

1. The flex hose shall have safety chains or cables securely attached across each union or splice and at intervals not to exceed 6 ft.

2. Hose end restraints shall be securely attached to the structure in a manner that in no way interferes with the hose flexibility.

3. Restraint devices shall be capable of withstanding not less than 6 times the open line pressure force.

4. The design safety factor for restraint devices shall not be less than 3 on material yield strength.

5. Temporary flex hose installations may be weighted with 50-lb sand bags, lead ingots, or other suitable weights at intervals not to exceed 6 ft.

e. Flex hose installation shall be designed to avoid abrasive contact with adjacent structures or moving parts.

f. Flex hose assemblies shall not be installed in a manner that will place a mechanical load on the hose or hose fittings to an extent that will degrade hose strength or cause the hose fitting to loosen.

g. Flexible hose shall not be supported by rigid lines or components if excessive loads from flex hose motion can occur.

h. Flexible hose between two components may have excessive motion restrained where necessary, but shall never be rigidly supported by a tight rigid clamp around the flexible hose.

i. Flex hoses shall not be exposed to temperatures that exceed the rated temperature of the hose.

j. Flex hoses that are permitted to pass close to a

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heat source shall be protected with a fireproof boot or metal baffle.

k. Designs using convoluted, unlined bellows or flexible metal hoses shall be analyzed to verify premature failure caused by flow-induced vibration is precluded.

l. Acoustic coupling that can intensify the stresses caused by flow induced vibration shall be avoided by ensuring that normal fluid flow requirements do not exceed a velocity of Mach 0.2. **NOTE:** A guidance document for performing the flow-induced vibration analysis is MSFC 20MO2540.

m. The bend radius of flex hoses shall be designed to be no less than the safe minimum bend radius recommended in authoritative specifications for the particular hose and in no case less than 5 times the outside diameter of the hose.

n. A means of plugging or capping flex hoses shall be provided when the hose is not in use.

3.11.2.9 Ground Support Pneumatic System Pressure Relief Devices

3.11.2.9.1 Fixed Pressure Relief Devices.

a. All fixed pressure vessels shall be protected against overpressure by means of at least one conventional safety relief valve or pilot-operated pressure relief valve in accordance with ASME Code, Section VIII, Division 1, Paragraphs UG-125 through UG 136, or Division 2, Article R-1, as applicable.

b. A rupture disc may be installed between the pressure relief valve and the vessel provided that the limitations of ASME Code, Section VIII, Division 1, Paragraphs UG-127(a)(3)(b) and UG 127(a)(3)(c) or Division 2, Article R-1, Paragraphs AR-131.4 and AR-131.5 are met.

c. Particular care shall be taken to monitor and/or vent the space between the rupture disc and the relief valve as required.

d. All rupture discs installed in hazardous fluid systems shall be replaced every two years. **NOTE:** Providing a screen between the rupture disc and the valve to prevent rupture disc contamination of the relief valve should be considered.

e. Installation of the pressure relief devices shall be in accordance with ASME Code, Section VIII, Division 1, Paragraph UG-135 or Division 2, Article R-1.

f. The total relieving capacity of pressure relief devices shall be determined in accordance with ASME Code, Section VIII, Division 1, Paragraph

UG-133 or Division 2, Paragraph AR150, as applicable. The required relieving capacity shall be provided by a single valve where possible.

g. Pressure relief devices shall be set to operate at a pressure not to exceed the MAWP of the vessel. [See ASME Code, Section VIII, Division 1, Paragraphs UG-134(A), UG-134(b), UG-134(c), and UG-134(d)(1)]

h. Negative pressure protection shall be provided for vessels not designed to withstand pressures below 1 atmosphere. **NOTE:** This protection can be accomplished by the use of check valves or negative pressure relief devices.

i. Pressure vessel relief devices shall be located so that other components cannot render them inoperative except as specified in ASME Code, Section VII, Division 1, Paragraphs UG-135(e)(1), UG-135(e)(2), and Appendix M, Paragraphs M-5 and M-6. **NOTE:** When a shutoff valve is allowed in accordance with the ASME Code, the valve type shall have provisions for being safety wired in the OPEN or CLOSED position.

j. The shutoff valve shall have permanent marking clearly identifying its position (OPEN or CLOSED).

3.11.2.9.2 Portable and Mobile Pressure Vessels.

a. DOT pressure vessels shall be protected against over pressure in accordance with 49 CFR.

b. DOT pressure vessels used and approved for use in a fixed ground based system shall be provided overpressure protection in accordance with the ASME Code.

3.11.2.9.3 Pressure Relief Devices for Systems and Subsystems.

a. A pressure relief valve shall be installed as close as is practical downstream of each pressure reducing device (regulator, orifice) or downstream of any source of pressure such as compressors, gas rechargers, and tube bank trailer whenever any portion of the downstream system cannot withstand the full upstream pressure. **NOTE:** The criteria for *withstand* is that the upstream pressure shall not exceed the MAWP of any pressure vessel or component downstream of the regulator or pressure source.

b. A pressure relief valve shall be installed downstream of the last GSE regulator prior to flight hardware interface.

c. A pressure relief valve shall be installed

downstream of last GSE regulator prior to entering a container and/or black box purge system.

d. The relieving capacity of the relief valve shall be equal to or greater than the maximum flow capability of the upstream pressure reducing device or pressure source and shall prevent the pressure from rising more than 20 percent above the system MOP or that allowed by ANSI/ASME B31.3, whichever is less.

e. Pressure relief valves shall be set to operate at a pressure not to exceed 110 percent of the system MOP or that allowed by ANSI/ASME B31.3, whichever is less.

f. Pressure system relief devices shall have no intervening stop valves between piping being protected and the relief devices or between the relief device and the point of discharge except as allowed by ANSI/ASME B31.3, Paragraph 322.6.1. **NOTE:** When a shutoff valve is allowed in accordance with the ANSI or ASME Code, the valve shall have provisions for being safety wired in the OPEN or CLOSED position. The valve shall have permanent marking clearly identifying its position (OPEN or CLOSED).

3.11.2.9.4 Relief Device General Design Requirements.

a. The flow capacity for all relief devices shall be certified in accordance with ASME Code, Section VIII, Division 1, Paragraph UG-127, UG-129, UG 131, and UG 132, as applicable.

b. The body and other pressure containing parts for pressure relief devices should be 300-series stainless steel. *EXCEPTION: DOT cylinders or trailer relief devices may contain parts of brass or bronze.*

c. The relief valve outlet piping shall be sized in accordance with ASME VIII, Division 1, UG-135(g).

d. The static back pressure developed at the discharge flange of the relief valve shall be held to within 10 percent of the set pressure of the relief valve.

e. All relief valves and piping shall be structurally restrained to eliminate any thrust effects from transferring moment forces to the vessel nozzles or lines.

f. The effects of the discharge from relief devices shall be assessed and analyzed to ensure that operation of the device will not be hazardous to personnel or equipment. Items to be analyzed are thrust loads, noise, impingement of high velocity gas or entrained particles, toxicity, oxygen enrichment,

flammability, and oxygen deprivation.

g. All pressure relief devices shall be vented separately unless the following can be positively demonstrated:

1. The creation of a hazardous mixture of gases in the vent system and the migration of hazardous gases into an unplanned environment is impossible.

2. The capacity of the vent system is adequate to prevent a pressure rise more than 20 percent above MOP or exceed 10 percent of the set pressure of the valve in accordance with ASME Section VIII, Division 1, Appendix M, Paragraph M-8. **NOTE:** The analysis shall assume that all relief valves connected to the vent system are open and flowing full capacity.

3.11.2.10 Ground Support Pneumatic System Vents

a. Pressure systems shall be designed so that pressure cannot be trapped in any part of the system without vent capability. *EXCEPTION: Loosening of fittings to vent trapped pressure is allowed when the fluid under pressure is non-hazardous and only for the purpose of calibrating or replacing pressure gauges or transducers that are provided with an upstream isolation valve where the total trapped volume does not exceed 1 and 1/2 cubic in.*

b. Vent system outlets shall be in a location normally inaccessible to personnel and shall be conspicuously identified.

c. Vent outlets shall be protected against rain intrusion and entry of birds, insects, and animals.

d. Oxidizer and fuel vent outlets to the atmosphere shall be separated sufficiently to prevent mixing of vented fluids.

e. All vent outlets shall be designed to preclude accumulation of vented fluid in dangerous concentrations in areas frequented by unprotected personnel or motor vehicles.

f. Vent line supports shall be designed to withstand reaction loads due to the actuation of safety relief devices in accordance with ANSI/ASME B31.3, Paragraph 322.6.2.

g. Each line venting into a multiple use vent system shall be protected against back pressurization by a check valve if the upstream system cannot withstand the back pressure or where contamination of the upstream system cannot be tolerated.

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3.11.2.11 Test Requirements for Ground Support Pneumatic Systems Prior to Assembly

a. All permanently installed pressure vessels except DOT vessels shall be hydrostatically tested in accordance with ASME Code, Section VIII, Division 1, Paragraph UG-99, UG-100 or Division 2, Article T-3 or T-4, as applicable.

b. Pressure vessels designed to meet DOT specifications shall undergo qualification and proof testing in accordance with DOT requirements.

c. All other fluid system components such as piping, tubing, flex hoses, valves, filters, fittings, and pressure regulators (not including pressure gauges, transducers, or rupture discs) shall be hydrostatically tested to a minimum of 1.5 times the component MAWP for a minimum of 5 min.

d. Hydrostatic or pneumatic testing shall demonstrate that there is no distortion, damage, or leakage of components at the appropriate test level pressure.

e. Both the inlet and discharge sides of a relief valve shall be hydrostatically tested. When the discharge side has a lower pressure rating than the inlet side, they are to be hydrostatically tested independently.

f. The following inspections shall be performed after hydrostatic testing:

1. Mechanical components such as valves, regulators, piping, and fitting shall be inspected for distortion or other evidence of physical damage. Damaged components shall be rejected.

2. After completion of the hydrostatic tests, a function and leak test shall be performed at the MAWP of the component.

g. Pressure relief valves shall be tested for proper setting prior to installation and periodically thereafter.

h. Pressure gauges and transducers shall be hydrostatically tested to a minimum of 1.5 times the system MOP.

i. Pressure gauges and transducers shall be calibrated prior to installation and periodically thereafter.

j. Pneumatic testing to a test pressure of 1.25 times MAWP in lieu of hydrostatic testing is permissible if hydrostatic testing is impractical, impossible, or will jeopardize the integrity of the component or system. **NOTE:** Prior approval for pneumatic proof testing at the Ranges shall be obtained from Range Safety.

k. Components may be initially hydrostatically

tested to 1.5 times the system MOP after installation in a system. **NOTE:** This approach should be avoided if possible and shall be approved by Range Safety.

3.11.2.12 Test Requirements for Ground Support Pneumatic Systems After Assembly

3.11.2.12.1 Hydrostatic Tests. All newly assembled pressure systems shall be hydrostatically tested to 1.5 times MOP prior to use. **NOTE:** Where this is not possible, Range Safety will determine the adequacy of component testing and alternate means of testing the assembled system.

3.11.2.12.2 Leak Tests.

a. All newly assembled pressure systems, except systems designed, fabricated, inspected, and tested in accordance with DOT requirements, shall be leak tested at the system MOP prior to first use at the Ranges.

b. This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

c. Minimum test requirements are as follows:

1. The gas used during the leak test shall be the same as the system fluid media except those used for hazardous gas systems. A system compatible non-hazardous gas may be used that has a density as near as possible to the system fluid (for example, helium should be used to leak test a gaseous hydrogen system).

2. At a minimum, all items such as mechanical connections, gasketed joints, seals, valve bonnets, and weld seams shall be visually bubble tight for a minimum of 1 min when leak tested with MIL-L-25567 Type 1 or equivalent leak test solution.

3. Alternate methods of leak testing such as the use of portable mass spectrometers may be approved on a case-by-case basis.

4. Non-hazardous liquid systems may be leak tested using the normal system service.

3.11.2.12.3 System Validation and Functional Tests.

a. All newly assembled pressure systems shall have a system validation test and a functional test of each component at system MOP prior to first operational use at the Ranges.

b. These tests shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

c. Minimum test requirements are as follows:

1. Tests shall demonstrate the functional capability of all components such as valves, regulators, orifices, and gauges.

2. All operational sequences for the system shall be executed.

3. All shutoff and block valves shall be leak checked downstream to verify their shutoff capability in the CLOSED position.

3.11.2.12.4 Bonding and Grounding Tests. All newly assembled pressure systems that contain flammable/combustible fluids shall be tested to verify that the requirements of the **Ground Support Pressure Systems Bonding and Grounding** section of this Chapter have been met.

3.11.2.13 Periodic Test Requirements for Ground Support Pneumatic Pressure System Components

a. Flex hoses shall be hydrostatically proof tested to 1.5 times their MAWP once a year. *EXCEPTION: This requirement does not apply to flex hoses that are permanently installed, located, and operated in an environment that does not exceed the rated temperature, pressure, and shelf life of the hose.*

b. At least annually, all permanently installed flex hoses shall be visually inspected over their entire length for damaged fittings, broken braid, kinks, flattened areas, or other evidence of degradation.

c. Pressure gauges and transducers shall be calibrated once a year.

d. Pressure relief valves shall be tested for proper setting and operation once a year.

e. All newly assembled pressure systems that contain flammable or combustible fluids shall be tested to verify that the bonding and grounding requirements of the **Ground Support Pressure System Bonding and Grounding** section of this Chapter have been met.

3.11.2.14 Testing Modified and Repaired Ground Support Pneumatic Systems

a. Any pressure system or system component including fittings or welds that has been repaired, modified, or possibly damaged, subsequent to having been hydrostatically tested, shall be retested hydrostatically to 1.5 time MAWP prior to reuse. **NOTE:** Replacement of gaskets, seals, and valve seats that do not affect the structural integrity does not require a retest.

b. After hydrostatic testing, modified or repaired pneumatic systems shall be leak tested at the system

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MOP prior to placing them back in service. **NOTE:** This test shall be conducted at the Ranges unless prior approval has been obtained from Range Safety.

c. After hydrostatic testing, modified or repaired pneumatic systems shall be functionally tested at the system MOP prior to reuse.

d. All pneumatic system mechanical joints affected in the disconnection, connection, or replacement of components shall be leak tested at the system MOP before being placed back in service.

3.11.3 Ground Support Hydraulic Systems

3.11.3.1 Ground Support Hydraulic System General Design Requirements

a. Where necessary, hydraulic system “low-points” shall be fitted with a drain fitting (bleed ports) to allow draining of condensates or residue. **NOTE:** Entrapped air, moisture, and cleaning solvents are examples of foreign substances that may be hazardous to the system, component, or control equipment.

b. Bleed ports should be located so that they can be operated with minimal removal of other components and permit the attachment of a hose to direct the bleed off material into a container, away from the positions of the operators.

c. Test points shall be provided on hydraulic systems so that disassembly for test is not required.

d. Test points shall be easily accessible for attachment of ground test equipment.

e. For all power-generating components, pump pulsations shall be controlled to a level that does not adversely affect system tubing, components, and support installation.

f. When two or more hydraulic actuators are mechanically tied together, only one lock valve shall be used to hydraulically lock all the actuators.

g. The ambient operating temperature for hydraulic systems shall not exceed 275°F for systems using petroleum based fluids.

h. Fluids for systems operating at temperatures higher than 275°F shall be fire resistant or fireproof for the intended service.

i. Where system leakage can expose hydraulic fluid to potential ignition sources, fire resistant or flameproof hydraulic fluid shall be used.

j. All hydraulic piping installations shall be designed, installed, and tested in accordance with

ANSI/ASME B31.3.

3.11.3.2 Ground Support Hydraulic System Accumulators and Reservoirs

a. Accumulators and reservoirs that are pressurized with gas to pressures greater than 250 psig shall be designed, constructed, tested, certified, and code stamped in accordance with ASME Code, Section VIII, Division 1 or Division 2.

b. Hydraulic system reservoirs shall be provided with a fluid level indicator. **NOTE:** If a sight glass is used for a liquid level indicator, it shall be properly protected from physical damage.

c. Only inert gases shall be used in pressurization accumulators in systems operating at pressures in excess of 200 psi or temperatures over 160°F unless adequate fire and explosion resistance is demonstrated.

d. For a gas pressurized reservoir, the gas pressure shall be controlled by an externally non-adjustable pressure regulating device to control the gas pressure in the reservoir.

e. Hydraulic systems having reservoir filling caps shall include design provisions that will automatically vent the reservoir opening.

3.11.3.3 Ground Support Hydraulic System Pumps

a. The *Standards of the Hydraulic Institute* should be used as a guide in selecting a safe pump.

b. Gear pumps shall not be used for high pressure applications.

c. The inlet pressure of hydraulic pumps should be controlled to prevent cavitation effects in the pump passage or outlets.

d. Hydraulic pumps required to provide emergency power shall not be used for any other function.

e. Hydraulic pressure systems shall have regulators with a pressure relieving or self-bleeding feature.

3.11.3.4 Ground Support Hydraulic System Pressure Gauges

a. Pressure snubbers shall be used with all hydraulic pressure transmitters, hydraulic pressure switches, and hydraulic pressure gauges. *EXCEPTION: Pneumatic pressure gauges are excluded from this requirement.*

b. A gauge indicating accumulator gas pressure shall never be used to indicate equivalent hydraulic

lic pressure.

3.11.3.5 Ground Support Hydraulic System Pressure Relief Devices

a. A pressure relief valve shall be installed as close as is practical downstream of each pressure reducing device (regulator or orifice) or downstream of any source of pressure (pump, reservoir, or accumulator) whenever any portion of the downstream system cannot withstand the full upstream pressure. **NOTE:** The criteria for *withstand* is that the upstream pressure shall not exceed the MAWP of any component downstream of the regulator or pressure source.

b. A pressure relief valve shall be installed downstream of the last GSE regulator prior to flight hardware interface.

c. The relieving capacity of the relief devices shall be equal to or greater than the maximum flow capacity of the upstream pressure source and shall prevent the pressure from rising more than 20 percent of MOP or that allowed by ANSI/ASME 31.3, Paragraphs 301.2.2 and 322.6.3, whichever is less.

d. Pressure relief valves shall be set to operate at a pressure not to exceed 110 percent of the system MOP or that allowed by ANSI/ASME, whichever is less.

e. The effects of discharge from relief devices shall be assessed and analyzed to ensure that operation of the device will not be hazardous to personnel or equipment. **NOTE:** Items to be analyzed are thrust loads, toxicity, combustibility, and flammability.

f. Pressure system relief devices shall have no intervening stop valves between piping being protected and the relief devices or between the relief device and the point of discharge, except as allowed per ANSI/ASME B31.1, Paragraph 322.6.1.

g. When a shutoff valve is allowed in accordance with the ASME Code, the valve type shall have provisions for being safety wired in the OPEN or CLOSED position.

h. The shutoff valve shall have permanent marking clearly identifying its position (OPEN or CLOSED).

i. Thermal expansion relief valves shall be installed as necessary to prevent system damage from thermal expansion of hydraulic fluid.

j. The thermal relief valve setting shall not exceed either the system test pressure or 120 percent of the system MOP.

3.11.3.6 Test Requirements for Ground Support Hydraulic System Components Prior to Assembly

a. All accumulators and reservoirs that are pressurized with gas to pressures greater than 250 psig shall be hydrostatically tested in accordance with ASME Code, Section VIII, Division 1, Paragraph UG-99, UG-100 or Division 2, Article T-3 or T-4, as applicable.

b. All other hydraulic system components (not including pumps, pressure gauges and transducers, and rupture disks) shall be hydrostatically tested to 1.5 times the component MAWP for a minimum of 5 min. **NOTE:** Testing shall demonstrate that the components will sustain test pressure levels without distortion, damage, or leakage.

c. Both the inlet and outlet sides of a relief valve shall be hydrostatically tested. When the discharge side has a lower pressure rating than the inlet side, they are to be hydrostatically tested independently.

d. The following inspections shall be performed after hydrostatic testing:

1. Mechanical components such as valves, filters, piping, fittings, and regulators shall be inspected for distortion or other evidence of physical damage. Damaged components shall be rejected.

2. After completion of hydrostatic tests, functional and leak tests shall be performed at the component MAWP.

e. Pressure gauges and transducers shall be calibrated prior to installation and periodically thereafter.

f. Pressure relief valves shall be tested for proper setting prior to installation and periodically thereafter.

g. Components may be initially hydrostatically tested to 1.5 times the system MOP after installation in a system. **NOTE:** This approach should be avoided, if possible. Range Safety approval is required to use this approach.

3.11.3.7 Test Requirements for Ground Support Hydraulic Systems After Assembly

3.11.3.7.1 Hydrostatic Testing. All newly assembled hydraulic pressure systems shall be hydrostatically tested to 1.5 times MOP prior to use. **NOTE:** Where this is not possible, Range Safety will determine the adequacy of component testing and an alternate means of testing the assembled system.

3.11.3.7.2 Leak Tests.

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a. All newly assembled hydraulic systems shall be leak tested at the system MOP prior to first use at the Ranges.

b. This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

c. Minimum test requirements are as follows:

1. The fluid used during the leak test shall be the same as the system fluid media.

2. Mechanical connections, joints with gaskets, seals, valve bonnets, and other components shall be inspected for leaks while monitoring for any pressure decay.

3.11.3.7.3 System Validation and Functional Tests.

a. All newly assembled hydraulic pressure systems shall have a system validation test and a functional test of each component at system MOP prior to first use at the Ranges.

b. These tests shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

c. Minimum test requirements are as follows:

1. Tests shall demonstrate the functional capability of all components such as valves, pumps, orifices, and gauges.

2. All operational sequences for the system shall be executed.

3. All shutoff and block valves shall be leak checked downstream to verify their shutoff capability in the CLOSED position.

3.11.3.8 Periodic Test Requirements for Ground Support Hydraulic System Components

a. Flex hoses shall be hydrostatically tested to 1.5 times their MAWP once a year. *EXCEPTION: This requirement does not apply to flex hoses that are permanently installed, located, and operated in an environment that does not exceed the rated temperature, pressure and shelf life of the hose.*

b. All permanently installed flex hoses shall be visually inspected over their entire length at least annually for damaged fittings, broken braid, kinks, flattened areas, or other evidence of degradation.

c. Pressure gauges and transducers shall be calibrated once a year.

d. Pressure relief valves shall be tested for proper setting and operation once a year.

3.11.3.9 Testing Modified and Repaired Ground Support Hydraulic Systems

a. Any hydraulic system or system component, including fittings or welds, that has been repaired, modified, or possibly damaged, subsequent to having been hydrostatically tested, shall be retested hydrostatically prior to reuse. **NOTE:** Replacement of gaskets, seals, and valve seats that do not affect the valve structural integrity does not require a retest.

b. After hydrostatic testing, modified or repaired hydraulic systems shall be leak tested at the system MOP before being placed back in service. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

c. After hydrostatic testing, modified or repaired hydraulic systems shall be functionally tested at the system MOP prior to being placed back in service.

d. All hydraulic system mechanical joints affected in the disconnection, connection, or replacement of components shall be leak tested at the system MOP.

3.11.4 Ground Support Hypergolic Propellant Systems

This section contains minimum design requirements for all fixed, mobile, or portable equipment used to handle hypergolic propellants (Nitrogen Tetroxide [N_2O_4], Hydrazine [N_2H_4], Unsymmetrical Dimethyl Hydrazine [UDMH], Aerozine 50 [A-50], Mono Methyl Hydrazine [MMH]).

3.11.4.1 Ground Support Hypergolic Propellant System General Design Requirements

a. GSE used to handle hypergolic propellant systems shall be designed to ensure that all incompatible fuels and oxidizers are separated so that operations during the prelaunch phase cannot cause inadvertent mixing of the propellants.

b. Propellant systems shall have low point drain capability.

c. Low point drains shall be accessible and located in the system to provide the capability of removing propellant from the tanks, piping, lines, and components.

d. Pumps used in hypergolic propellant systems shall be of the centrifugal type and specifically designed for pumping hypergolic propellants.

e. Bi-propellant propellant systems shall have the

capability of loading fuel and oxidizer systems one at a time.

f. Systems shall be designed so that the system being loaded (flight propulsion systems or ground propellant tanks) and the propellant loading system can be commonly grounded and bonded during propellant transfer operations. **NOTE:** Loading systems include portable vessels and units.

g. For failure modes that could result in a time-critical emergency, provision shall be made for automatic switching to a safe mode of operation. **NOTE:** Caution and warning signals shall be provided for these time-critical functions.

h. Pneumatic systems servicing fixed, portable, and mobile hypergolic propellant systems shall comply with the **Ground Support Pneumatic Systems** section of this Chapter.

i. Components used in any fuel or oxidizer system shall not be interchanged after exposure to the respective media.

j. Lubricants for hypergolic systems shall be approved compatible lubricants only. **NOTE:** See KSC-SPEC-Z-0006 for guidance.

3.11.4.2 Mobile and Portable Ground Support Hypergolic Propellant Systems

a. Mobile equipment for public and Range highway use shall be designed to meet the requirements in 49 CFR, Subpart 6, Parts 100 through 199. **NOTE:** A copy of any DOT approved exemptions shall be provided to Range Safety.

b. Portable equipment used for storage or transportation of hypergol propellants or hypergol waste shall be designed to meet applicable requirements for packaging set by the DOT in 49 CFR. **NOTE:** Consideration in the design shall be given to the limitations imposed on individuals dressed in SCAPE.

3.11.4.3 Ground Support Pneumatic and Hypergolic Propellant Systems Interface

The minimum design requirements for controlling the migration of liquid or gas hypergolic propellant into an associated pneumatic system are as follows:

a. Each pneumatic branch line that interfaces with a hypergolic propellant system shall have a hand-operated shutoff valve upstream of a regulator and a spring-loaded, poppet-type check valve to permit positive shutoff of the pneumatic supply and prevent back flow through the branch.

b. Each pneumatic branch supply shall interface with only one type of hypergolic propellant (fuel or

oxidizer).

c. A sampling port shall be provided upstream and downstream of each regulator referred to in the *a* above to permit periodic sampling and analysis of the pneumatic medium for hypergol contamination.

d. A single pressure gauge shall be provided at some point downstream either in the pneumatic system or the hypergol system of each check valve referred to in paragraph *a* above to indicate the pressure in the hypergolic propellant system.

e. Gage calibration ports shall be designed to limit potential impingement of contaminated gas on personnel.

f. Downstream of the pneumatic pressure regulator, including the regulator seat, the pneumatic system shall be constructed of materials that are compatible with all of the hypergolic propellants serviced by the pneumatic supply.

g. Downstream of the pneumatic pressure regulator, the pneumatic system shall be identified and marked as a hypergolic system.

3.11.4.4 Ground Support Fixed and Mobile Hypergolic Propellant Storage Vessels

a. All permanently installed pressure vessels shall be designed, constructed, tested, certified, registered, and code stamped in compliance with the ASME Boiler and Pressure Vessel Code, Section VIII, Pressure Vessels (Unfired), Division 1 or Division 2, Lethal Service.

b. All ASME code stamped vessels shall be registered with the National Board of Boiler and Pressure Vessel Inspectors.

c. The following additional design, fabrication, and inspection requirements shall be met:

1. Pressure vessels shall be designed with an opening for inspection purposes.

2. Pressure retaining welds including all shell, head nozzle and nozzle to head and shell welds shall be inspected using volumetric NDE techniques.

3. At a minimum, all attachment welds such as supports, lugs, pads, and name plates shall be inspected using surface NDE techniques.

4. Welded attachments such as stiffening rings or supports shall be continuously welded.

5. Welded and bolted attachments to the pressure vessel such as piping, supports, ladders, and platforms shall be minimized.

6. External and internal surfaces of vessels shall be free of crevices and other areas that can trap moisture or contaminants.

7. All attachments shall be positioned in such a

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manner that no attachment weld will overlap any category A or B weld as defined by ASME Code, Section VIII, Division 1 or Division 2.

8. All fixed pressure vessels exposed to the atmosphere and winds shall be designed with a minimum 2 psig external pressure load.

9. Pressure vessel material shall be stainless steel, type 304L, unless otherwise approved. **NOTE:** The use of high carbon content stainless steel such as type 304 is subject to chromium carbide precipitation during welding and bending activities.

10. A 1/16-in. additional thickness shall be added to the design wall thickness above the minimum required for pressure, liquid head, and other load conditions.

11. All pressure vessels shall be designed to allow for a minimum 10 percent ullage space at full load conditions.

12. Pressure vessel saddle support shall be designed in accordance with ASME Boiler and Pressure Vessel Code, Appendix G sanctioned guidelines, such as those developed by L.P. Zick, or a detailed (finite element) analysis shall be performed.

13. Consideration shall be given to anchor bolt design capability for hold down in the event of a deluge water filled bay (buoyant force of vessel), if applicable.

14. One of the two supports of a fixed vessel shall be capable of providing for expansion and contraction of the vessel.

15. A suitable anti-friction solid material shall be placed between sliding surfaces.

16. Slots shall be provided for bolts to account for expansion.

17. All fixed hypergolic fuel vessels shall be designed with a minimum value of 75 psig MAWP.

18. All fixed hypergolic oxidizer vessels shall be designed with a minimum value of 100 psig MAWP.

19. Liquid sensors, suitable for indicating the presence or absence of liquid, shall be provided.

(a) Metals that could come in contact with the service medium shall be type 304 or 316 stainless steel.

(b) Liquid level indicators that contain welded portions (typically magnetic float type) shall be constructed from type 304L or 316L stainless steel.

(c) The use of glass faced or radiation source

emitting liquid level indicators is prohibited. Other prohibited types include capacitance, conductive, and pressure/density types due to historical operational failures and continuous maintenance problems.

(d) Sight glasses used for liquid level indicators shall be protected from physical damage.

20. Waste tank design and operating criteria shall be determined by the type (hazardous or non-hazardous) to be maintained in the specified tank.

(a) All underground hazardous waste tanks and ancillary piping shall comply with the requirements in 40 CFR 264.193 and 40 CFR, Part 280.

(b) Waste tanks may be located above ground or underground.

(c) All underground waste tanks and ancillary piping shall have secondary containment systems with leak detection capability.

21. Portable and/or mobile pressure vessels used for the transportation of hazardous materials shall be designed, fabricated, inspected, and tested in accordance with 49 CFR.

3.11.4.5 Ground Support Hypergolic Propellant System Piping

3.11.4.5.1 Piping Design and Material.

a. All hypergol piping design shall be in accordance with ANSI/ASME B31.3, Category M.

b. Pipe shall conform to ANSI/ASME B36.19.

c. The pipe material shall comply with ASTM A312, type 304L or 316L.

d. Only seamless, cold-drawn pipes shall be used for hypergol services.

e. NPT connectors shall not be used.

3.11.4.5.2 Pipe Fittings.

a. Pipe fittings shall be full penetration butt weld only and shall conform to ANSI B16.9.

b. Fittings shall be type 304L or 316L material conforming to ASTM A403.

c. Welded fittings such as tees, elbows, reducers, crosses, lap joint, and stub ends shall be seamless (WP-S) or welded and X-rayed (WP-WX) type.

d. Socket weld and pipe thread fittings are not permitted.

3.11.4.5.3 Flanges and Flange Connections.

a. Flanged connections shall use weld neck or lap joint flanges only.

b. Pipe flanges shall conform to ANSI B16.5 and be constructed of forged type 304L or 316L

material in accordance with ASTM A182.

c. All flanges shall be raised face and shall be concentric serrated per MSS-SP-6.

d. Flange gaskets shall conform to ANSI B16.21 and shall be installed between flanges at all flanged connections.

e. Flange gasket material shall be shown to be compatible with the hypergol.

f. Flange bolting and studs shall conform to ANSI/ASME B18.2.1 recommended dimensions and shall use ANSI/ASME B1.1 coarse threads.

g. Bolt materials shall be in accordance with ASTM A193 (type 304 stainless steel) or ASTM A320 (type 316 stainless steel).

h. Nuts for flange bolting and studs shall conform to ASME B18.2.2 heavy hex type per ASTM A194 (type 304 stainless steel) or ASTM A194 (type 316 stainless steel) and shall use ANSI/ASME B1.1 coarse threads.

i. Type 304 or 316 stainless steel washers shall be used at both ends of each flange bolt or stud.

3.11.4.5.4 Piping and Fitting Weld Inspection.

a. All piping and fitting welds shall be 100 percent radiographically inspected.

b. The accept and reject criteria shall be in accordance with Table 341.3.2A of ANSI/ASME B31.3.

3.11.4.6 Ground Support Hypergolic Propellant System Tubing

a. Tubing shall be seamless, type 304 or type 316 stainless steel per ASTM A269 or KSC-SPEC-Z-0007.

b. Tubing used with AN or MS fittings shall be flared per MS33584, and tubing used with KSC-GP-425 fittings shall be flared per KSC-GP-425.

c. Mechanical connections in tubing shall use type 316 stainless steel precision-type 37E threaded fittings per AN, MS, or KSC-GP-425 standards. All seals for tube fittings shall be teflon. Crush washers are prohibited.

d. Fabrication and installation of tubing using KSC-P-425 fittings shall be in accordance with KSC-SPEC-Z-0008.

e. The number of mechanical joints in tubing systems shall be kept to a minimum.

f. All tubing welds shall be 100 percent radiographically inspected. The accept and reject criteria shall be in accordance with section 4.5.2 of KSC-SPEC-Z-0020. **NOTE:** If this criteria cannot be met, the Range User shall submit alternate

accept and reject criteria to Range Safety for review and approval.

g. NPT connectors shall not be used.

3.11.4.7 Ground Support Hypergolic Propellant System Valves

a. Metal-to-metal seats for shutoff valves in hypergolic service are not permitted without Range Safety approval.

b. Remote operated flow control valves shall be operated pneumatically, electrically, or hydraulically and shall be capable of fail-safe operation to either the OPEN or CLOSED position. **NOTE:** Determination of fail-safe mode (the OPEN or CLOSED position) shall depend on the system characteristics and shall be approved by Range Safety.

c. Check valves shall be the spring-loaded type with soft seats.

d. Electrically operated (solenoid) valves may be used, although pneumatically operated valves are preferred. Both primary and secondary valve seals shall be compatible with the service fluid.

e. Metal valve parts in contact with the working fluid shall be type 304, 304L, 316, or 316L stainless steel.

f. Manual and remote controlled valve actuators shall be capable of completely opening or closing shutoff valves under the maximum possible pressure and flow conditions in the system.

g. Valve stem travel shall be limited by a positive stop at each extreme position.

h. The application or removal of force to a valve stem positioning device shall not cause disassembly of the pressure containing structure of the valve.

i. Valves with uncontained seats are prohibited.

j. All electrical control circuits for remotely actuated valves shall be shielded or otherwise protected from hazardous stray energy.

k. Manually operated valves shall be designed so that overtightening the valve stem cannot damage soft seats to the extent that seat leakage occurs.

l. Isolation valves shall be bi-directional and capable of isolating MAWP in both directions without seat failure.

m. Inlet and outlet isolation valves and appropriate intermediate vent valves shall be provided for shutdown and maintenance.

n. Local or remote stem position indicators shall sense the position of the stem directly, not the position of the actuating device.

o. Valves used in flared tubing system applica-

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tions shall be designed for panel or other rigid mounting.

p. Valves that are not intended to be reversible shall be designed or marked so that they will not be connected in a reverse mode.

q. Systems shall have shutoff valves located as close to the supply vessel as practical and be readily accessible.

r. Check valves shall be provided where back flow of fluids would create a hazard.

s. The use of sheathed flexible actuators such as push pull wires and torque wires for valve control is prohibited.

t. Valve connectors and connections shall be designed, selected, or located (or as a last resort marked) so that they are unlikely to be inadvertently connected to an incompatible system.

u. All hazardous pressure system valves that shall remain in a CLOSED or OPEN position during system operation shall be protected against inadvertent actuation by mechanical stops, lock wires, or access control.

v. Remotely controlled valves shall provide for remote monitoring of OPEN and CLOSED positions.

3.11.4.8 Ground Support Hypergolic Propellant System Indicating Devices

a. A pressure indicating device such as a pressure gauge, pressure switch, or pressure transducer shall be connected downstream of each pressure regulator, on each storage system, and on any section of the system where pressure can be trapped.

b. As determined by Range Safety, remote read-out pressure transducers are required when it is necessary to monitor hazardous operations from a remote location.

c. Pressure gauges shall conform to the ANSI/ASME B40.1. except as specified below:

1. Gauges shall be selected so that the normal operating pressure falls between 25 percent and 75 percent of the scale range, except for gauges used in applications that require a very wide range of operating pressure. For these applications, the pressure gauges shall be selected so that the maximum pressure that can be applied shall not exceed 95 percent of the scale range of the gauge.

2. Pressure gauges shall be of one-piece, solid-front, metal case construction, with an optically clear shatterproof window of high-impact, non-cracking plastic, heat-treated glass, or laminated

glass.

3. All pressure gauges shall be equipped with a full diameter pressure release back capable of being sized for maximum flow without case rupture. The use of blowout plugs is not recommended.

4. Gauges shall be securely attached to a panel or other rigid mounting.

5. All pressure gauges should be provided with a bourdon tube tip bleeder or equivalent device to facilitate cleaning.

d. All pressure gauge material normally in contact with hypergolic fluid shall be type 316 stainless steel except that the bourdon-tube bleed screw may be made from any of the 300 series stainless steels.

e. Each pressure indicating device shall be provided with an isolation valve and a test connection (test port) between the isolation valve and the pressure indicating device.

f. Trapped volume between the isolation valve and the pressure indicating device shall not exceed 1.5 cubic in.

g. Pressure gauge isolation valves shall be designed so that they can be lock wired in the OPEN position.

h. Gauge installations shall be designed to have a minimum 1-in. clearance in the back to provide unrestricted venting in the event the gauge vents.

i. Personnel and critical equipment shall be protected from potential venting hazards.

3.11.4.9 Ground Support Hypergolic Propellant System Flexible Hoses

a. Flexible hoses shall be used only when required for hookup of portable and mobile equipment or to provide for movement between interconnecting fluid lines when no other feasible means are available.

b. Hoses shall consist of a seamless polytetrafluoroethylene (PTFE) or compounded PTFE inner tube reinforced with a 300-series stainless steel wire construction of braid or spiral wrap, or a combination thereof, or shall consist of a flexible 300-series stainless steel pressure carrier reinforced with 300-series stainless steel braid.

c. Hoses shall be provided with 300-series stainless steel end fittings of the coupling nut, 37E flared type, or with the appropriate ANSI/ASME B16.4 raised-face pipe flange with concentric serrations per MSS-SP-6. **NOTE:** Other end fittings may be used for unique applications, subject to Range Safety approval.

d. Flex hose installation shall be designed to avoid abrasive contact with adjacent structures or moving parts.

e. Flex hose assemblies shall not be installed in a manner that will place a mechanical load on the hose or hose fittings to an extent that will degrade hose strength or cause the hose fitting to loosen.

f. Flexible hose shall not be supported by rigid lines or components if excessive loads from flex hose motion can occur.

g. Flexible hose between two components may have excessive motion restrained where necessary, but shall never be rigidly supported by a tight rigid clamp around the flexible hose.

h. The bend radius of flex hoses shall be designed to be no less than the safe minimum bend radius recommended in authoritative specifications for the particular hose and in no case less than 5 times the outside diameter of the hose.

i. A means of plugging or capping flex hoses shall be provided when they are not in use.

j. All flexible hoses that are not lined shall be subjected to a flow-induced vibration analysis. **NOTE:** A guidance document for performing this analysis is MSFC 20MO2540.

3.11.4.10 Ground Support Hypergolic Propellant System Pressure Relief Devices

a. All fixed hypergolic pressure vessels shall be protected from overpressure by means of at least one spring-loaded type relief valve. **NOTE:** Required relieving capacity should be provided by means of a single relief valve, if possible. Rupture disks alone shall not be used to protect against overpressure.

1. A rupture disc may be installed upstream or downstream of a hypergol vessel relief valve, provided the limitations of ASME Code, Section VIII, Division 1, Paragraphs UG-127(a)(3)(b) and UG-127(a)(3)(c), or Division 2, Article R-1, Paragraphs AR-131.4 and AR-131.5 are met.

2. The space between a rupture disc and a relief valve shall be designed to allow annual testing for leakage and/or contamination.

3. All rupture discs shall be replaced every two years or sooner based on manufacturer recommendations. **NOTE:** Providing a screen between the rupture disc and the valve to prevent rupture disc contamination of the relief valve should be considered.

4. Installation of relief valves shall be in accordance with ASME Code, Section VIII, Division 1,

Paragraph UG-135 or Division 2, Article R-1.

5. The required total relieving capacity required shall be determined in accordance with ASME Code, Section VIII, Division 1, Paragraph UG-133 or Division 2, Paragraph AR-150, as applicable.

6. Relieving capacity required due to possible exposure of hypergol vessels to fire conditions shall be incorporated in accordance with the ASME Code, Section VIII, Division 1, Appendix M, Paragraph M-14, and applicable references therein. **NOTE:** Reductions in required relieving capacity due to lowering of heat input because of water deluge systems should be considered in the design. Refer to NFPA codes for Compressed Gas Association (CGA) correlation to reduced heat input factors.

7. Pressure relief devices shall be set to operate at a pressure not to exceed the MAWP of the vessel. See ASME Code, Section VIII, Division 1, Paragraphs UG-134(a), UG-134(b), UG-134(c), and UG-134(d)(1).

8. Negative pressure protection shall be provided for vessels not designed to withstand pressures below 1 atmosphere. **NOTE:** This protection can be accomplished by the use of check valves or negative pressure relief devices.

b. DOT pressure vessels shall be protected against overpressure in accordance with 49 CFR.

c. A pressure relief valve shall be installed immediately upstream of the GSE/flight hardware interface. Minimum flow and set pressure requirements are as follows:

1. The relieving capacity shall be sufficient to prevent the downstream pressure from exceeding the allowable limits of the flight hardware or 20 percent above the GSE system MOP, whichever is less. **NOTE:** The analysis shall assume that all relief valves connected to the vent system are open and flowing full capacity.

2. The relief valve shall be set to operate no higher than 110 percent of the GSE MOP or the flight hardware pressure limit, whichever is less.

3.11.4.11 Ground Support Hypergolic Propellant System General Relief Devices

a. The flow capacity for all relief devices shall be certified in accordance with ASME Code, Section VIII, Division 1, Paragraphs UG-127, UG-129, UG-131, and UG-132, as applicable.

b. The body and other pressure containing parts for pressure relief devices shall be type 304 or 316 stainless steel.

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c. The relief valve outlet piping shall be sized in accordance with ASME VIII, Division 1, UG-135(g). The static back pressure developed at the discharge flange of the relief valve shall be held to within 10 percent of the set pressure of the relief valve.

d. All relief valves and piping shall be structurally restrained to eliminate any thrust effects from transferring moment forces to the vessel nozzles or lines.

e. The effects of the discharge from relief valves shall be assessed and analyzed to ensure that operation of the device will not be hazardous to personnel or equipment. **NOTE:** Items to be analyzed are thrust loads, noise, impingement, and high velocity gas or entrained particles, toxicity, and flammability.

f. No obstructions to flow shall be installed downstream of any relief device except as allowed per ASME Code, Section VIII, Division 1, Appendix M, Paragraph M-6. **NOTE:** Shutoff valves that are permitted shall be permanently marked to identify valve position (OPEN or CLOSED).

g. Pressure relief systems shall be equipped with an isolation valve between the relief valve inlet manifold and the vessel outlet nozzle for inspection and repair purposes. **NOTE:** This valve shall be designed to be locked open.

h. A three-way valve with dual relief valve is required where continuous operation of the system is needed during relief valve calibration.

3.11.4.12 Ground Support Hypergolic Propellant System Vents

a. All hypergolic vent effluent resulting from routine operations shall be scrubbed prior to venting to the atmosphere through vent stacks.

b. GSE that is intended to transfer hypergolic propellants shall be designed to preclude unnecessary liquid traps.

c. All scrubber and incinerator designs and qualification tests shall be reviewed and approved by Range Safety, Bioenvironmental Engineering, and Civil Engineering.

d. Hypergolic systems shall be designed so that pressure cannot be trapped in any part of the system without vent capability.

e. Vent system outlets shall be in a location normally inaccessible to personnel and shall be conspicuously identified.

f. Vent outlets shall be protected against rain intrusion and entry of birds, insects, and animals.

g. Oxidizer and fuel vent outlets to the atmosphere shall be separated sufficiently to prevent mixing of vented fluids.

h. Special attention shall be given to the design of vent line supports at vent outlets due to potential thrust loads. **NOTE:** See ANSI/ASME B31.3, Paragraph 322.6.2.

i. Each line venting into a multiple use vent system shall be protected against back pressurization by means of a check valve if the upstream system cannot withstand the back pressure or where contamination of the upstream system cannot be tolerated.

j. Pressure relief vents shall be designed and located so that vapors will not enter any inhabited areas.

k. Incompatible fluids shall not be discharged into the same vent or drain system.

l. Fuel and oxidizer vent systems shall be equipped with a means of purging the system with an inert gas to prevent explosive mixtures.

m. Vent systems shall be sized to provide minimum back pressures consistent with required venting flow rates. In no case shall back pressures interfere with proper operation of relief devices.

3.11.4.13 Testing Ground Support Hypergolic Propellant System Components Prior To Assembly

a. All permanently installed hypergolic pressure vessels, except DOT vessels, shall be hydrostatically tested in accordance with ASME Code, Section VIII, Division 1, Paragraph UG-99, UG-100 or Division 2, Article T-3 or T-4, as applicable.

b. Hypergolic pressure vessels designed to meet DOT specifications shall undergo qualification and hydrostatic testing in accordance with DOT requirements.

c. All components (not including pressure gauges and transducers and rupture disks) shall be hydrostatically tested to 1.5 times the component MAWP for a minimum of 5 min. **NOTE:** The test shall demonstrate that the components will sustain this test pressure without distortion, damage, or leakage.

d. Both the inlet and outlet sides of relief valves shall be pressure tested. When the discharge side has a lower pressure rating than the inlet side, the inlet and outlet shall be hydrostatically tested independently.

e. All mechanical components such as valves, fil-

ters, flex hoses, and piping shall be inspected for external distortion or other evidence of physical damage. Damaged components shall be rejected.

f. Functional and leak tests shall be performed at the component MAWP after completion of hydrostatic tests.

g. Pressure relief valves shall be tested for proper setting prior to installation and periodically thereafter.

h. Pressure gauges and transducers shall be hydrostatically tested to a minimum of 1.5 times the system MOP.

i. Pressure gauges and transducers shall be calibrated prior to installation and periodically thereafter.

j. Components may be hydrostatically tested to 1.5 times the system MOP after installation into a system; however, this approach should be avoided if possible and approved by Range Safety.

k. Pneumatic testing to a pressure level of 1.25 times MAWP is permissible only if hydrostatic testing is impractical, impossible, or will jeopardize the integrity of the system or system component. Prior approval for pneumatic testing at the Ranges shall be obtained from Range Safety.

l. All valves shall be tested for both external and internal leakage at MAWP with a 10 percent/ 90 percent helium/nitrogen mixture.

1. No external leakage is allowed (bubble-tight).

2. Internal leakage of valves shall not exceed limits specified in the valve performance specification.

3. Where no valve specification exists, the leak rate shall not exceed 1×10^{-6} cc/sec at standard temperature and pressure.

m. Certain critical system components may require further testing (mass spectrometer) in accordance with ASME Code, Section V, Article 10, Appendix IV or V.

3.11.4.14 Testing Ground Support Hypergolic Propellant Systems After Assembly

3.11.4.14.1 Hydrostatic Tests. All newly assembled hypergolic pressure systems shall be hydrostatically tested to 1.5 times MOP prior to use. **NOTE:** Where this is not possible, Range Safety will determine the adequacy of component testing and alternate means of testing the assembled system.

3.11.4.14.2 Leak Tests.

a. After hydrostatic testing and prior to the in-

roduction of propellant, a pneumatic leak test of completely assembled systems shall be conducted at the system MOP using a 10 percent/90 percent helium/nitrogen mixture.

b. All mechanical joints such as gasket joints, seals, threaded joints, connections, and valve bonnets and weld joints shall be visually bubble tight when tested with leak test solution per MIL-L-25567 Type I or equivalent.

c. The functional capability of isolation valves shall be checked. Isolation valves shall not leak internally in either direction with MOP differential applied.

d. Alternate methods of leak testing such as the use of portable mass spectrometers may be specified when required on a case-by-case basis.

e. Systems designed to meet DOT specifications and regulations shall undergo leak testing in accordance with DOT requirements.

3.11.4.14.3 System Validation Test. All newly assembled hypergolic systems shall have a system validation test (hot flow test) performed at the system MOP prior to first operational use at the Ranges. Minimum test requirements are as follows:

a. As applicable, hypergolic fuels or oxidizers shall be used as the test fluid media.

b. The functional capability of all components and subsystems shall be validated.

c. All operational sequences for the system shall be exercised, including emergency shutdown and safing procedures.

3.11.4.14.4 Grounding and Bonding. All newly assembled hypergolic fuel systems shall be tested to verify that the bonding and grounding requirements of the **Ground Support Pressure Systems Grounding and Bonding** section of this Chapter have been met.

3.11.4.15 Periodic Test Requirements for Ground Support Hypergolic Systems

a. Flex hoses shall be hydrostatically tested to 1.5 times their MAWP once a year. *EXCEPTION:* This requirement does not apply to flex hoses that are permanently installed, located, and operated in an environment that does not exceed the rated temperature, pressure, and shelf life of the hose.

b. At least annually, all permanently installed flex hoses shall be visually inspected over their entire length for damaged fittings, broken braid, kinks, flattened areas, or other evidence of degradation.

c. Pressure gauges and transducers shall be cali-

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brated once a year.

d. Pressure relief valves shall be tested for proper setting and operation once a year.

3.11.4.16 Testing Ground Support Modified and Repaired Hypergolic Systems

a. Any hypergolic pressure system or system component, including fittings or welds, that has been repaired, modified, or possibly damaged, subsequent to having been hydrostatically tested, shall be retested hydrostatically to 1.5 times MAWP prior to reuse. **NOTE:** Replacement of gaskets, seals, and valve seats that do not affect the structural integrity does not require a retest.

b. A hypergolic system that has been modified or repaired shall be leak tested at the system MOP before being placed back in service. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

c. Modified or repaired hypergolic systems and components shall be functionally tested (re-validated) at the system MOP before being placed back in service.

d. All hypergolic system mechanical joints affected in the disconnection, connection, or replacement of components shall be leak tested at the system MOP before being placed back in service.

3.11.5 Ground Support Cryogenic Systems

This section contains the minimum design requirements for all fixed, mobile, and portable equipment used to handle liquid oxygen (LO₂ or LOX), or liquid hydrogen (LH₂), liquid helium (LHe), liquid nitrogen (LN₂) and their respective vent gases.

3.11.5.1 Ground Support Cryogenic Systems General Design Requirements

a. Cryogenic systems shall be designed to ensure separation of fuels and oxidizers to prevent their mixing due to inadvertent operations.

b. Cryogenic systems shall be provided with readily accessible low point drain capability to allow draining of tanks and piping systems. **NOTE:** Small volumes contained in valves, filters, and other containers that will boil off in a short period of time do not require low point drain capability.

c. Cryogenic fuel and oxidizer systems shall have the capability of loading one commodity at a time.

d. For failure modes that could result in a time-critical emergency, provision shall be made for automatic switching to a safe mode of operation. **NOTE:** Caution and warning signals shall be provided for these time-critical functions.

e. Systems shall be designed so that the system being loaded (flight propulsion systems or propellant tanks) and the propellant loading system can be commonly grounded and bonded during propellant transfer operations. **NOTE:** Loading systems include portable vessels and units.

f. Pneumatic systems servicing fixed, portable, and mobile cryogenic systems shall comply with the requirements of the **Ground Support Pneumatic Systems** section of this Chapter.

g. Cryogenic systems shall be insulated with compatible material or be vacuum-jacketed to avoid liquefaction of air. **NOTE:** Drip pans or other equivalent means should be provided under flanges when there exists the possibility of leaking liquefied air. Such systems that are not fully insulated and sealed tight or double-walled with a jacket may leak liquefied air.

h. Insulation used in the design of cryogenic systems shall be compatible. **NOTE:** See the **Ground Support Pressure System Material Selection and Compatibility** section of this Chapter for guidance.

i. Vacuum-jacketed systems shall be capable of having the vacuum verified.

j. Purge gas for LH₂ and cold gaseous hydrogen (GH₂) lines shall be gaseous helium (GHe). Neither gaseous nitrogen (GN₂) nor LN₂ shall be introduced into any LH₂ line that interfaces with a liquid storage tank cold port.

k. Precautions shall be taken to prevent cross mixing of media through common purge lines by use of check valves to prevent back flow from a system into a purge distribution manifold.

l. Cross connection of GN₂ and GHe systems is prohibited.

m. Sample ports shall be provided at the system low points.

n. Titanium and titanium alloys shall not be used where exposure to gaseous oxygen (GOX) (cryogenic) or LOX is possible.

3.11.5.2 Mobile and Portable Equipment Used to Transport Cryogenic Fluids

a. Mobile equipment for public and Range high-

way use shall be designed to meet the requirements of 49 CFR. **NOTE:** A copy of any DOT approved exemptions shall be provided to Range Safety.

b. Portable equipment that is designed for use for storage or transportation of cryogenic fluids shall be designed to meet applicable requirements for packaging set by 49 CFR.

c. The total maximum weight of portable equipment shall meet the Occupational Safety and Health Administration (OSHA) requirements related to permissible weight limit for an individual to transport.

3.11.5.3 Ground Support Cryogenic System Storage Vessels

a. All permanently installed cryogenic vessels shall consist of an inner and an outer shell.

b. The annular space between the inner and outer shell shall be insulated and may be vacuum-jacketed or purged. **EXCEPTION:** *LH₂ and LHe vessels shall be vacuum-jacketed.*

c. The inner shell shall be designed, constructed, tested, certified, and code stamped on the exterior of the vessel in compliance with ASME, Section VIII, Division 1 or Division 2.

d. In lieu of the code stamp, a nameplate bearing the required inner shell data shall be attached to the outer shell. **NOTE:** An additional nameplate (marked DUPLICATE) may be attached to the support structure.

e. All ASME code stamped vessels shall be registered with the National Board of Boiler and Pressure Vessel Inspectors.

f. The outer shell shall be designed for 0.0 psig internal pressure and 15.0 psig external pressure.

g. For non-vacuum-jacketed vessels, the annular space shall be protected by means of a vacuum breaker.

h. The inner shell and piping in the annular space should be type 304 or 316 (304L or 316L if welded) stainless steel. **NOTE:** The outer shell and supports may be stainless steel or carbon steel.

i. Pressure vessels shall be designed with an opening for inspection purposes.

j. All inner shell pressure retaining welds including shell, head, nozzle, and nozzle to head and shell welds shall be inspected by radiographic and/or ultrasonic volumetric NDE.

k. All inner shell attachment welds for items such as supports, lugs, and pads shall be inspected by liquid penetrant, ultrasonic, magnetic particle, eddy current, and/or radiographic surface NDE.

l. Welded attachments to the inner vessel such as stiffening rings or supports shall be continuously welded.

m. All attachments to the inner shell shall be positioned so that no attachment weld overlaps any Category A or B weld as defined in ASME Code, Section VIII, Division 1, Paragraph UW-3.

n. Local and remote readout liquid level indicators shall be provided for LH₂ and LO₂ storage vessels.

o. At a minimum, local readout capability shall be provided for all other cryogenic storage vessels.

p. Portable and mobile cryogenic storage vessels used for transportation shall be designed, fabricated, inspected, and tested in accordance with 49 CFR.

3.11.5.4 Ground Support Cryogenic System Piping

3.11.5.4.1 Piping Design, Insulation, and Material.

a. All cryogenic piping shall be designed in accordance with ANSI/ASME B31.3.

b. Vacuum-jacketed or other types of thermal insulation shall be based on system heat leak rate and failure mode and effect determination.

c. Gasket material used in LH₂ transfer piping flanged joints shall be glass-filled 3/32-in. thick Teflon. **NOTE:** Recommended materials may be obtained from the following companies: Garlock 8573, Garlock, Inc., Palmyra, NY; Fluorgold, Fluorocarbon Co., Anaheim, CA; and Fluorogreen E-600, Peabody Company, (Peabody-Dore Co.), Houston, TX.

d. Gaskets shall not be reused.

3.11.5.4.2 Piping System Joints, Connections, and Fittings.

a. Joints in piping systems shall be of the butt weld, flanged, bayonet, or hub type in accordance with KSC-GP-425, KC159/KC163, or the commercial equivalent.

b. Butt welded joint designs shall meet the requirements of ANSI B16.9.

c. Flanged joints shall be either weld neck or lap joint, raised face type conforming to ANSI B16.5, and shall be constructed of forged ASTM A182 type 304L or 316L material. **NOTE:** The use of slip-on flanges shall be avoided.

d. Flange faces or lap-joint stub end faces shall be concentrically serrations conforming to MSS-SP-6.

e. LH₂ vent system flanged joints shall be

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metal-to-metal and shall be seal-welded unless otherwise approved by Range Safety.

f. Flange bolting and studs shall conform to ANSI/ASME B18.2.1 recommended dimensions and shall use ANSI/ASME B1.1 threads.

g. Bolt materials shall be per ASTM A193 or ASTM A320.

h. Nuts for flange bolting and studs shall conform to ANSI/ASME B18.2.2 heavy hex type per ASTM A194 (type 304 stainless steel) or ASTM A194 (type 316 stainless steel) and shall use ANSI/ASME B1.1 threads.

i. Pipe fittings such as tees, elbows, crosses, reducers, and lap joint stub ends shall be butt welded only conforming to ANSI/ASME B16.9 and shall be type WP-304L or WP-316 material in accordance with ASTM A 403.

j. Bayonet fittings shall be used on vacuum-jacketed lines where butt welding is not practical and a mechanical joint is required.

k. Metal-to-metal couplings shall be the butt welded type. **NOTE:** The gaskets (not reusable) should be constructed of stainless steel only. The V-band clamps should be constructed of stress-corrosion-resistant material.

3.11.5.4.3 Non-Vacuum-Jacketed Cryogenic Piping. All non-vacuum-jacketed cryogenic piping shall conform to ANSI B36.19M and shall be seamless, type 304L or 316L material in accordance with ASTM A 312.

3.11.5.4.4 Vacuum-Jacketed Piping.

a. Vacuum-jacketed pipe may have an inner pipe of Invar 36 or NILO 36 or type 304L or 316L material meeting the above requirements for stainless steel piping. The outer jacket shall be type 304L or 316L material.

b. Vacuum-jacketed pipe should not use bellows in the inner pipe. Allowance for differential expansion between inner and outer pipe shall be provided by bellows in the outer pipe.

3.11.5.4.5 Thermal Expansion and Contraction. Cryogenic piping systems shall provide for thermal expansion and contraction without imposing excessive loads on the system. **NOTE:** Offset bends and loops rather than bellows should be used for this purpose wherever possible.

3.11.5.4.6 Cryogenic Pipe Weld Inspection.

a. All inner pipe welds shall be 100 percent radiographically inspected.

b. The accept and reject criteria shall be in accordance with Table 341.3.2A of ANSI/ASME B31.3.

3.11.5.5 Ground Support Cryogenic System Valves

a. Inlet and outlet isolation valves and appropriate intermediate vent valves shall be provided for shut-down and maintenance.

b. Systems shall have shutoff valves located as close to the supply vessel as practicable and be readily accessible.

c. Cryogenic systems shall be designed to ensure icing does not render the valve inoperable.

d. Remotely controlled valves shall provide the remote monitoring of OPEN and CLOSED positions.

e. Remotely operated valves shall be designed to be fail-safe if pneumatic or electric control power is lost. **NOTE:** Fail-safe criteria (fail-open or fail-close) shall be determined on a case-by-case basis.

f. All electrical control circuits for remotely actuated valves shall be shielded or otherwise protected from hazardous stray energy.

g. Gate valves shall be designed with the volume between the valve discs and the trapped volume in the bonnet vented upstream.

h. Manually operated valves shall be designed so that overtightening the valve stem cannot damage seats to the extent that seat failure occurs.

i. Designs using uncontained seats are prohibited.

j. Valve stem travel shall be limited by a positive stop at each extreme position.

k. The application or removal of force to the valve stem positioning device shall not cause disassembly of the pressure containing structure of the valve.

l. Manual and remotely controlled valve actuators shall be capable of completely opening or closing shutoff valves under maximum possible pressure and flow conditions in the system.

m. Cryogenic valves with extended stems shall be installed with the actuator approximately vertical above the valve.

n. Valves that are not intended to be reversible shall be designed or marked so that they will not be connected in a reverse mode.

o. All valves should be fabricated from Type 304 or 316 stainless steel (type 304L or 316L if welded) with minimum wall thickness equivalent to Sched-

ule 10 pipe.

p. Design of the valve jacket shall not adversely affect the function or maintainability of the valve.

q. Local or remote stem position indicators shall sense the position of the stem directly, not the position of the actuating device.

3.11.5.6 Ground Support Cryogenic System Pressure Indicating Devices

a. A pressure indicating device shall be located on any storage system and on any section of the system where pressure can be trapped.

b. As determined by Range Safety, remote read-out pressure transducers are required when it is necessary to monitor hazardous operations from a remote location.

c. Gauges shall be selected so that the normal operating pressure falls between 25 percent and 75 percent of the scale range, except for gauges used in applications that require a very wide range of operating pressure. For these applications, the pressure gauges shall be selected so that the maximum pressure that can be applied shall not exceed 95 percent of the scale range of the gauge.

d. Pressure gauges shall be of one piece, solid front, metal case construction, using an optically clear shatterproof window made of high-impact, non-cracking plastic, heat-treated glass, or laminated glass.

e. Pressure gauges shall be equipped with a full-diameter pressure release back capable of accommodating maximum flow without rupturing the case. **NOTE:** The use of blowout plugs is not recommended.

f. All pressure gauge material normally in contact with the service fluid should be type 316 stainless steel.

g. If pressure gauge isolation valves are used, they shall be designed so that they can be lock-wired in the OPEN position.

h. The operating range of pressure transducers used for monitoring pressures during hazardous operations shall not be less than 1.2 and not more than 2.0 times the system MOP.

i. Gauge installations shall be designed to have a minimum 1-in. clearance in back to provide unrestricted venting.

j. Personnel and critical equipment shall be protected from potential venting hazards.

3.11.5.7 Ground Support Cryogenic System Flexible Hoses

a. Flexible (flex) hoses shall be used only when required to isolate vibration and piping movement and for hookup of portable and mobile equipment.

b. Flexible hoses shall be of the single-wall, double-wall, or double-wall vacuum-jacketed type.

c. All convoluted portions of flexible hoses shall be covered with stainless steel wire braid.

d. Flex hose installation shall be designed to avoid abrasive contact with adjacent structures or moving parts.

e. Flex hose assemblies shall not be installed in a manner that will place a mechanical load on the hose or hose fittings to an extent that will degrade hose strength or cause the hose fitting to loosen.

f. Flexible hose shall not be supported by rigid lines or components if excessive loads from flex hose motion can occur.

g. Flexible hose between two components may have excessive motion restrained where necessary but shall never be rigidly supported by a tight rigid clamp around the flexible hose.

h. The bend radius of flex hoses shall be designed to be no less than the safe minimum bend radius recommended in authoritative specifications for the particular hose and in no case less than 5 times the outside diameter of the hose.

i. A means of plugging or capping flex hoses shall be provided when they are not in use.

j. All flexible hoses that are not lined shall be subjected to a flow induced vibration analysis. **NOTE:** A guidance document for performing this analysis is MSFC 20MO2540.

3.11.5.8 Ground Support Cryogenic System Pressure Relief Devices

a. All fixed cryogenic storage vessels shall be protected from overpressure by means of at least one spring-loaded or pilot-operated relief valve. **NOTE:** Required relief capacity should be provided by means of a single relief valve, if possible.

1. A rupture disc may be installed in series with the relief valve to prevent loss of hazardous fluids, provided that the limitations of ASME Code, Section VIII, Division 1, Paragraphs UG-127(a)(3)(b) and UG-127(a)(3)(c) or Division 2, Article R-1, Paragraphs AR-131.4 and AR-131.5 are met.

2. The space between the rupture disc and the relief valve shall be designed so that it can be tested at least annually for leakage past the rupture diaphragm.

REFERENCED DOCUMENTS

3. Rupture discs in systems containing reactant fluids shall be replaced every two years or sooner based on manufacturer recommendations. **NOTE:** Providing a screen between the rupture disc and the valve to prevent rupture disc contamination of the relief valve should be considered.

4. Installation of pressure relief devices shall be in accordance with ASME Code, Section VIII, Division 1, Paragraph UG-135 or Division 2, Article R-1.

5. The total relieving capacity required shall be determined in accordance with ASME Code, Section VIII, Division 1, Paragraph UG-133 or Division 1, Paragraph AR 150 as applicable.

6. The primary relief device shall be set at a pressure not to exceed the MAWP of the cryogenic storage vessel. (See ASME Code, Section VIII, Division 1, Paragraphs UG-134 or Division 2, Article R-3, Paragraph AR-140 for pressure setting and tolerance requirements.)

b. DOT vessels shall be protected against overpressure in accordance with 49 CFR.

c. Pressure relief devices shall be provided in each segment of a system where a cryogenic liquid can be trapped. The flow and set pressure requirements for these relief valves are as follows:

1. The relief valve capacity shall prevent the pressure from rising more than 20 percent above the system MOP or that allowed by ANSI/ASME B31.3, whichever is less.

2. The relief valve shall be set to operate at a pressure not to exceed 110 percent of the system MOP or that allowed by ANSI/ASME B31.3, whichever is less.

d. Ground Support Cryogenic System General Relief Devices

1. The flow capacity for all relief devices shall be certified in accordance with ASME Code, Section VIII, Division 1, Paragraphs UG-127, UG-129, UG-131 and UG-132, as applicable.

2. The body and other pressure containing parts for pressure relief devices should be type 304 or 316 (or 304L or 316L if welded) stainless steel.

3. Pressure system relief devices shall have no intervening stop valves between piping being protected and the relief devices or between the relief device and the point of discharge except as allowed by ANSI/ASME B31.3, Paragraph 322.6.1.

4. When a shutoff valve is allowed in accordance with the ANSI or ASME Code, the valve

type shall have provisions for being safety wired in the OPEN or CLOSED position. **NOTE:** The valve shall have permanent marking clearly identifying its position (OPEN or CLOSED).

5. The relief valve outlet piping shall be sized in accordance with ASME VIII, Division 1, UG-135(g). **NOTE:** The static back pressure developed at the discharge flange of the relief valve shall be held to within 10 percent of the set pressure of the relief valve.

6. All relief valve installations shall be designed to withstand reaction loads due to operation of the relief valve.

7. The effects of the discharge from relief devices shall be assessed and analyzed to ensure that operation of the device will not be hazardous to personnel or equipment. Items to be analyzed are thrust loads, noise impingement of high velocity gas or entrained particles, toxicity, oxygen enrichment, flammability, and oxygen deprivation.

8. No obstructions to flow shall be placed downstream of any relief device except as allowed per ASME Code, Section VIII, Division 1, Appendix M, Paragraph M-6 or ASME B31.3, Paragraph 322.6.1.

3.11.5.9 Ground Support Cryogenic System Vents

a. GH₂ shall be vented to the atmosphere through a burner system unless otherwise agreed to by Range Safety.

b. GH₂ burner design and testing requirements shall be approved by Range Safety.

c. Cryogenic systems shall be designed so that fluids cannot be trapped in any part of the system without drain or vent (relief valve or vent valve) capability.

d. Each line venting into a multiple use vent system shall be protected against back pressurization by means of a check valve if the upstream system cannot withstand the back pressure or where contamination of the upstream system cannot be tolerated.

e. Vent systems shall be sized to provide minimum back pressures consistent with required venting flow rates. **NOTE:** In no case shall back pressures interfere with proper operation of relief devices.

f. Vents shall be placed in a location normally inaccessible to personnel and at a height or location where venting will not normally be deposited into

habitable spaces.

g. Each vent shall be conspicuously identified using appropriate warning signs, labels, and markings.

h. Vent outlets shall be located far enough away from incompatible propellant systems and incompatible materials to ensure no contact is made during vent operations.

i. Incompatible fluids shall not be discharged into the same vent or drain system.

j. Vent outlets shall be protected against rain intrusion and entry of birds, insects, and animals.

k. All vent line supports shall be designed to withstand reaction loads due to actuation of safety relief devices. (See ANSI/ASME B31.3, Paragraph 322.6.2.)

l. Fuel and oxidizer vent systems shall be equipped with a means of purging the system with an inert gas to prevent explosive mixture.

3.11.5.10 Testing Ground Support Cryogenic Systems Prior to Assembly

a. All permanently installed cryogenic storage vessels except DOT vessels shall be hydrostatically tested in accordance with ASME Code, Section VIII, Division 1, Paragraphs UG-99 and UG-100 or Division 2, Article T-3 or T-4, as applicable.

b. Vessels designed to meet DOT specifications and regulations shall undergo qualification and hydrostatic testing in accordance with DOT requirements.

c. All components such as valves, filters, pipes, pipe fittings, and hoses (not including pressure gauges, transducers, and rupture disks) shall be hydrostatically tested to a minimum of 1.5 times the component MAWP at ambient temperature for a minimum of 5 min to demonstrate that the components will sustain test pressure levels without distortion, damage, or leakage.

d. All mechanical components such as valves, regulators, filters, piping, and hoses shall be inspected for distortion or other evidence of physical damage. **NOTE:** Damaged components shall be rejected.

e. Functional and leak tests shall be performed at the component MAWP after the hydrostatic tests.

f. Both the inlet and outlet sides of a relief valve shall be pressure tested. When the discharge side has a lower pressure rating than the inlet side, the inlet side and the outlet side shall be tested independently.

g. Pressure relief valves shall be tested for proper

setting prior to installation and periodically thereafter.

h. Pressure gauges and transducers shall be hydrostatically tested to a minimum of 1.5 times the system MOP.

i. Pressure gauges and transducers shall be calibrated prior to installation and periodically thereafter.

j. Pneumatic testing to a pressure level of 1.25 times MAWP is permissible only if hydrostatic testing is impractical, impossible, or will jeopardize the integrity of the system or system element. **NOTE:** Prior approval for pneumatic testing at the Ranges shall be obtained from Range Safety.

3.11.5.11 Testing Ground Support Cryogenic Systems After Assembly

3.11.5.11.1 Hydrostatic Tests.

a. All cryogenic systems shall be hydrostatically tested to at least 1.25 times system MOP using an inert cryogenic fluid at or below the expected lowest temperature.

b. Cryogenic systems that cannot be chilled and hydrostatically tested with an inert fluid at or below the lowest expected temperature will require both a cold shock demonstration test and analysis (a hazard analysis and a fracture mechanics safe-life analysis in accordance with Appendix 3C) approved by Range Safety.

c. The hydrostatic test or cold shock/soak test (for at least 1 h) shall demonstrate that the system or components will sustain test pressure level and temperature gradient without distortion, damage, or leakage.

3.11.5.11.2 Inspections for Vacuum-Jacketed Systems. In addition to the hydrostatic test requirements stated above, the following inspections shall be performed on vacuum-jacketed systems:

a. An examination for cold spots on vacuum jackets. **NOTE:** Cold spots in the outer line shall not be 5°C colder than the surrounding area, except in cases where system heat-leak requirements permit colder temperatures, such as around low-point drain valves, relief valves, or other areas where a direct thermal path is available.

b. Vacuum readings for all vacuum volumes shall be taken and recorded. **NOTE:** These readings shall be taken before, during, and after the test.

c. The vacuum readings after the hydrostatic or cold shock/soak using a cryogenic fluid shall be taken when the system returns to ambient temperature.

REFERENCED DOCUMENTS

3.11.5.11.3 Pneumatic Leak Test.

a. After successful completion of the hydrostatic test using a cryogenic fluid, a pneumatic leak test of the complete system shall be performed at the system MOP using helium or a mixture of nitrogen with a minimum of 25 percent helium.

b. There shall be no leakage into the vacuum volume in excess of 10^{-6} cc/sec. **NOTE:** The sensitivity of the instrumentation used to measure leak rate shall be a minimum of 1 times 10^{-9} std cm³/sec/div in accordance with article 10 of the ASME Code.

c. All pressure boundary welds and mechanical points such as gasket joints, seals, threaded connections, and valve bonnets shall be visually bubble tight during the leak test.

3.11.5.11.4 System Validation Test. Following the leak test, all newly assembled cryogenic systems shall have a system validation test performed at MOP prior to first operational use at the Ranges. Minimum test requirements are as follows:

a. The intended service fluid (LO₂, LH₂, LN₂, LHe) shall be used as the test fluid.

b. The functional capability of all components and subsystems shall be validated.

c. All operational sequences for the system shall be exercised, including emergency shutdown/safing and unloading procedures.

d. All newly assembled cryogenic systems shall be tested to verify that the bonding and grounding requirements of the **Ground Support Pressure System Bonding and Grounding** section of this Chapter have been met.

3.11.5.12 Ground Support Cryogenic Systems Periodic Tests

a. Flex hoses shall be hydrostatically proof tested to 1.5 times their MAWP once a year unless otherwise approved by Range Safety.

b. Pressure gauges and transducers shall be calibrated once a year.

c. Pressure relief valves shall be tested for proper setting and operation once a year.

3.11.5.13 Testing Modified and Repaired Ground Support Cryogenic Systems Tests

a. Any cryogenic system component, including fittings or welds, that has been modified or repaired shall be tested prior to reuse.

b. Components that are modified or repaired in

any way shall be pressure tested prior to reuse.

c. The component retest sequence shall be as follows unless otherwise approved by Range Safety:

1. The component shall be hydrostatically tested to 1.5 times the components MAWP. **NOTE:** The fluid shall be at ambient temperature.

2. A hydrostatic test using an inert cryogenic fluid at or below the expected lowest temperature shall be performed in the same manner as described in section 3.11.5.11.1 above.

3. The component shall be reinstalled in the system and a leak test performed in the same manner as described in section 3.11.5.11.3 above.

d. All cryogenic system mechanical joints affected in disconnection, connection, or replacement of components shall be pneumatically leak tested at the system MOP prior to being placed back in service. **NOTE:** This test shall be conducted as described in section 3.11.5.11.3 above.

3.11.6 Ground Support Pressure Systems Data Requirements

This section lists the minimum data required to certify compliance with the design, analysis, and test requirements of the **Ground Support Pressure Systems** section of this Chapter. Data required by paragraphs 3.11.6.1 through 3.11.6.4 in this section shall be incorporated into the MSPSP or submitted as a separate package when appropriate. Data required by paragraph 3.11.6.5 shall be placed in a certification file to be maintained by the hazardous pressure system operator. This data shall be reviewed and approved by Range Safety prior to first operational use of hazardous pressure systems at the Ranges.

3.11.6.1 Ground Support Pressure Systems General Data Requirements

The following general ground support equipment data is required in the MSPSP (See Appendix 3A.):

a. Hazard analysis of hazardous pressure systems in accordance with a jointly tailored System Safety Program Plan (Chapter 1, Appendix 1B.).

b. A compliance checklist of all design, test, analysis, and data submittal requirements in this Chapter.

c. The material compatibility analysis in accordance with the **Ground Support Pressure System Material Selection and Compatibility** section of this Chapter.

d. Inservice operating, maintenance, and inspection

tion plan in accordance with the **Inservice Operating, Maintenance, and Inspection Plan** section of this Chapter.

e. Physical and chemical properties and general characteristics of the propellant, test fluid, and gases. **NOTE:** Data shall be provided to Range Safety, Bioenvironmental Engineering, Bioenvironmental Planning, 30 CEG, and 30 SW/ET, as applicable.

f. For hazardous propellants, fluids, and gases, the following data shall be submitted:

1. Specific health hazards such as toxicity and physiological effects

2. Threshold Limit Values (TLV), maximum allowable concentration (MAC) for 8-hr day, 5-day week of continuous exposure

3. Emergency tolerance limits including length of time of exposure and authority for limits, such as the Surgeon General, National Institute of Occupational Safety and Health (NIOSH), and independent study

4. Maximum credible spill (volume and surface area) and supporting analysis.

5. Description of hazards other than toxicity, such as flammability and reactivity

6. Identification of material incompatibility problems in the event of a spill

7. Personal protective equipment to be used in handling and using propellants, when this equipment will be used during an operation, and manufacturer, model number, and other identifying data

8. Manufacturer, model number, specifications, operating limits, type of certification, and general description of vapor detecting equipment

9. Recommended methods and techniques for decontamination of areas affected by spills or vapor clouds and hazardous waste disposal procedures

3.11.6.2 Ground Support Pressure Systems Design Data Requirements

a. A copy of any DOT approved exemptions for mobile and portable hazardous pressure systems shall be submitted to Range Safety.

b. A schematic that presents the system in a clear and easily readable form, with complete subsystems grouped and labeled accordingly; nomenclature of each element should be made adjacent to or in the vicinity of each element. The schematic or corresponding data sheet shall contain the following information:

1. Identification of all pressure system compo-

nents such as valves, regulator, tubes, hoses, vessels, and gauges using standard symbols. **NOTE:** A legend is recommended and the original mechanical drawings should be referenced

2. MOP of all systems and subsystems at expected operating temperatures and identification of expected source pressures and expected delivery pressures

3. All relief valve pressure settings and flow rates

4. System fluid and maximum expected temperature

5. Pressure ranges of all pressure gauges

6. Pressure settings of pressure regulators

7. Charging pressure of reservoirs and vessels, their nominal capacities, and wall thickness

8. Pressure setting of all pressure switches

9. Nominal outside diameter and wall thickness of all tubing

10. Flowpath through all components. **NOTE:** When the system is to be used in several operating modes, it is easier to provide a separate schematic that shows flowpaths for each operating mode.

11. Identification of each component (reference designations) so that cross-reference between schematics and drawings and a pressure system component list or other documentation is possible

12. End-to-end electrical schematics of electrical and electronic components giving full functional data and current loads

13. Connections for testing or servicing

14. A narrative that provides the following information:

(a) Description of the system and its operating modes

(b) Discussion of operational hazards

(c) Discussion of accessibility of components

15. A sketch or drawing of the system that shows physical layout and dimensions

16. System information shall be placed in tables (See Appendix 3A for guidance.)

3.11.6.3 Ground Support Pressure Systems Component Design Data

a. Identification of each component with a reference designation permitting cross-reference with the system schematic

b. MAWP for all pressure system components and the MOP the component shall see when installed in the system

c. Safety factors or design burst pressure for all

REFERENCED DOCUMENTS

pressure system components and identification of actual burst pressures, if available

d. Hydrostatic test pressure for each system component and identification of the test pressure the component will see after installation in the system, if applicable

e. Materials used in the fabrication of each element in the components, including soft goods and other internal elements

f. Cycle limits if fatigue is a factor of the component

g. Temperature limits of each system component

h. Manufacturer name, model number, and part number of all components

i. Component information should be placed in tables (See Appendix 3A for guidance.)

3.11.6.4 Ground Support Pressure Systems Test Procedures and Reports

a. All test plans, test procedures and test reports required to be performed by the **Ground Support Pressure Systems** section of this Chapter shall be submitted to Range Safety for review and approval.

b. A list and synopsis of all hazardous pressure system operational procedures to be performed at the Ranges shall be provided.

3.11.6.5 Ground Support Pressure Systems Certification Files

3.11.6.5.1 Ground Support Pressure Systems Certification Files General Requirements.

a. Certification files shall be maintained and updated by the hazardous pressure system operator.

NOTE 1: These files shall be located at the Range User facility at the Ranges. **NOTE 2:** Vessels and systems, including mobile and portable systems, that do not have current certification files may be deactivated and removed from service by Range Safety.

b. Certification files shall be updated within 90 calendar days of completion of periodic inspections and tests.

c. Updated information shall include any changes to the current certification files and the following:

1. Temperature, pressurization history, and pressurizing fluid for both the tests and operations

2. Results of any inspection conducted, including the name of the inspector, inspection dates, inspection techniques used, location and character of defects, defect origin, and defect cause

3. Maintenance and corrective actions performed from the time of manufacture throughout operational life, including refurbishment

4. Sketches and photographs to show areas of structural damage and extent of repairs

5. Certification and recertification tests performed, including test conditions and results

6. Analysis records and drawings supporting the repair or modification

3.11.6.5.2 Ground Support Pressure Systems Certification Data.

a. The certification file for each hazardous pressure system shall contain the data required in sections 3.11.6.1, 3.11.6.2, 3.11.6.3, and 3.11.6.4 of this Chapter.

b. The following data shall also be included:

1. Design calculations for stress, fatigue, and other items that verify compliance with applicable code requirements such as ASME, ANSI, and DOT

2. Structural load analysis for hazardous pressure systems exposed to severe launch environments such as vibration, shock, and temperature

3. In-process fabrication and construction inspection plans and results

4. Pressure vessel manufacturer data reports

5. Specification drawings and documents for all components

6. If available, maintenance manuals for all components

7. If available, component operating manual.

8. As required, a cross-sectional assembly drawing of the component to assess the safety aspects of the internal elements

9. System operating and maintenance plans and procedures

10. Certification that welding and weld NDE meet applicable standards such as ASME and ANSI

11. Unique qualification and acceptance test plans and test reports

12. Certification documentation showing that vessels are designed, fabricated, and tested in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1/Division 2 or 49 CFR

13. Certification that all components, including pipe and tube fittings have successfully passed a hydrostatic test

3.11.7 Ground Support Pressure Systems Recertification

3.11.7.1 Ground Support Pressure Systems General Recertification Requirements

a. Guidance for performing recertification can be found in ESMC TR-88-01

b. The recertification period for vessels and systems shall not exceed the shortest period resulting from or determined by the following criteria:

1. The shortest service life determined based on an assessment of inservice failure mechanisms in accordance with paragraph 3.11.1.14.

2. Twenty years for systems and for vessels that can be 100 percent inspected both internally and externally

3. Ten years for systems and for vessels that cannot be 100 percent inspected internally but can be 100 percent inspected externally

4. Five years for systems and for vessels that cannot be 100 percent inspected either internally or externally

5. Manufacturer recommendations

c. All fixed hazardous pressure vessels shall also be recertified when one or more of the following changes or conditions occur:

1. The vessel is planned for service at higher or lower temperatures than those of the previous certification and/or recertification

2. The vessel was removed from service and deactivated without protection from environmental effects; for example, a vessel is not stored inside an environmentally controlled building and does not have a positive internal pressure

3. The vessel was relocated from another installation, agency, or source

4. There is a change of service or commodity, resulting in a new or a change in failure mechanisms

5. The vessel was repaired or modified

6. The vessel has reached the end of its certification or recertification period

d. Portable or mobile vessels and packaging used for transportation of pressurized or hazardous commodities shall be designed, maintained, and recertified in accordance with 49 CFR. **NOTE:** If a DOT vessel is installed on a permanent basis, it shall fall under the recertification requirement for a fixed system.

e. Periodic inspections shall be performed on hazardous pressure systems in accordance with the ISI Plan (See the **Inservice Operating, Maintenance,**

and Inspection Plan section of this Chapter). These inspections shall be performed during the following periods:

1. From initial operational use of the vessel and/or system until the vessel and/or system requires recertification. (Called *certification period*)

2. Period from first recertification effort until second recertification. (Called *first recertification period*)

3. All subsequent recertification periods

f. The hazardous pressure system operator shall retain all documentation generated as a result of the recertification effort and place this documentation in the system certification and recertification file located at the Ranges.

3.11.7.2 Ground Support Systems Engineering Assessment and Analysis

3.11.7.2.1 Ground Support Systems Engineering Assessment and Analysis General Requirements

a. An engineering assessment and analysis shall be performed prior to the start of the first recertification period.

b. The engineering assessment of the design, fabrication, material, service, inspection, and testing shall be evaluated against the latest codes, standards, regulations, and requirements identified in this Chapter.

c. Discrepancies with the latest requirements shall be resolved by repair, modification, analysis, inspection, or test.

3.11.7.2.2 Design, Fabrication, and Installation Deficiencies. At a minimum, the following potential design, fabrication and installation type deficiencies shall be assessed:

a. Design deficiencies such as design notches, weld joint design, and reinforcements

b. Material deficiencies such as laminations, laps, seams, cracks, hardness variations, and notch brittleness

c. Welding deficiencies such as cracks, incomplete fusion, lack of penetration, overlap, undercut, arc strikes, porosity, slag inclusions, weld spatter, residual stresses, and distortion

d. Installation deficiencies such as fit-up, alignment, attachments, and supports

3.11.7.2.3 Operation and Maintenance Deficiencies. At a minimum, the following potential operation and maintenance deficiencies shall be assessed:

a. Refurbishment damage

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- b. Modification and/or repair deficiencies
- c. Operation beyond allowable limits or improper sequence
- d. Maintenance deficiencies

3.11.7.2.4 Analysis Methodology. An engineering analysis shall be performed as follows:

a. A stress analysis of all vessels and piping shall be available for evaluation or performed to verify that stresses are within allowable limits of current codes, standards, and regulations as identified in this Chapter.

b. The number of stress cycles experienced by the vessel during the certification period shall be determined.

c. Using fracture mechanics analysis, the cyclic limits for vessels with pressures greater than 2500 psig, burst before leak failure mode, or corrosive and/or toxic fluids shall be determined.

d. The safe-life analysis shall be performed under the assumption of pre-existing cracks. **NOTE:** This does not imply that cracks are allowed. All unacceptable indications shall be repaired. The safe-life analysis shall be conducted in accordance with the following requirements:

1. The analysis shall show that the vessel will service at least four times the cycles expected during the recertification period.

2. The analysis shall calculate and evaluate the results from the worst combination of crack sizes (refer to MSFC-STD-1249 for guidance) and location such as boss transition area, heat affected area, weld joint, and membrane section within the vessel.

3. The appropriate stress component in the vessel shall be used in the analysis.

4. The initial flaw size shall be based on the recertification hydrostatic test pressure to NDE (Refer to MSFC-STD-1249 for guidance).

5. Calculated cycles to failure shall be based on the maximum and minimum operating pressure.

6. A liner elastic fracture mechanic parameter (stress-intensity factors) shall be used to determine critical crack sizes. **NOTE:** The most conservative deformation mode shall be used to determine the appropriate stress-intensity factors (fracture toughness) as appropriate for the parent, weld, and joint materials.

7. Fracture mechanics shall only be used to predict the sub-critical crack propagation life prior to unstable crack growth.

8. The safe-life analysis results shall be reduced by a factor of four in conjunction with assuming the most conservative bounds on material properties and crack growth data for the vessel environment.

9. Failure mode determination shall be in accordance with Appendix 3C.

10. Vessels subject to stress corrosion (sustained stress) shall show that the corresponding applied stress intensity during operation is less than the threshold stress intensity in the intended environment.

11. Corrosion allowance and the remaining wall shall be determined based on MIL-HDBK-729.

3.11.7.2.5 Ground Support Pressure Systems Recertification Test Requirements. Testing requirements for recertification of components and systems are as follows:

a. Vessels and packaging designed to 49 CFR specification shall be retested to DOT requirements.

b. All systems shall be hydrostatically tested at ambient temperatures to 150 percent of the system MOP.

c. Vessels designed to ASME Section VIII, Division 2 that are prohibited from hydrostatic testing to 150 percent of the MOP shall be hydrostatically tested to 125 percent of system MOP at a minimum.

d. Cryogenic systems shall be retested in accordance with the **Testing Ground Support Cryogenic Systems After Assembly** section of this Chapter.

e. 100 percent visual inspection of all joints and connections shall be performed before and after hydrostatic tests. **NOTE:** Parts that indicate a change in volume, permanent deformation, leakages, or cracks shall be rejected.

f. 100 percent visual inspection of the external surfaces of a vessel and system and 100 percent of the internal surfaces for vessels shall be performed.

1. Any sign of corrosion, dents, or other damages shall be identified and annotated on permanently maintained recertification documents.

2. For corroded areas, the corrosion shall be removed.

3. Using Ultrasonic Testing (UT), the entire surface area affected by corrosion shall be measured and the remaining wall thickness determined.

4. Wall areas that are below the minimum required thickness and other unacceptable findings

shall be fixed prior to placing the system back into service.

5. The susceptibility effects of corrosion such as cracking, delamination, or intergranular attack should be addressed.

g. All weld joints on vessels and systems with pressure greater than 500 psig or containing a hazardous fluid shall be 100 percent volumetrically and surface inspected.

1. Radiographic examination shall be used to the maximum extent possible.

2. UT shall be used if Radiographic Testing (RT) is determined to be ineffective.

3. Surface and volumetric testing shall be performed after the hydrostatic test only.

h. All components and systems shall be leak checked and functionally tested.

i. Leaks shall be repaired and components that do not function properly shall be repaired or replaced prior to starting the subsequent recertification period.

3.12 FLIGHT HARDWARE PRESSURE SYSTEMS AND PRESSURIZED STRUCTURES

This section establishes minimum design, fabrication, installation, testing, inspection, certification, and data requirements for flight aerospace vehicle equipment (AVE) and pressurized structures. All criteria are mandatory unless tailored by Range Safety for specific applicability for the projected design. **NOTE:** The term *hydraulics* as used in this section does not include cryogenic fluids or fluids considered hazardous as described in the paragraph below.

3.12.1 Flight Hardware Pressure Systems and Pressurized Structures General Requirements

Hazardous flight hardware pressure systems are defined as follows: (1) flight systems containing hazardous fluids such as cryogenics, flammables, combustibles, and toxics; (2) systems used to transfer hazardous fluids such as cryogenics, flammables, combustibles, and hypergols; (3) systems with operating pressures that exceed 100 psig; (4) systems with stored energy levels exceeding 14,240 ft lb; and (5) systems that are identified by Range Safety as safety critical.

3.12.1.1 Flight Hardware Pressure Vessels, Systems, and Pressurized Structures General Requirements

a. The structural design of all pressure vessels and pressurized structures shall employ proven processes and procedures for manufacture and repair.

b. The design shall emphasize the need for access, inspection, service, repair, and refurbishment.

c. For all reusable pressure vessels and pressurized structures, the design shall permit these hardware to be maintained in and refurbished to a flightworthy condition.

d. Repaired and refurbished hardware shall meet the same conditions of flightworthiness as new hardware.

3.12.1.2 Flight Hardware Pressure Systems Fault Tolerance

a. Airborne hazardous pressure systems shall be designed to be single fault tolerant against inadvertent actuations that could result in a critical hazard during prelaunch operations. **NOTE:** Structural failure of tubing, piping, and vessels are not to be considered single failures.

b. A pressure system shall be dual fault tolerant if the failure of two components could result in a catastrophic hazard.

3.12.1.3 Flight Hardware Pressure System Offloading

a. Hazardous pressure systems shall be designed so that depressurization and drain fittings are accessible and do not create a personnel or equipment hazard for off-loading hazardous fluids at the launch complex. **NOTE:** This requirement is intended for contingency safing operations.

b. The design goal is to be able to offload these pressure systems at any point after pressurization or loading, including the ability to offload all systems at the launch pad without demating of the spacecraft from the launch vehicle or any other disassembly of vehicle systems.

c. In cases in which the Range User and Range Safety decide that design prohibits offload capability of a mated spacecraft at the launch pad, offload shall be possible within the launch complex.

3.12.1.4 Flight Hardware Pressure Systems Operations

The requirements for operating hazardous pressure

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systems found in Chapter 6 of this document shall be taken into consideration in the design and testing of these systems in addition to the general requirements identified in paragraph 3.12.5.

3.12.1.5 Flight Hardware Pressure Systems and Pressurized Structures Analyses

3.12.1.5.1 Flight Hardware Pressure System Hazard Analysis.

a. A hazard analysis shall be performed on all hazardous systems hardware and software (if applicable) in accordance with a jointly tailored System Safety Program Plan (Appendix 1B)

b. Prelaunch and launch hazards shall be analyzed.

3.12.1.5.2 Flight Hardware Pressures Systems Functional Analysis. A detailed system functional analysis shall be performed to determine that the operation, interaction, or sequencing of components shall not lead to damage to the launch vehicle, payload, or associated ground support equipment.

a. The analysis shall identify all possible malfunctions or personnel errors in the operation of any component that may create conditions leading to an unacceptable risk to operating personnel or equipment.

b. The analysis shall also evaluate any secondary or subsequent occurrence, failure, or component malfunction that, initiated by a primary failure, could result in personnel injury.

c. Such items identified by the analysis shall be designated safety critical and shall require the following considerations.

1. Specific Design Action
2. Special Safety Operating Requirements
3. Specific Hazard Identification and Proposed Corrective Action

4. Special Safety Supervision

d. Systems analysis data shall show that:

1. The system provides the capability of maintaining all pressure levels in a safe condition in the event of interruption of any process or control sequence at any time during test or count-down.

2. Redundant pressure relief devices have mutually independent pressure escape routes.

3. In systems where pressure regulator failure may involve critical hazard to the crew or mission success, regulation is redundant and where passive

redundant systems are specified includes automatic switchover.

4. When the hazardous effects of safety critical failures or malfunctions are prevented through the use of redundant components or systems, it shall be mandatory that all such redundant components or systems are operational prior to the initiation of irreversible portions of safety critical operations or events.

3.12.1.5.3 Flight Hardware Pressure Vessel and Pressurized Structure Stress Analysis.

a. General Requirements. A detailed and comprehensive stress analysis of each pressure vessel and pressurized structure shall be conducted under the assumption of no crack-like flaws in the structure.

1. The analysis shall determine stresses resulting from the combined effects of internal pressure, ground or flight loads, and thermal gradients.

2. Both membrane stresses and bending stresses resulting from internal pressure and external loads shall be calculated to account for the effects of geometrical discontinuities, design configuration, and structural support attachments.

3. Loads shall be combined by using the appropriate design limit or ultimate safety factors on the individual loads and comparing the results to material allowables.

4. Safety factors shall be as determined in Section 3.12.2.

5. Safety factors on external (support) loads shall be as assigned to primary structure supporting the pressurized system.

b. Metallic Pressure Vessels and Pressurized Structures

1. For metallic pressure vessels and pressurized structures, classical solutions are acceptable if the design geometries and loading conditions are sufficiently simple and the results are sufficiently accurate to warrant their application.

2. Finite element or other equivalent structural analysis techniques shall be used to calculate the stresses, strains, and displacements for complex geometries and loading conditions.

3. Local structural models shall be constructed, as necessary, to augment the overall structural model in areas of rapidly varying stresses.

4. Minimum material gage as specified in the design drawings shall be used in calculating stresses.

5. The allowable material strengths shall reflect the effects of temperature, thermal cycling and gradients, processing variables, and time associated with the design environments.

6. Minimum margins of safety associated with the parent materials, weldments and heat-affected zones shall be calculated and tabulated for all pressure vessels and pressurized structures along with their locations and stress levels.

7. The margins of safety shall be positive against the strength and stiffness requirements of Sections 3.12.1.7 and 3.12.1.8, respectively.

c. Composite Hardware

1. For composite overwrapped pressure vessels (COPVs) and pressurized structures made of composite materials, the state-of-the-art methodology using composite laminate theory shall be employed.

2. Interlamination normal and shear stresses as well as in-plane stress components shall be calculated.

3. Effects of ply orientation, stacking sequence, and geometrical discontinuities shall be accounted for.

3.12.1.5.4 Flight Hardware Pressure Vessels and Pressurized Structure Fatigue Analysis. When conventional fatigue analysis is used to demonstrate the fatigue-life of an unflawed pressure vessel or pressurized structure, nominal values of fatigue-life characteristics including stress-life (S-N) data, strain-life (ϵ - N) data of the structural materials shall be used.

a. These data shall be taken from reliable sources such as MIL-HDBK-5, the *Aerospace Structural Metals Handbook* or other sources approved by the procuring agency.

b. The analysis shall account for the spectra of expected operating loads, pressure and environments.

c. Fatigue damage cumulative technique such as Miner's rule is an acceptable method for handling variable amplitude fatigue cyclic loadings.

3.12.1.5.5 Flight Hardware Pressure Vessel and Pressurized Structure Safe-Life Analysis. When crack growth safe-life analysis is used to demonstrate safe-life of a pressure vessel or a pressurized structure, undetected flaws shall be assumed to be in the critical locations and in the most unfavorable orientation with respect to the applied stress and material properties.

a. The size of the flaws shall be based on either the appropriate non-destructive inspection (NDI) techniques or defined by the acceptance proof testing.

b. Both the crack growth safe-life analysis and the proof test flaw screening logic, if utilized, shall be based on the state-of-the-art fracture mechanics methodology.

c. Nominal values of fracture toughness and fatigue crack-growth rate data associated with each alloy, temper, product form, thermal, and chemical environments shall be used in the safe-life analysis. However, if proof test logic is used for the determining of the initial flaw size, an upper bound fracture toughness value shall be used in determining both the initial flaw size and the critical flaw size at fracture.

d. Pressure vessels or pressurized structures that experience sustained stresses shall also show that the corresponding maximum stress intensity factor (K_{MAX}) during sustained load in operation is less than the stress-corrosion cracking threshold (K_{ISCC}) data in the appropriate environment, $K_{MAX} < K_{ISCC}$.

e. State-of-the-art crack growth software package shall be used to conduct the safe-life analysis.

f. Aspect ratio ($a/2c$) changes shall be accounted for in the analysis.

g. Retardation effects on crack growth rates from variable amplitude loading shall not be considered without approval by the procuring agency.

h. Tensile residual stresses shall be included in the analysis.

i. The safe-life analysis shall be included in the stress analysis report. In particular, loading spectra, environments, assumed initial flaw sizes, crack-growth models, fatigue crack growth rate and fracture data, shall be delineated. Summary of significant results shall be clearly presented.

3.12.1.6 Flight Hardware Pressure Vessel and Pressurized Structures Loads, Pressures, and Environments

a. The entire anticipated load-pressure-temperature history and associated environments throughout the service life shall be determined in accordance with specified mission requirements.

b. At a minimum, the following factors and their statistical variations shall be considered:

1. The environmentally induced loads and pressures.

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2. The environments acting simultaneously with these loads and pressures with their proper relationships.

3. The frequency of application of these loads, pressures, environments, and their levels and duration.

c. These data shall be used to define the design load and environment spectra that shall be used for both design analysis and testing. The design spectra shall be revised as the structural design develops and the loads analysis matures.

3.12.1.7 Flight Hardware Pressure Vessel and Pressurized Structure Strength Requirements

a. All pressure vessels and pressurized structures shall possess sufficient strength to withstand limit loads and MEOP in the expected operating environments throughout their respective service lives without experiencing detrimental deformation.

b. They shall also withstand ultimate loads and design burst pressure in the expected operating environments without experiencing rupture or collapse.

c. Pressure vessels and pressurized structures shall be capable of withstanding ultimate external loads and ultimate external pressure (destabilizing) without collapse or rupture when internally pressurized to the minimum anticipated operating pressure.

d. All pressure vessels and pressurized structures shall sustain proof pressure without incurring gross yielding or detrimental deformation and shall sustain design burst pressure without rupture.

e. When proof tests are conducted at temperatures other than design temperatures, the change in material properties at the proof temperature shall be accounted for in determining proof pressure.

f. Pressurized structures subject to instability modes of failure shall not collapse under ultimate loads nor degrade the functioning of any system due to elastic buckling deformation under limit loads.

g. Evaluation of buckling strength shall consider the combined action of primary and secondary stresses and their effects on general instability, local or panel instability, and crippling.

h. Design loads for buckling shall be ultimate loads, except that any load component that tends to alleviate buckling shall not be increased by the ultimate design safety factor.

i. Destabilizing pressures shall be increased by the ultimate design factor, but internal stabilizing pressures shall not be increased unless they reduce structural capability.

j. The margin of safety shall be positive and shall be determined by analysis or test at design ultimate and design limit levels, when appropriate, at the temperatures expected for all critical conditions.

3.12.1.8 Flight Hardware Pressure Vessel and Pressurized Structure Stiffness Requirements

a. Pressure vessels and pressurized structures shall possess adequate stiffness to preclude detrimental deformation at limit loads and pressures in the expected operating environments throughout their respective service lives.

b. The stiffness properties of pressure vessels and pressurized structures shall be such as to prevent all detrimental instabilities of coupled vibration modes, minimize detrimental effects of the loads and dynamics response that are associated with structural flexibility, and avoid adverse contact with other vehicle systems.

3.12.1.9 Flight Hardware Pressure Vessel and Pressurized Structure Thermal Requirements

a. Thermal effects, including heating rates, temperatures, thermal gradient, thermal stresses and deformations, and changes in the physical and mechanical properties of the material of construction shall be considered in the design of all pressure vessels and pressurized structures.

b. These effects shall be based on temperature extremes that simulate those predicted for the operating environment plus a design margin as specified in MIL-STD-1540 or equivalent.

3.12.1.10 Composite Overwrapped Pressure Vessels Requirements

Additional design and test requirements for graphite epoxy (Gr/EP) composite overwrapped pressure vessels (COPVs) can be found in the 23 November 1993 letter "Interim Safety Requirements for Design, Test, and Ground Processing of Flight Graphite Epoxy (Gr/EP) Composite Overwrapped Pressure Vessels (COPVs) at the Kennedy Space Center (KSC), Cape Canaveral Air Force Station (CCAFS), and Vandenberg Air Force Base (VAFB)" issued by the Director, Safety and Reliability, NASA, KSC and the Chiefs of Safety,

USAF, 30 SW and 45 SW. **NOTE 1:** The requirements stipulated in this letter are interim requirements for GR/EP COPVs. Final requirements will be incorporated in this document when the results of the GR/EP COPV test programs are complete. **NOTE:** A copy of the interim safety requirements may be obtained from the Safety Office.

3.12.1.11 Physical Arrangement of Flight Hardware Pressure Systems and System Components

3.12.1.11.1 General Requirements.

a. The design of hypergolic systems shall take into consideration limitations imposed on individuals dressed in SCAPE during fill and drain operations.

b. Sufficient clearances are needed for the insertion of assembly tools.

c. Redundant pressure components and systems shall be separated from main systems for maximum safety advantage in case of damage, fire, or malfunction.

d. Pressure systems shall be shielded from other systems when required to minimize all hazards caused by proximity to combustible gases, heat sources, and electrical equipment.

e. Any failure in any such adjacent system shall not result in combustion or explosion of pressure fluids or components.

f. Safety critical pressure systems shall be designed so that special tools shall not be required for removal and replacement of components unless it can be shown that the use of special tools is unavoidable.

3.12.1.11.2 Components and Fixtures.

a. Fixtures for safe handling and hoisting with coordinated attachment points in the system structure shall be provided for equipment that cannot be hand carried.

b. Components shall be designed so that, during the assembly of parts, sufficient clearance exists to permit assembly of the components without damage to seals, O-rings, or backup rings where they pass over threaded parts or sharp corners.

c. Pressure fluid reservoirs shall be shielded or isolated from combustion apparatus or other heat sources.

d. Handling and hoisting loads shall be in accordance with OSHA requirements, ASME/ANSI B30 series, and sections 3.6 and 6.6 of this document.

e. All incompatible propellant system connections shall be keyed, sized, or located so that it is physically impossible to interconnect them.

3.12.1.11.3 Tubing and Piping.

a. In general, tubing and piping shall be located so that damage will not occur due to being stepped on, used as handholds, or by manipulation of tools during installation.

b. Straight tubing and piping runs shall be avoided between two rigid connection points.

c. Where such straight runs are necessary, provisions shall be made for expansion joints, motion of the units, or similar compensation to insure that no excessive strains will be applied to the tubing and fittings.

d. Line bends shall be used to ease stresses in-

REFERENCED DOCUMENTS

duced in tubing by alignment tolerances and vibration.

3.12.1.11.4 Valves, Vents, Vent Lines, and Drains.

a. Manually operated valves should be located to permit operation from the side or above to prevent spillage of service fluid on the operator due to leak or failure of the valve seals.

b. For remotely controlled valves, positive indication of actual valve position shall be displayed at the control station. **NOTE 1:** Indication of valve stem position or flow measurement is an acceptable indication. **NOTE 2:** Indication of an electrical control circuit actuation is not a positive indication of valve position.

c. Vent lines for flammable and combustible vapors shall be extended away from work areas to prevent accidental ignition of vapors and/or injury to personnel.

d. Vent outlets shall be located far enough away from incompatible propellant systems and incompatible materials to ensure no contact is made during vent operations.

e. Safety valves and burst diaphragms shall be located so that their operation will not cause injury to personnel standing close by or damage to the installation or equipment, or they shall be equipped with deflection devices to protect personnel and equipment.

f. Lines, drains, and vents shall be separated or shielded from other high-energy systems; for example, heat, high voltage, combustible gases, and chemicals.

g. Drain and vent lines shall not be connected to any other lines in any way that could generate a hazardous mixture in the drain/vent line, or allow feedback of hazardous substances to the components being drained or vented.

h. When lines are required for draining liquid explosive, flammable liquids or explosive waste, they shall be free of pockets or low spots so that a positive flow is achieved at all points in the drain line.

i. The slope shall not be less than 1/4 inch per foot at any point on the drain line.

j. The drain system shall include a sump or basin where the fluid can safely collect. This sump or basin shall be designed so that it can be easily cleaned, and drainage easily removed.

3.12.1.11.5 Test Points.

a. If required, test points shall be provided so that disassembly for test is not required.

b. The test points shall be easily accessible for attachment of ground test equipment.

c. Common-plug test connectors for pressure and return sections shall be designed to require positive removal of the pressure connection prior to unsealing the return connections.

d. Individual pressure and return test connectors shall be designed to positively prevent inadvertent cross-connections.

3.12.1.12 Flight Hardware Pressure System and Pressurized Structures Supports and Clamps

a. All rigid pipe and tubing assemblies shall be supported by a firm structure to restrain destructive vibration, shock, and acceleration.

b. Components within a system should be supported by a firm structure and not the connecting tubing or piping unless it can be shown by analysis that the tubing or piping can safely support the component.

c. Pipe and tube accessories such as supports, anchors, and braces shall be compatible with hypergolic vapors when installed in a hypergolic propellant system.

d. All threaded parts in safety critical components shall be securely locked to resist uncoupling forces by acceptable safe design methods.

e. Safety wiring and self-locking nuts are examples of acceptable safe design.

f. Torque for threaded parts in safety critical components shall be specified.

g. Friction-type locking devices shall be avoided in safety critical applications.

h. Star washers and jam nuts shall not be used as locking devices.

i. The design of internally threaded bosses shall preclude the possibility of damage to the component or the boss threads because of screwing universal fittings to excessive depths in the bosses.

j. Retainers or snap rings shall not be used in pressure systems where failure of the ring would allow connection failures or blow-outs caused by internal pressure.

k. Snubbers shall be used with all Bourdon-type pressure transmitters, pressure switches, and pressure gauges, except air pressure gauges.

3.12.1.13 Flight Hardware Pressure System Bonding and Grounding

a. Hazardous pressure systems shall be designed so that the flight system being loaded or unloaded and the ground support loading system can be commonly grounded and bonded during transfer operations. When the flight system and the ground system are connected, maximum DC resistance from any flight system tubing or tanks to the nearest earth electrode plate shall be 100 milliohms or less.

NOTE: See paragraph 3.11.1.18.6.

b. Propellant system components and lines shall be grounded to metallic structures.

c. All hazardous pressure systems shall be properly bonded to the flight vehicle to minimize the DC resistance between the hazardous pressure system and the flight vehicle.

3.12.1.14 Flight Hardware Pressure System and Pressurized Structure Material Compatibility and Selection

3.12.1.14.1 Compatibility.

a. Materials shall be compatible throughout their intended service life with the service fluids and the materials used in the construction and installation of tankage, piping, and components as well as with nonmetallic items such as gaskets, seals, packing, seats, and lubricants.

b. At a minimum, material compatibility shall be determined in regard to flammability, ignition and combustion, toxicity, and corrosion.

c. Materials that could come in contact with fluid from a ruptured or leaky tank, pipe, or other components that contain hazardous fluids shall be nonflammable and non-combustible.

d. Compatible materials selection shall be obtained from one of the following sources:

1. T.O. 00-25-223
2. Chemical Propulsion Information Agency (CPIA) 394
3. MSFC-HDBK-527
4. Compatibility test criteria and test results shall be submitted to Range Safety for review and approval.

e. Compatibility Analysis. The Range User shall prepare a compatibility analysis containing the following information:

1. List of all materials used in system
2. Service fluid in contact with each material
3. Source document or test results showing material compatibility in regards to flammability, toxicity, corrosion, and ignition and combustion

3.12.1.14.2 Selection.

a. Material "A" allowable values shall be used for pressure vessels, and pressurized structures where failure of a single load path would result in loss of structural integrity.

b. For redundant pressurized structures where failure of a structural element would result in a safe redistribution of applied loads to other load-carrying members, material "B" allowables may be used.

c. The fracture toughness shall be as high as practicable within the context of structural efficiency and fracture resistance.

d. For pressure vessels and pressurized structures to be analyzed with linear elastic fracture mechanics, fracture properties shall be accounted for in material selection.

e. These properties include fracture toughness; threshold values of stress intensity under sustained loading; subcritical crack-growth characteristics under sustained and cyclic loadings; the effects of fabrication and joining processes; the effects of cleaning agents, dye penetrants, coatings and proof test fluids; and the effects of temperature, load spectra, and other environmental conditions.

f. Materials that have a low K_{ISCC} , in the expected operating environments shall not be used in pressure vessels and pressurized structures unless adequate protection from the operating environments can be demonstrated by tests.

g. If the material has a less than 60 percent of the plane-strain fracture toughness, K_{IC} , under the conditions of its application, it shall be mandatory to show, by a "worst case" fracture mechanics analysis, that the low threshold stress intensity factor will not precipitate premature structural failure.

3.12.1.15 Flight Hardware Pressure System Contamination and Cleanliness Requirements

a. Adequate levels of contamination control shall be established by relating the cleanliness requirements to the actual needs and nature of the system and components.

b. General contamination control requirements are as follows:

1. Components and systems shall be protected from contaminants by adequate filtration, sealed modules, clean fluids, and clean environment during assembly, storage installation, and use.
2. Systems shall be designed to verify that the lines and components are clean after flushing and

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purging the system.

3. Systems shall be designed to ensure that contaminants or waste fluids can be flushed and purged after fill and drain operations.

3.12.1.16 Flight Hardware Pressure System Components Service Life and Safe Life

a. All hazardous pressure system components shall be designed for safe endurance against hazardous failure modes for not less than 400 percent of the total number of expected prelaunch cycles.

b. The safe-life shall be determined by analysis, test, or both, and shall be at least four times the specified service life for those pressure vessels and pressurized structures that are not accessible for periodic inspection and repair.

c. For those pressure vessels and pressurized structures that are readily accessible for periodic inspection and repair, the safe-life, as determined by analysis and test, shall be at least four times the interval between scheduled inspection and/or refurbishment.

d. All pressure vessels and pressurized structures that require periodic refurbishment to meet safe-life requirements shall be recertified after each refurbishment by the same techniques and procedures used in the initial certification, unless an alternative recertification plan has been approved by the procuring agency.

3.12.1.17 Flight Hardware Metallic Materials

3.12.1.17.1 Selection. Metallic materials shall be selected on the basis of proven environmental compatibility, material strengths, fracture properties, fatigue life, and crack growth characteristics consistent with the overall program requirements.

3.12.1.17.2 Evaluation. Metallic material evaluation shall be conducted based on the following considerations:

a. The metallic materials selected for design shall be evaluated with respect to material processing, fabrication methods, manufacturing operations, refurbishment procedures and processes, and other pertinent factors that affect the resulting strength and fracture properties of the material in the fabricated as well as the refurbished configurations.

b. The evaluation shall ascertain that the mechanical properties, strengths, and fracture properties used in design and analyses will be realized in

the actual hardware and that these properties are compatible with the fluid contents and the expected operating environments.

c. Materials that are susceptible to stress-corrosion cracking or hydrogen embrittlement shall be evaluated by performing sustained threshold-stress-intensity tests when applicable data are not available.

3.12.1.17.3 Characterization. Metallic material characterization shall be based on the following considerations:

a. The allowable mechanical properties, strength and fracture properties of all metallic materials selected for pressure vessels and pressurized structures shall be characterized in sufficient detail to permit reliable and high confidence predictions of their structural performance in the expected operating environments unless these properties are available from reliable sources such as MIL-HDBK-5, ASTM Standards, *Damage Tolerant Design Handbook*, MIL Specifications, *Aerospace Structural Metals Handbook*, and other sources approved by the procuring agency.

b. Where material properties are not available, they shall be determined by test methods approved by the procuring agency.

c. The characterization shall produce the following strength and fracture properties for the parent metals, weldments, and heat-affected zones as a function of the fluid contents, loading spectra, and the expected operating environments, including proof test environments, as appropriate:

1. Tensile yield strength, σ_{ys} , and ultimate tensile strength, σ_u

2. Fracture toughness, K_{Ic} , K_{Ie} , K_{Ic} , K_{ISCC}

3. Sustained-stress crack-growth data, da/dt versus K_{max}

4. Fatigue crack-growth data, da/dN versus ΔK and load ratio, R

d. Proven test procedures shall be used for determining material fracture properties as required. **NOTE:** These procedures shall conform to recognized standards, such as standard test methods developed by the American Society for Testing and Materials (ASTM).

e. The test specimens and procedures used shall provide valid test data for the intended application.

f. Enough tests shall be conducted so that meaningful nominal values of fracture toughness and crack-growth rate data corresponding to each alloy system, temper, product form, thermal and chemical environments and loading spectra can be established to evaluate compliance with safe-life requirements.

g. If the conventional fatigue analysis is to be performed, the stress-life (S-N) or the strain-life (ϵ -N) fatigue data need to be generated in accordance with the standard test methods developed by ASTM.

3.12.1.17.4 Fabrication and Process Control. Proven processes and procedures for fabrication and repair shall be used to preclude damage or material degradation during material processing, manufacturing operations, and refurbishment.

a. In particular, special attention shall be given to ascertain that the melt process, thermal treatment, welding process, forming, joining, machining, drilling, grinding, repair and rewelding operations, etc., are within the state-of-the-art and have been used on similar hardware.

b. The fracture toughness, mechanical and physical properties of the parent materials, weldments and heat-affected zones shall be within established design limits after exposure to the intended fabrication processes.

c. The machining, forming, joining, welding, dimensional stability during thermal treatments, and through-thickness hardening characteristics of the material shall be compatible with the fabrication processes to be encountered.

d. Fracture control requirements and precautions shall be defined in applicable drawings and process specifications.

e. Detailed fabrication instructions and controls shall be provided to ensure proper implementation of the fracture control requirements.

f. Special precautions shall be exercised throughout the manufacturing operations to guard against processing damage or other structural degradation. In addition, procurement requirements and controls shall be implemented to ensure that suppliers and subcontractors employ fracture control procedures and precautions consistent with the fabrication and inspection processes intended for use during actual hardware fabrication.

3.12.1.18 Flight Hardware Pressure Vessel and Pressurized Structure Quality Assurance Program Requirements

a. A quality assurance (QA) program, based on a comprehensive study of the product and engineering requirements, such as drawings, material specifications, process specifications, workmanship standards, design review records, and failure mode analysis, shall be established to ensure that the necessary NDI and acceptance tests are effectively performed to verify that the product meets the requirements of this document.

b. The program shall ensure that materials, parts, subassemblies, assemblies, and all completed and refurbished hardware conform to applicable drawings and process specifications; that no damage or degradation has occurred during material processing, fabrication, inspection, acceptance tests, shipping, storage, operational use and refurbishment; and that defects that could cause failure are detected or evaluated and corrected.

3.12.1.18.1 QA Program Inspection Plan. At a minimum, the following considerations shall be included in structuring the quality assurance program:

a. An inspection master plan shall be established prior to start of fabrication.

b. The plan shall specify appropriate inspection points and inspection techniques for use throughout the program, beginning with material procurement and continuing through fabrication, assembly, acceptance proof test, operation, and refurbishment, as appropriate.

c. In establishing inspection points and inspection techniques, consideration shall be given to the material characteristics, fabrication processes, design concepts, structural configuration and accessibility for inspection of flaw.

d. For metallic hardware, the flaw geometries shall encompass defects commonly encountered, including surface crack at the open surface, corner crack or through-the-thickness crack at the edge of fastener hole, and surface crack at the root of intersecting prismatic structural elements.

e. Acceptance and rejection standards shall be established for each phase of inspection, and for each type of inspection technique.

f. For composite pressure vessels or COPVs, defects such as delamination, fiber breakage, surface cut or dent, shall be considered.

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3.12.1.18.2 Inspection Techniques. At a minimum, the following considerations shall be included in determining the appropriate inspection techniques:

a. The selected NDI inspection techniques for metallic hardware must have the capability to determine the size, geometry, location and orientation of a flaw or defect; to obtain, where multiple flaws exist, the location of each with respect to the other and the distance between them; and to differentiate among defect shapes, from tight cracks to spherical voids.

b. Two or more NDI methods shall be used for a part or assembly that cannot be adequately examined by only one method.

c. The flaw detection capability of each selected NDI technique for metallic hardware or the metallic liner of a COPV shall be based on past experience on similar hardware.

d. Where this experience is not available or is not sufficiently extensive to provide reliable results, the capability, under production or operational inspection conditions, shall be determined experimentally and demonstrated by tests approved by the procuring agency on representative material product form, thickness, and design configuration.

e. The flaw detection capability shall be expressed in terms of detectable crack length and crack depth.

f. The selected NDI should be capable of detecting allowable initial flaw size corresponding to a 90 percent probability of detection at a 95 percent confidence level.

g. The most appropriate NDI technique(s) for detecting commonly encountered flaw types shall be used for all metallic pressure vessels, pressurized structures, and other hardware based on their flaw detection capabilities.

3.12.1.18.3 Inspection Data. At a minimum, inspection data shall be dispositioned as follows:

a. Inspection data in the form of flaw histories shall be maintained throughout the life of the pressure vessel and pressurized structure.

b. These data shall be periodically reviewed and assessed to evaluate trends and anomalies associated with the inspection procedures, equipment and personnel, material characteristics, fabrication processes, design concept and structural configuration.

c. The result of this assessment shall form the basis of any required corrective action.

3.12.1.18.4 Flight Hardware Pressure Vessels, Pressurized Structures, and Pressurized System Components Acceptance Proof Test.

a. All pressure vessels, pressurized structures, and pressure components shall be proof-pressure tested in accordance with the requirements of Sections 3.12.2 through 3.12.5, as applicable, to verify that the hardware has sufficient structural integrity to sustain the subsequent service loads, pressure, temperatures, and environments.

b. For pressure vessels, pressurized structures, and other pressurized components, the temperature shall be consistent with the critical use temperature, or, as an alternative, tests may be conducted at an alternate temperature if the test pressures are suitably adjusted to account for temperature effects on strength and fracture toughness.

c. Proof-test fluids shall be compatible with the structural materials in the pressure vessels and pressurized structures.

d. Proof test fluids shall not pose a hazard to test personnel.

e. If such compatibility data is not available, required testing shall be conducted to demonstrate that the proposed test fluid does not deteriorate the test article.

f. Accept/reject criteria shall be formulated prior to the acceptance proof test.

g. Every pressure vessel and pressurized structure shall not leak, rupture, or experience gross yielding during acceptance testing.

3.12.1.19 Flight Hardware Pressure Systems and Pressurized Structures Operations and Maintenance

3.12.1.19.1 Safe Operating Limits.

a. Safe operating limits shall be established for each pressure vessel and each pressurized structure based on the appropriate analysis and testing employed in its design and qualification in accordance with Sections 3.12.2, 3.12.3, and 3.12.4.

b. These safe operating limits shall be summarized in a format that will provide rapid visibility of the important structural characteristics and capability.

3.12.1.19.2 Operating Procedures.

a. Operating procedures shall be established for each pressure vessel and pressurized structure.

b. These procedures shall be compatible with the safety requirements and personnel control requirements at the facility where the operations are conducted.

c. Step-by-step directions shall be written with sufficient detail to allow a qualified technician or mechanic to accomplish the operations.

d. Schematics that identify the location and pressure limits of relief valves and burst discs shall be provided when applicable, and procedures to insure compatibility of the pressurizing system with the structural capability of the pressurized hardware shall be established.

e. Prior to initiating or performing a procedure involving hazardous operations with pressure systems, practice runs shall be conducted on non-pressurized systems until the operating procedures are well rehearsed.

f. Initial tests shall then be conducted at pressure levels not to exceed 50 percent of the normal operating pressures until operating characteristics can be established and stabilized.

g. Only qualified and trained personnel shall be assigned to work on or with high pressure systems.

h. Warning signs with the hazard(s) identified shall be posted at the operations facility prior to pressurization.

3.12.1.19.3 Inspection and Maintenance.

a. The results of the appropriate stress, and safe-life analyses shall be used in conjunction with the appropriate results from the structural development and qualification tests to develop a quantitative approach to inspection and repair.

b. Allowable damage limits shall be established for each pressure vessel and pressurized structure so that the required inspection interval and repair schedule can be established to maintain hardware to the requirements of this document.

c. NDI technique(s) and inspection procedures to reliably detect defects and determine flaw size under the condition of use shall be developed for use in the field and depot levels.

d. Procedures shall be established for recording, tracking, and analyzing operational data as it is accumulated to identify critical areas requiring corrective actions.

e. Analyses shall include prediction of remaining life and reassessment of required inspection intervals.

3.12.1.19.4 Repair and Refurbishment.

a. When inspections reveal structural damage or defects exceeding the permissible levels, the damaged hardware shall be repaired, refurbished, or replaced, as appropriate.

b. All repaired or refurbished hardware shall be recertified after each repair and refurbishment by the applicable acceptance test procedure for new hardware to verify their structural integrity and to establish their suitability for continued service.

3.12.1.19.5 Storage Requirements.

a. When pressure vessels and pressurized structures are put into storage, they shall be protected against exposure to adverse environments that could cause corrosion or other forms of material degradation.

b. They shall be protected against mechanical degradation resulting from scratches, dents, or accidental dropping of the hardware.

c. Induced stresses due to storage fixture constraints shall be minimized by suitable storage fixture design.

d. In the event storage requirements are violated, recertification shall be required prior to acceptance for use.

3.12.1.19.6 Reactivation.

a. Pressure vessels and pressurized structures that are reactivated for use after an extensive period in either an unknown, unprotected, or unregulated storage environment shall be recertified to ascertain their structural integrity and suitability for continued service before commitment to flight.

b. Recertification tests for pressurized hardware shall be in accordance with the appropriate Recertification Test Requirement.

3.12.1.20 Flight Hardware Pressure Systems and Pressurized Structures Documentation Requirements

a. Inspection, maintenance, and operation records shall be kept and maintained throughout the life of each pressure vessel and each pressurized structure.

b. At a minimum, the records shall contain the following information:

1. Temperature, pressurization history, and pressurizing fluid for both tests and operations

REFERENCED DOCUMENTS

2. Number of pressurizations experienced as well as number allowed in safe-life analysis

3. Results of any inspection conducted, including: inspector, inspection dates, inspection techniques employed, location and character of defects, defect origin, and cause

4. Storage condition

5. Maintenance and corrective actions performed from manufacturing to operational use, including refurbishment

6. Sketches and photographs to show areas of structural damage and extent of repairs

7. Acceptance and recertification test performed, including test conditions and results

8. Analyses supporting the repair or modification that may influence future use capability

3.12.2 Flight Hardware Pressure Vessels Design, Analysis, and Test Requirements

3.12.2.1 Flight Hardware Metallic Pressure Vessels General Design, Analysis, and Verification Requirements

Two approaches for the design, analysis and verification of metallic pressure vessels can be selected as shown in Figure 3-1. Selection of the approach to be used depends on the desired efficiency of design coupled with the level of analysis and verification testing required.

3.12.2.1.1 Approach A. Approach A in Figure 3-1 shows the steps required for verification of a metallic pressure vessel designed with a burst factor equal to 1.5 or greater.

a. Based on the results of the failure mode determination, one of two distinct verification paths must be satisfied: (1) leak-before-burst (LBB) with leakage of the contents not creating a condition that could lead to a mishap (such as Toxic gas venting or pressurization of a compartment not capable of the pressure increase, and (2) brittle failure mode or LBB in which, if allowed to leak, the leak causes a hazard.

b. The verification requirements for path 1 are delineated in Section 3.12.2.2, and the verification requirements for path 2 in Section 3.12.2.3.

3.12.2.1.2 Approach B. Approach B, Figure 3-1 shows the steps required for verification of a metallic pressure vessel designed using the ASME

Boiler and Pressure Vessel Code or the Department of Transportation Pressure Vessel Codes.

3.12.2.2 Flight Hardware Metallic Pressure Vessels with Non-Hazardous LBB Failure Mode

a. The LBB failure mode shall be demonstrated analytically or by test showing that an initial surface flaw with a shape ($a/2c$) ranging from 0.05 to 0.5 will propagate through the vessel thickness to become a through-the-thickness crack with a length less than or equal to ten times the vessel thickness and will still be stable at MEOP.

b. Fracture mechanics shall be used if the failure mode is determined by analysis.

c. A pressure vessel that contains non-hazardous fluid and exhibit LBB failure mode is considered as a non-hazardous LBB pressure vessel.

3.12.2.2.1 Factor of Safety Requirements.

a. Metallic pressure vessels that satisfy the non-hazardous LBB failure mode criterion may be designed conventionally, wherein the design factors of safety and proof test factors are selected on the basis of successful past experience.

b. Unless otherwise specified, the minimum burst factor shall be 1.5.

3.12.2.2.2 Fatigue-Life Demonstration.

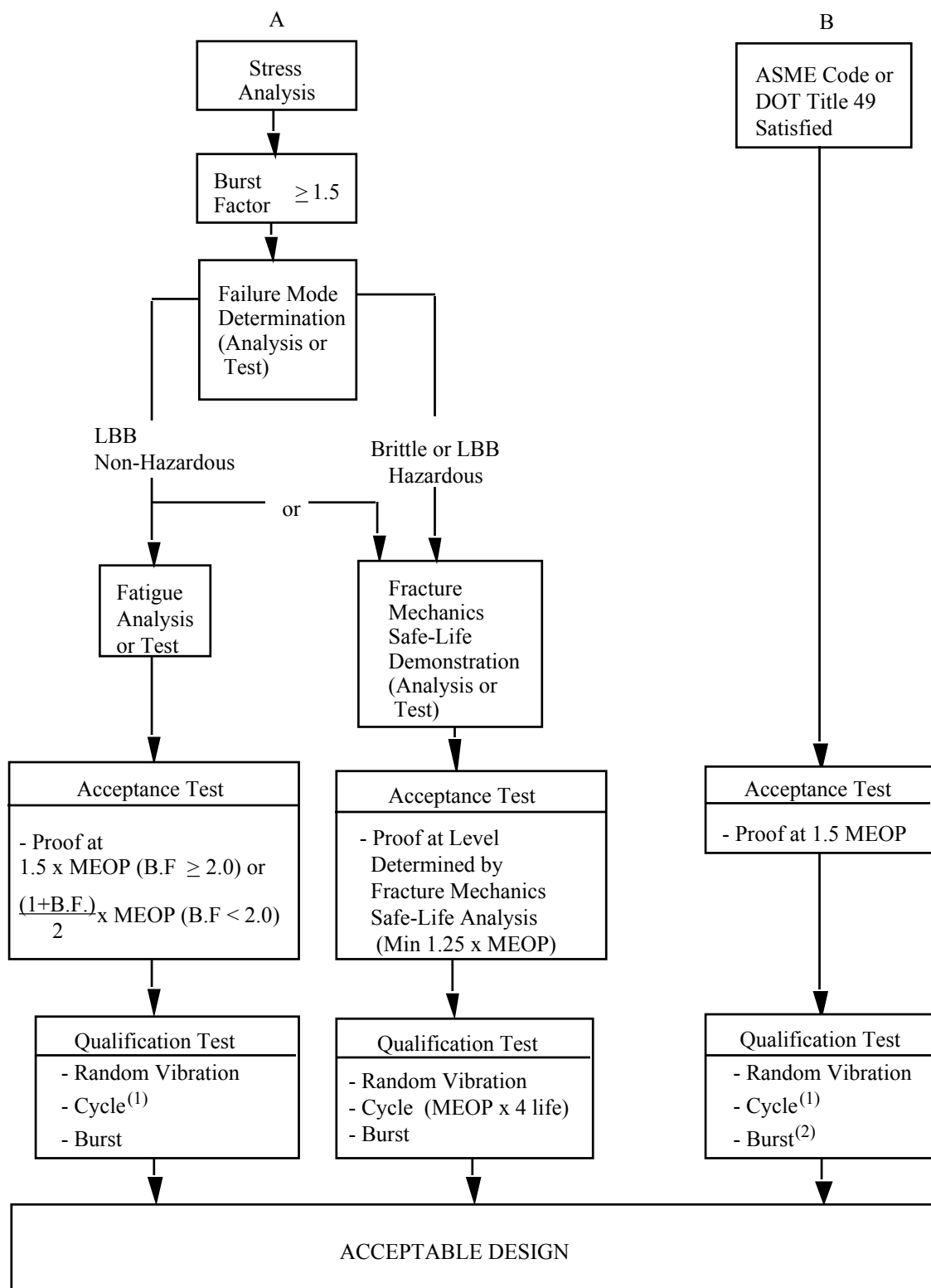
a. After completion of the stress analysis conducted in accordance with the requirements of Section 3.12.2.5, conventional fatigue-life analysis shall be performed, as appropriate, on the unflawed structure to ascertain that the pressure vessel, acted upon by the spectra of operating loads, pressures, and environments will meet the life requirements.

b. A life factor of 5 shall be used in the analysis.

c. Testing of unflawed specimens to demonstrate fatigue-life of a specific pressure vessel together with stress analysis is an acceptable alternative to fatigue test of the vessel.

d. Fatigue-life requirements are considered demonstrated when the unflawed specimens that represent critical areas such as membrane section, weld joints, heat-affected zone, and boss transition section successfully sustain the limit loads and MEOP in the expected operating environments for the specified test duration without rupture.

e. The required test duration is four times the specified service life.



NOTES: (1) Cycle test at either MEOP x 4-life or 1.5 MEOP x 2 life

Figure 3-1. Pressure Vessel Design Verification Approach

REFERENCED DOCUMENTS

3.12.2.2.3 Qualification Test Requirements.

a. Qualification tests shall be conducted on flight-quality hardware to demonstrate structural adequacy of the design.

b. The test fixtures, support structures, and methods of environmental application shall not induce erroneous test conditions.

c. The types of instrumentation and their locations in qualification tests shall be based on the results of the stress analysis of Section 3.12.1.5.3.

d. The instrumentation shall provide sufficient data to ensure proper application of the accept/reject criteria, which shall be established prior to test.

e. The sequences, combinations, levels, and duration of loads, pressure, and environments shall demonstrate that design requirements have been met.

f. Qualification testing shall include random vibration testing and pressure testing. The following delineates the required tests:

1. Random Vibration Testing. Random vibration qualification testing shall be performed in accordance with the requirements of MIL-STD-1540 or equivalent unless it can be shown that the vibration requirement is enveloped by other qualification testing performed.

2. Pressure Testing. Required qualification pressure testing levels are shown in Table 3-1. Requirement for application of external loads in combination with internal pressures during testing must be evaluated based on the relative magnitude and/or destabilizing effect of stresses due to the external load. If limit combined tensile stresses are enveloped by test pressure stresses, the application

of external loads shall not be required. If the application of external loads is required, the load shall be cycled to limit for four times the predicted number of operating cycles of the most severe design condition (e.g., destabilizing load with constant minimum internal pressure or maximum additive load with a constant maximum expected operating pressure.

3.12.2.2.4 Acceptance Test Requirements.

a. Acceptance tests shall be conducted on every pressure vessel before commitment to flight. Accept/reject criteria shall be formulated prior to tests.

b. The test fixtures and support structures shall be designed to permit application of all test loads without jeopardizing the flightworthiness of the test article.

c. At a minimum, the following are required:

1. Non-Destructive Inspection. A complete inspection by the selected non-destructive inspection (NDI) technique(s) shall be performed prior to proof pressure test to establish the initial condition of the hardware.

2. Proof Pressure Test. Every pressure vessel shall be proof-pressure tested to verify that the materials, manufacturing processes, and workmanship meet design specifications and that the hardware is suitable for flight. The proof pressure shall be equal to:

$$P_{\text{proof}} = \left(\frac{1 + \text{Burst Factor}}{2} \right) \times (\text{MEOP})$$

for burst factor less than 2.0 or 1.5 x (MEOP) for burst factor equal or greater than 2.0

Table 3-1
Qualification Pressure Test Requirements

Test Item	No Yield after	No Burst at(1)
Vessel #1(2)	Cycle at 1.5 x MEOP for 2x predicted number of service life. (50 cycles minimum) or Cycle at 1.0 x MEOP for 4x predicted number of service life. (50 cycles minimum)	Burst Factor x MEOP
Vessel #2		Burst Factor x MEOP

(1) Unless otherwise specified, after demonstrating no burst at the design burst pressure test level, increase pressure to actual burst of vessel. Record actual burst pressure.

(2) Test may be deleted at discretion of the Range User.

3.12.2.2.5 Recertification Test Requirements.

All refurbished pressure vessels shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight. Pressure vessels that have exceeded the approved storage environment (temperature, humidity, time, and others) shall also be recertified by the acceptance test requirements for new hardware.

3.12.2.2.6 Special Provisions. For one-of-a-kind applications, a proof test of each flight unit to a minimum of 1.5 times MEOP and a conventional fatigue analysis showing a minimum of 10 design lifetimes may be used in lieu of the required pressure testing as defined in paragraph 3.12.2.1.f.6 (b). The implementation of this option needs prior approval by the procuring agency and the appropriate launch and/or test range approval authority.

3.12.2.3 Flight Hardware Metallic Pressure Vessels with Brittle Fracture or Hazardous LBB Failure Mode.**3.12.2.3.1 Factor of Safety Requirements.**

a. Safe-life design methodology based on fracture mechanics techniques shall be used to establish the appropriate design factor of safety and the associated proof factor for metallic pressure vessels that exhibit brittle fracture or hazardous leak-before-burst failure mode.

b. The loading spectra, material strengths, fracture toughness, and flaw-growth rates of the parent material and weldments, test program requirements, stress levels, and the compatibility of the structural materials with the thermal and chemical environments expected in service shall be taken into consideration.

c. Nominal values of fracture toughness and flaw-growth rate data corresponding to each alloy system, temper, and product form shall be used along with a life factor of four on specified service life in establishing the design factor of safety and the associated proof factor.

d. Unless otherwise specified the minimum burst factor shall be 1.5.

3.12.2.3.2 Safe-Life Demonstration Requirements.

a. After completion of the stress analysis conducted in accordance with the requirements of Section 3.12.1.5.3, safe-life analysis of each pressure vessel covering the maximum expected operating loads and environments, shall be performed

under the assumption of pre-existing initial flaws or cracks in the vessel.

b. In particular, the analysis shall show that the metallic pressure vessel with flaws placed in the most unfavorable orientation with respect to the applied stress and material properties, of sizes defined by the acceptance proof test or NDI and acted upon by the spectra of expected operating loads and environments, will meet the safe-life requirements of 3.12.1.16.

c. Nominal values of fracture toughness and flaw-growth rate data associated with each alloy system, temper, product form, thermal and chemical environments, and loading spectra shall be used along with a life factor of four on specified service life in all safe-life analyses.

d. Pressure vessels that experience sustained stress shall also show that the corresponding applied stress intensity (K_I) during operation is less than K_{ISCC} in the appropriate environment.

e. Testing of metallic pressure vessels under fracture control in lieu of safe-life analysis is an acceptable alternative, provided that, in addition to following a quality assurance program (Section 4.6) for each flight article, a qualification test program is implemented on pre-flawed specimens representative of the structure design.

f. These flaws shall not be less than the flaw sizes established by the acceptance proof test or the selected NDI method(s).

g. Safe-life requirements of 3.12.1.16 are considered demonstrated when the pre-flawed test specimens successfully sustain the limit loads and pressure cycles in the expected operating environments without rupture.

h. A life factor of four on specified service life shall be applied in the safe-life demonstration testing.

i. A report that documents the fracture mechanics safe-life analysis or safe-life testing shall be prepared to delineate the following:

1. Fracture mechanics data (fracture toughness and fatigue crack growth rates)
2. Loading spectrum and environments
3. Initial flaw sizes
4. Analysis assumptions and rationales
5. Calculation methodology
6. Summary of significant results
7. References

j. This report shall be closely coordinated with the stress analysis report and shall be periodically revised and updated during the life of the program.

REFERENCED DOCUMENTS

3.12.2.3.3 Qualification Test Requirements.

a. Qualification tests shall be conducted on flight-quality hardware to demonstrate structural adequacy of the design.

b. The test fixtures, support structures, and methods of environmental application shall not include erroneous test conditions.

c. The types of instrumentation and their locations in qualification tests shall be based on the results of the stress analysis of Section 3.12.1.5.3.

d. The instrumentation shall provide sufficient data to ensure proper application of the accept/reject criteria, which shall be established prior to test.

e. The sequences, combinations, levels, and duration of loads, pressure and environments shall demonstrate that design requirements have been met.

f. Qualification testing shall include random vibration testing, and pressure testing. The following delineates the required tests:

1. Random Vibration. Random vibration qualification testing shall be performed per requirements of MIL-STD-1540 or equivalent unless it can be shown the vibration requirement is enveloped by other qualification testing performed.

2. Pressure Testing. Required qualification pressure testing levels are shown in Table 3-1. Requirement for application of external loads in combination with internal pressures during testing must be evaluated based on the relative magnitude and/or destabilizing effect of stresses due to the external load. If limit combined tensile stresses are enveloped by test pressure stresses, the application of external loads shall not be required. If the application of external loads is required, the load shall be cycled to limit for four times the predicted number of operating cycles of the most severe design condition (e.g., destabilizing load with constant minimum internal pressure, or maximum additive load with constant maximum expected operating pressure). Qualification test procedure shall be approved by the procuring agency and the appropriate launch or test range approval authority.

3.12.2.3.4 Acceptance Test Requirements.

The acceptance test requirements for pressure vessels that exhibit brittle fracture, or hazardous LBB, failure mode are identical to those with ductile fracture failure mode as defined in Section

3.12.2.2.4 except that test level shall be that defined by the fracture mechanics analysis whenever possible. Surface and Volume NDI shall be performed before and after proof test on the weld joints as a minimum. Cryo-proof acceptance test procedures may be required to adequately verify initial flaw size. The pressure vessel shall not rupture or leak at the acceptance test pressure.

3.12.2.3.5 Recertification Test Requirements.

All refurbished pressure vessels shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight. Pressure vessels that have exceeded the approved storage environment (temperature, humidity, time, etc.) shall also be recertified by the acceptance test requirements for new hardware.

3.12.2.3.6 Special Provisions. For one-of-a-kind applications, a proof test of each flight unit to a minimum of 1.5 times MEOP and a conventional fatigue analysis showing a minimum of 10 design lifetimes may be used in lieu of the required pressure testing as defined in Section 3.12.2.2.3 for qualification. The implementation of this option needs prior approval by Range Safety.

3.12.2.4 Flight Hardware Metallic Pressure Vessels Designed Using ASME Boiler Code

Metallic pressure vessels may be designed and manufactured per the rules of the ASME Boiler and Pressure Vessel Code, Section VIII, Divisions 1 or 2.

3.12.2.4.1 Qualification Test Requirements.

a. Required qualification pressure testing levels are shown in Table 3-1.

b. Requirement for application of external loads in combination with internal pressures during testing must be evaluated based on the relative magnitude and/or destabilizing effect of stresses due to the external load.

c. If limit combined tensile stresses are enveloped by test pressure stresses, the application of external loads shall not be required.

d. If the application of external loads is required, the load shall be cycled to limit for four times the predicted number of operating cycles of the most severe design condition (for example, destabilizing load with constant minimum internal

pressure, or maximum additive load with constant MEOP).

3.12.2.4.2 Acceptance Test Requirements.

a. A proof test shall be performed as specified in ASME Code pressure test at 1.5 x MAWP unless otherwise prohibited by the Code.

b. NDI shall be performed in accordance with the ASME Code and RT and/or UT as appropriate to quantify defects in all full penetration welds after the proof test.

3.12.2.5 Flight Hardware Metal-Lined Composite Overwrapped Pressure Vessels

Flight Hardware composite overwrapped pressure vessels (COPVs) with metallic liners may be designed using either of the two paths of Approach A shown in Figure 3-1. The failure mode designation for a metal lined COPV shall be based on its environment and operational criteria while used at the launch site. Additional guidance can be found in paragraph 3.12.1.10.

3.12.2.6 COPVs with Non-Hazardous LBB Failure Mode

a. Applicable fracture mechanics analysis and/or tests of metal lined composite pressure vessels shall verify the LBB failure mode of the metal liner.

b. In particular the effects of the liner sizing operation on the fracture mechanics characteristics of the liner should be accounted for in the LBB evaluation.

3.12.2.6.1 Factor of Safety Requirements.

a. Nonmetallic pressure vessels that satisfy the non-hazardous LBB failure mode criterion may be designed conventionally, wherein the design factors of safety and proof test factors are selected on the basis of successful past experience.

b. Unless otherwise specified, the minimum burst factor shall be 1.5.

3.12.2.6.2 Fatigue-Life Demonstration.

a. After completion of the stress analysis conducted in accordance with the requirements of Section 3.12.1.5.3, conventional fatigue-life analysis shall be performed, as appropriate, on the unflawed structure to ascertain that the pressure ves-

sel, acted upon by the spectra of operating loads, pressures and environments will meet the life requirements.

b. A life factor of 5 shall be used in the analysis.

3.12.2.6.3 Qualification Test Requirements.

a. Qualification tests shall be conducted on flight-quality hardware to demonstrate structural adequacy of the design.

b. The test fixtures, support structures, and methods of environmental application shall not induce erroneous test conditions.

c. The types of instrumentation and their locations in qualification tests shall be based on the results of the stress analysis of Section 3.12.1.5.3.

d. The instrumentation shall provide sufficient data to ensure proper application of the accept/reject criteria, that shall be established prior to test.

e. The sequences, combinations, levels, and duration of loads, pressures, and environments shall demonstrate that design requirements have been met.

f. Qualification testing shall include random vibration testing and pressure testing. The following delineates the required tests:

1. Random Vibration Testing. Random vibration qualification testing shall be performed in accordance with the requirements of MIL-STD-1540 or equivalent unless it can be shown that the vibration requirement is enveloped by other qualification testing performed.

2. Pressure Testing

(a) Required qualification pressure testing levels are shown in Table 3-1.

(b) Requirement for application of external loads in combination with internal pressures during testing shall be evaluated based on the relative magnitude and/or destabilizing effect of stresses due to the external load.

(c) If limit combined tensile stresses are enveloped by test pressure stresses, the application of external loads shall not be required.

(d) If the application of external loads is required, the load shall be cycled to limit four times the predicted number of operating cycles of the most severe design condition (for example, destabilizing load with constant minimum internal pressure or maximum additive load with a constant MEOP).

REFERENCED DOCUMENTS

3.12.2.6.4 Acceptance Test Requirements.

a. Acceptance tests shall be conducted on every pressurized structure before commitment to flight.

b. Accept/reject criteria shall be formulated prior to tests.

c. The test fixtures and support structures shall be designed to permit application of all test loads without jeopardizing the flightworthiness of the test article.

d. At a minimum, the following are required:

1. A complete inspection by the selected non-destructive inspection (NDI) technique(s) shall be performed prior to proof pressure test to establish the initial condition of the hardware.

2. Every pressurized structure shall be proof tested to verify that the materials, manufacturing processes, and workmanship meet design specifications and that the hardware is suitable for flight. Unless otherwise specified, the proof pressure shall be 1.1 times MEOP.

3.12.2.6.5 Recertification Test Requirements.

a. All refurbished pressure vessels shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight.

b. Pressure vessels that have exceeded the approved storage environment (temperature, humidity, time, and others) shall also be recertified by the acceptance test requirements for new hardware.

3.12.2.7 Flight Hardware COPVs with Brittle Fracture or Hazardous LBB Failure Mode

This section is applicable only to flight hardware COPVs with metal liners that exhibit brittle fracture or hazardous LBB failure mode.

3.12.2.7.1 Factor of Safety Requirements.

Unless otherwise specified the minimum burst factor shall be 1.5.

3.12.2.7.2 Safe-Life Demonstration Requirements.

a. In addition to the stress analysis conducted in accordance with the requirements of Section 3.12.1.5.3, safe-life analysis of each pressure vessel covering the maximum expected operating loads and environments, shall be performed under

the assumption of pre-existing initial flaws or cracks in the vessel.

b. In particular, the analysis shall show that the metallic pressure vessel with flaws placed in the most unfavorable orientation with respect to the applied stress and material properties, of sizes defined by the acceptance proof test or NDI and acted upon by the spectra of expected operating loads and environments, will meet the safe-life requirements of Section 3.12.1.16.

c. Nominal values of fracture toughness and flaw-growth rate data associated with each alloy system, temper, product form, thermal and chemical environments, and loading spectra shall be used along with a life factor of four on specified service life in all safe-life analyses.

d. Pressure vessels that experience sustained stress shall also show that the corresponding applied stress intensity (K_I) during operation is less than K_ISCC in the appropriate environment.

e. Testing of metallic pressure vessels under fracture control in lieu of safe-life analysis is an acceptable alternative, provided that, in addition to following a quality assurance program for each flight article, a qualification test program is implemented on pre-flawed specimens representative of the structure design.

f. These flaws shall not be less than the flaw sizes established by the acceptance proof test or the selected NDI method(s).

g. Safe-life requirements of Section 3.12.1.16 are considered demonstrated when the pre-flawed test specimens successfully sustain the limit loads and pressure cycles in the expected operating environments without rupture.

h. A life factor of four on specified service life shall be applied in the safe-life demonstration testing.

i. A report that documents the fracture mechanics safe-life analysis or safe-life testing shall be prepared to delineate the following:

- 1.* Fracture mechanics data (fracture toughness and fatigue crack growth rates)
- 2.* Loading spectrum and environments
- 3.* Initial flaw sizes
- 4.* Analysis assumptions and rationales
- 5.* Calculation methodology
- 6.* Summary of significant results
- 7.* References

j. This report shall be closely coordinated with the stress analysis report and shall be periodically revised and updated during the life of the program.

3.12.2.7.3 Fatigue Life Demonstration. For fatigue life demonstration requirements, see section 3.12.2.6.2.

3.12.2.7.4 Qualification Test Requirements.

a. Qualification tests shall be conducted on flight-quality hardware to demonstrate structural adequacy of the design.

b. The test fixtures, support structures, and methods of environmental application shall not include erroneous test conditions.

c. The types of instrumentation and their locations in qualification tests shall be based on the results of the stress analysis of Section 3.12.1.5.3.

d. The instrumentation shall provide sufficient data to ensure proper application of the accept/-reject criteria, which shall be established prior to test.

e. The sequences, combinations, levels, and duration of loads, pressure and environments shall demonstrate that design requirements have been met.

f. Qualification testing shall include random vibration testing, and pressure testing. The following delineates the required tests:

1. Random Vibration. Random vibration qualification testing shall be performed per requirements of MIL-STD-1540 unless it can be shown the vibration requirement is enveloped by other qualification testing performed.

2. Pressure Testing. Required qualification pressure testing levels are shown in Table 3-1. Requirement for application of external loads in combination with internal pressures during testing must be evaluated based on the relative magnitude and/or destabilizing effect of stresses due to the external load. If limit combined tensile stresses are enveloped by test pressure stresses, the application of external loads shall not be required. If the application of external loads is required, the load shall be cycled to limit for four times the predicted number of operating cycles of the most severe design condition such as destabilizing load with constant minimum internal pressure, or maximum additive load with constant maximum expected operating pressure.

3.12.2.7.5 Acceptance Test Requirements.

a. Acceptance tests shall be conducted on every pressure vessel before commitment to flight. Accept/reject criteria shall be formulated prior to tests.

b. The test fixtures and support structures shall be designed to permit application of all test loads without jeopardizing the flightworthiness of the test article.

c. The following are required as a minimum.

1. Non-Destructive Inspection. A complete volumetric and surface inspection by the selected non-destructive inspection (NDI) technique(s) shall be performed prior to proof pressure test to establish the initial condition of the hardware.

2. Proof Pressure Test. Every COPV shall be proof-pressure tested to verify that the materials, manufacturing processes, and workmanship meet design specifications and that the hardware is suitable for ground processing safety. At a minimum, the proof pressure duration time shall meet or exceed a 30 minute hold time at proof pressure. The proof pressure shall be equal to:

$$P_{\text{proof}} = \left(\frac{1 + \text{Burst Factor}}{2} \right) \times (\text{MEOP})$$

or 1.5 x (MEOP) for burst factor equal or greater than 2.0

3.12.2.7.6 Recertification Test Requirements.

All refurbished pressure vessels shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight. Pressure vessels that have exceeded the approved storage environment (temperature, humidity, time, and others) shall also be recertified by the acceptance test requirements for new hardware.

3.12.2.8 Flight Hardware Composite Pressure Vessels

Composite pressure vessels shall be designed and manufactured per the rules of the ASME Boiler and Pressure Code, Section X.

3.12.2.8.1 Qualification Test Requirements.

Qualification testing shall include random vibration testing, and pressure testing. The following delineates the required tests:

a. Random Vibration. Random vibration qualification testing shall be performed per require-

REFERENCED DOCUMENTS

ments of MIL-STD-1540 unless it can be shown the vibration requirement is enveloped by other qualification testing performed.

b. Pressure Testing. Required qualification pressure testing levels are shown in Table 3-1. Requirement for application of external loads in combination with internal pressures during testing must be evaluated based on the relative magnitude and/or destabilizing effect of stresses due to the external load. If limit combined tensile stresses are enveloped by test pressure stresses, the application of external loads shall not be required. If the application of external loads is required, the load shall be cycled to limit for four times the predicted number of operating cycles of the most severe design condition such as destabilizing load with constant minimum internal pressure, or maximum additive load with constant maximum expected operating pressure.

3.12.2.8.2 Acceptance Test Requirements. Composite pressure vessels shall be proof pressure tested at 1.5 x MEOP, unless prohibited by Code.

3.12.3 Flight Hardware Metallic Pressurized Structures Analysis and Test Requirements

3.12.3.1 Flight Hardware Metallic Pressurized Structures General Requirements

For pressurized structures made of metallic materials such as the fuel tanks of a launch or an upper-stage vehicle, the design approach may be based on successful past experience when appropriate. However, the analysis and verification requirements specified in this section shall be met.

3.12.3.2 Flight Hardware Metallic Pressurized Structures with Non-Hazardous LBB Failure Mode

3.12.3.2.1 Factor of Safety Requirements. Unless otherwise specified, metallic pressurized structures that satisfy the LBB failure mode may be designed with a minimum ultimate safety factor of 1.25 for unmanned systems and 1.40 for manned systems.

3.12.3.2.2 Fatigue-Life Demonstration. In addition to the stress analysis conducted in accordance with the requirements of Section 3.12.1.5.3, conventional fatigue-life analysis shall be performed, as appropriate, on the unflawed structure to ascertain that the pressure vessel, acted upon by

the spectra of operating loads, pressures and environments will meet the life requirements. A life factor of five shall be used in the analysis.

3.12.3.2.3 Qualification Test Requirements.

a. Qualification tests shall be conducted on flight-quality hardware to demonstrate structural adequacy of the design.

b. Because of the potential test facility size limitation, the qualification testing may be conducted at the component level, provided that the boundary conditions are correctly simulated.

c. The test fixtures, support structures, and methods of environmental application shall not induce erroneous test conditions.

d. The sequences, combinations, levels, and duration of loads, pressure and environments shall demonstrate that design requirements have been met.

e. Qualification testing shall include pressure cycle testing and burst testing. The following delineates the required tests:

1. Pressure Cycle Testing

(a) Requirements for application of external loads in combination with internal pressure during testing shall be evaluated based on the relative magnitude and on the destabilizing effect of stresses due to the external loads.

(b) If limit combined tensile stresses are enveloped by the MEOP stress, the application of external load is not required.

(c) Unless otherwise specified, the peak pressure shall be equal to the MEOP during each pressure cycle, and the number of cycles shall be 4 times the predicted number of operating cycles or 50 MEOP cycles, whichever is greater.

(d) If the application of external loads is required, the load shall be cycled four (4) times the predicted number of operating cycles of the most severe design condition (e.g., destabilizing load with constant minimum internal pressure or maximum additive load with MEOP).

2. Burst Testing.

(a) After the pressure cycle testing, the test article shall be pressurized (pneumatically or hydrostatically, as applicable and safe) to the design burst pressure, while simultaneously applying the ultimate external loads, if appropriate.

(b) The design burst pressure shall be maintained for a period of time sufficiently to ensure that the proper pressure is achieved.

3.12.3.2.4 Acceptance Test Requirements.

a. Every pressurized structure shall be proof tested to verify that the materials, manufacturing processes, and workmanship meet design specifications and that the hardware is suitable for flight.

b. Acceptance tests shall be conducted on every pressurized structure before commitment to flight.

c. Accept/reject criteria shall be formulated prior to tests.

d. The test fixtures and support structures shall be designed to permit application of all test loads without jeopardizing the flightworthiness of the test article.

e. The following are required as a minimum:

1. A complete inspection by the selected surface and volumetric NDI techniques shall be performed prior to proof pressure test.

2. If personnel are exposed to the structure when pressurized above 50 percent of MEOP the minimum proof factor shall be 1.25. If personnel are not exposed to the structure when pressurized, the proof pressure factor shall be 1.1 times MEOP.

3. Every pressurized structure shall be proof-pressure tested to verify that the materials, manufacturing processes, and workmanship meet design specifications and that the hardware is suitable for ground processing safety. At a minimum, the proof pressure duration time shall meet or exceed a 5 minute hold time at proof pressure. The proof pressure shall be equal to:

$$P_{\text{proof}} = \left(\frac{1 + \text{Burst Factor}}{2} \right) \times (\text{MEOP})$$

or 1.5 x (MEOP) for burst factor equal or greater than 2.0

3.12.3.2.5 Recertification Test Requirements.

a. All refurbished pressure vessels shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight.

b. Pressure vessels that have exceeded the approved storage environment (temperature, humidity, time, and others) shall also be recertified by the acceptance test requirements for new hardware.

3.12.3.3 Flight Hardware Metallic Pressurized Structures with Hazardous LBB or Brittle Failure Mode

3.12.3.3.1 Factor of Safety Requirements. Unless otherwise specified, metallic pressurized structures that satisfy the LBB failure mode may be designed with a minimum ultimate safety factor of 1.25 for unmanned systems and 1.40 for manned systems.

3.12.3.3.2 Safe-Life Demonstration.

a. Safe-life analysis of each pressurized structure shall be performed under the assumption of pre-existing initial flaws or cracks in the structure as specified in Section 3.12.1.5.5.

b. In particular, the analysis shall show that the pressurized structure with flaws, placed in the most unfavorable orientation with respect to the applied stress and material properties, of sizes defined by the acceptance proof test or NDI and acted upon by the spectra of expected operating loads, pressure and environments, will meet the safe-life requirements of Section 3.12.1.16.

c. Nominal values of fracture toughness and flaw-growth rate data associated with each alloy system, temper, product form, thermal and chemical environments, and loading spectra shall be used along with a life factor of four on specified service life in all safe-life analysis.

d. Safe-life testing in lieu of safe-life analysis is an acceptable alternative, provided that, in addition to following a quality assurance program for each flight article, a qualification test program is implemented on pre-flawed specimens representative of the structural design.

e. These flaws shall not be less than the flaw sizes established by the acceptance proof test or the selected NDI method(s).

f. Safe-life requirements of Section 3.12.1.16 are considered demonstrated when the pre-flawed test specimens successfully sustain the limit loads and pressure cycles in the expected operating environments.

g. A life factor of four on specified pressure cycles in the service life shall be applied in the safe-life demonstration testing.

3.12.3.3.3 Qualification Test Requirements.

Qualification testing shall include pressure cycle testing and burst testing. The following delineates the required tests:

REFERENCED DOCUMENTS

a. Pressure Cycle Testing

1. Requirements for application of external loads in combination with internal pressure during testing shall be evaluated based on the relative magnitude and on the destabilizing effect of stresses due to the external loads.

2. If limit combined tensile stresses are enveloped by the MEOP stress, the application of external load is not required.

3. Unless otherwise specified, the peak pressure shall be equal to the MEOP during each pressure cycle, and the number of cycles shall be 4 times the predicted number of operating cycles or 50 MEOP cycles, whichever is greater.

4. If the application of external loads is required, the load shall be cycled 4 times the predicted number of operating cycles of the most severe design condition; for example, destabilizing load with constant minimum internal pressure or maximum additive load with MEOP.

b. Burst Testing

1. After the pressure cycle testing, the test article shall be pressurized (pneumatically or hydrostatically, as applicable and safe) to the design burst pressure, while simultaneously applying the ultimate external loads, if appropriate.

2. The design burst pressure shall be maintained for a period of time sufficiently to ensure that the proper pressure is achieved.

3. Unless otherwise specified, the minimum design burst pressure shall be 1.25 times MEOP for unmanned systems, and 1.4 times for manned systems.

3.12.3.3.4 Acceptance Test Requirements.

a. The acceptance test requirements for pressurized structures that exhibit brittle fracture failure mode or hazardous LBB failure mode are identical to those with non-hazardous LBB failure mode as defined in Section 3.12.3.2 except that the selected NDI techniques shall be capable of detecting flaws or cracks smaller than the allowable initial flaw size as determined by safe-life analysis.

b. Surface and volumetric NDI shall also be performed on welds before and after proof testing if personnel are exposed to the structure when pressurized above 50 percent of MEOP. If personnel will not be exposed to pressures greater than 50 percent perform surface and volumetric NDI on welds after proof test.

3.12.3.3.5 Recertification Test Requirements.

a. All refurbished pressure vessels shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight.

b. Pressure vessels that have exceeded the approved storage environment (temperature, humidity, time, and others) shall also be recertified by the acceptance test requirements for new hardware.

3.12.4 Flight Hardware Special Pressurized Equipment Design, Analysis, and Test Requirements

Batteries, cryostats (or dewars), heat pipes, and sealed containers are classified as special pressurized equipment. This section presents the detailed requirements design, analysis, and test requirements for this equipment.

3.12.4.1 Batteries with LBB Failure Mode

The battery cells shall be demonstrated to have a LBB failure mode per Section 3.12.2.2; and when sealed battery cases are used, they shall also be demonstrated to have a LBB failure mode.

3.12.4.1.1 Factor of Safety. Unless otherwise specified, the minimum burst factors for battery cells and sealed battery cases shall be 1.5.

3.12.4.1.2 Fatigue-Life Demonstration.

a. In addition to the stress analysis conducted in accordance with the requirements of Section 3.12.1.5.3, conventional fatigue-life analysis shall be performed, as appropriate, on the unflawed structure to ascertain that the pressure vessel, acted upon by the spectra of operating loads, pressures and environments will meet the life requirements.

b. A life factor of 5 shall be used in the analysis.

c. Testing of unflawed specimens to demonstrate fatigue-life of a specific pressure vessel together with stress analysis is an acceptable alternative to fatigue test of the vessel.

d. Fatigue-life requirements are considered demonstrated when the unflawed specimens that represent critical areas such as membrane section, weld joints, heat-affected zone, and boss transition section successfully sustain the limit loads and

MEOP in the expected operating environments for the specified test duration without rupture.

e. The required test duration is four times the specified service life.

3.12.4.1.3 Qualification Testing.

a. Qualification tests shall be conducted on flight quality batteries to demonstrate structural adequacy of the design.

b. The following tests are required:

1. Random Vibration Testing. Random vibration testing shall be performed on batteries per requirements of MIL-STD-1540.

2. Thermal Vacuum Testing. Thermal vacuum test shall be performed on batteries per requirements of MIL-STD-1540.

3. Pressure Testing. A pressure cycle test shall be conducted on battery cells. The peak pressure shall be equal to the MEOP of the battery cells during each cycle, and the number of cycles shall be 4 times the predicted number of operating cycles or 50 cycles, whichever is greater. After the completion of the pressure cycle test, the pressure shall be increased to actual burst of the battery cell. The actual burst pressure shall be greater than or equal to 1.5 times MEOP of the battery cell. For batteries having sealed cases, similar tests shall be conducted on the sealed cases, if applicable.

3.12.4.1.4 Acceptance Test Requirements.

a. Acceptance tests shall be conducted on batteries before being committed to flight.

b. The following tests are required:

1. Proof Pressure Test. Battery cells, whenever feasible, shall be proof-pressure tested to 1.25 times the MEOP of the cells. For sealed battery cases, pressure tests shall be performed at a level of 1.25 times the MEOP of the cases.

2. Non-destructive Inspection. Surface and volumetric NDI technique(s) shall be performed after the proof pressure test.

3.12.4.1.5 Recertification Test Requirements.

a. All refurbished pressure vessels shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight.

b. Pressure vessels that have exceeded the approved storage environment (temperature, humidity, time, and others) shall also be recertified by the acceptance test requirements for new hardware.

3.12.4.1.6 Special Requirements. Batteries shall be designed such that battery cells are within containment devices (or cases). These containment devices (or cases) shall be demonstrated to be able to prevent the escape of any hazardous contents over an insignificant quantity deemed acceptable by the procuring and safety agencies.

3.12.4.2 Batteries with Brittle Fracture Failure Mode

a. Batteries with battery cells exhibiting brittle fracture failure mode shall meet the requirements defined in Section 3.12.3.3.

b. In addition, a thermal vacuum test shall be conducted as part of the qualification testing.

3.12.4.3 Cryostats or Dewars with LBB Failure Mode

3.12.4.3.1 General Requirements. Pressure containers of the cryostat or Dewar shall be demonstrated to exhibit LBB failure mode in accordance with the following criteria:

a. The LBB failure mode shall be demonstrated analytically or by test showing that an initial surface flaw with a shape ($a/2c$) ranging from 0.05 to 0.5 will propagate through the vessel thickness to become a through-the-thickness crack with a length 10 times the vessel thickness and will still remain stable, at MEOP.

b. Fracture mechanics shall be used if the failure mode is determined by analysis.

c. A pressure vessel that contains non-hazardous fluid and exhibit LBB failure mode is considered as a non-hazardous LBB pressure vessel.

3.12.4.3.2 Factor of Safety Requirements. Unless otherwise specified, the minimum burst factor for the pressure container of a cryostat shall be 1.5.

3.12.4.3.3 Qualification Testing. Qualification tests shall be conducted on flight quality hardware to demonstrate structural adequacy of the design. The following tests are required:

a. Random Vibration Testing. Random vibration testing shall be performed on cryostats per requirements of MIL-STD-1540.

b. Pressure Testing. The cryostat (dewar) shall be pressurized to the design burst pressure that is 1.5 times MEOP of the pressure container. The design burst pressure shall be maintained for a period of time sufficient to ensure that the proper pressure was achieved.

REFERENCED DOCUMENTS

3.12.4.3.4 Acceptance Test Requirements.

a. Acceptance tests should be conducted on every cryostat (or dewar) before being committed to flight.

b. The following tests are required:

1. Proof-Pressure Test. Cryostats shall be proof-pressure tested to 1.25 times the MEOP of the pressure container.

2. Non-destructive Inspection. Surface and volumetric Selected NDI technique(s) shall be performed after proof pressure test.

3.12.4.3.5 Recertification Test Requirements.

All refurbished pressure vessels shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight. Pressure vessels that have exceeded the approved storage environment (temperature, humidity, time, and others) shall also be recertified by the acceptance test requirements for new hardware.

3.12.4.3.6 Special Requirements. Outer shells (vacuum jackets) shall have pressure relief capability to preclude rupture in the event of pressure container leakage. If pressure containers do not vent external to the cryostats (or dewars) but instead vent into the volume contained by outer shells, the relief devices of outer shells must be capable of venting at a rate to release full flow without outer shells rupturing. Relief devices must be redundant and individually capable of full flow. Furthermore, pressure relief devices must be certified to operate at the required condition of use.

3.12.4.4 Cryostats or Dewars with Brittle Fracture Failure Mode

3.12.4.4.1 Factor of Safety Requirements.

a. Safe-life design methodology based on fracture mechanics techniques shall be used to establish the appropriate design factor of safety and the associated proof factor for metallic pressure vessels that exhibit brittle fracture or hazardous leak-before-burst failure mode.

b. The loading spectra, material strengths, fracture toughness, and flaw-growth rates of the parent material and weldments, test program requirements, stress levels, and the compatibility of the structural materials with the thermal and chemical environments expected in service shall be taken into consideration.

c. Nominal values of fracture toughness and flaw-growth rate data corresponding to each alloy system, temper, and product form shall be used along with a life factor of four on specified service life in establishing the design factor of safety and the associated proof factor.

d. Unless otherwise specified the minimum burst factor shall be 1.5.

3.12.4.4.2 Safe-Life Demonstration Requirements.

a. After completion of the stress analysis conducted in accordance with the requirements of Section 3.12.1.16, safe-life analysis of each pressure container covering the maximum expected operating loads and environments, shall be performed under the assumption of pre-existing initial flaws or cracks in the vessel.

b. In particular, the analysis shall show that the metallic cryostat with flaws placed in the most unfavorable orientation with respect to the applied stress and material properties, of sizes defined by the acceptance proof test or NDI and acted upon by the spectra of expected operating loads and environments, will meet the safe-life requirements of Section 3.12.1.16.

c. Nominal values of fracture toughness and flaw-growth rate data associated with each alloy system, temper, product form, thermal and chemical environments, and loading spectra shall be used along with a life factor of four on specified service life in all safe-life analyses.

d. Cryostats that experience sustained stress shall also show that the corresponding applied stress intensity (K_I) during operation is less than K_{ISCC} in the appropriate environment.

e. Testing of metallic cryostats under fracture control in lieu of safe-life analysis is an acceptable alternative, provided that, in addition to following a quality assurance program (Section 3.12.1.18) for each flight article, a qualification test program is implemented on pre-flawed specimens representative of the structure design.

f. These flaws shall not be less than the flaw sizes established by the acceptance proof test or the selected NDI method(s).

g. Safe-life requirements of Section 3.12.1.16 are considered demonstrated when the pre-flawed test specimens successfully sustain the limit loads and pressure cycles in the expected operating environments without rupture.

h. A life factor of four on specified service life shall be applied in the safe-life demonstration testing.

i. A report that documents the fracture mechanics safe-life analysis or safe-life testing shall be prepared to delineate the following:

1. Fracture mechanics data (fracture toughness and fatigue crack growth rates)
2. Loading spectrum and environments
3. Initial flaw sizes
4. Analysis assumptions and rationales
5. Calculation methodology
6. Summary of significant results
7. References

j. This report shall be closely coordinated with the stress analysis report and shall be periodically revised and updated during the life of the program.

3.12.4.4.3 Qualification Test Requirements.

a. Qualification tests shall be conducted on flight-quality hardware to demonstrate structural adequacy of the design.

b. The test fixtures, support structures, and methods of environmental application shall not include erroneous test conditions.

c. The types of instrumentation and their locations in qualification tests shall be based on the results of the stress analysis of Section 3.12.1.5.3.

d. The instrumentation shall provide sufficient data to ensure proper application of the accept/reject criteria, which shall be established prior to test.

e. The sequences, combinations, levels, and duration of loads, pressure and environments shall demonstrate that design requirements have been met.

f. Qualification testing shall include random vibration testing, and pressure testing. The following delineates the required tests:

1. Random Vibration. Random vibration qualification testing shall be performed per requirements of MIL-STD-1540 or equivalent unless it can be shown the vibration requirement is enveloped by other qualification testing performed.

2. Pressure Testing. Required qualification pressure testing levels are shown in Table 3-1. Requirement for application of external loads in combination with internal pressures during testing must be evaluated based on the relative magnitude and/or destabilizing effect of stresses due to the external load. If limit combined tensile stresses are enveloped by test pressure stresses, the application of external loads shall not be required. If the appli-

cation of external loads is required, the load shall be cycled to limit for four times the predicted number of operating cycles of the most severe design condition; for example, destabilizing load with constant minimum internal pressure, or maximum additive load with constant maximum expected operating pressure. The qualification test procedure shall be approved by the procuring agency and the appropriate launch or test range approval authority.

3.12.4.4.4 Acceptance Test Requirements.

a. The acceptance test requirements for cryostats that exhibit brittle fracture or hazardous LBB, failure mode are identical to those with ductile fracture failure mode as defined in Section 3.12.2.2.4 except that test level shall be that defined by the fracture mechanics analysis whenever possible.

b. At a minimum, surface and volumetric NDI techniques shall be performed on all weld joints before and after the proof test.

c. Cryo-proof acceptance test procedures may be required to adequately verify initial flaw size.

d. The pressure container shall not rupture or leak at the acceptance test pressure.

3.12.4.4.5 Recertification Test Requirements.

a. All refurbished cryostats shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight.

b. Cryostats that have exceeded the approved storage environment (temperature, humidity, time, and others) shall also be recertified by the acceptance test requirements for new hardware.

3.12.4.4.6 Special Provisions.

a. For one-of-a-kind applications, a proof test of each flight unit to a minimum of 1.5 times MEOP and a conventional fatigue analysis showing a minimum of 10 design lifetimes may be used in lieu of the required pressure testing as defined in Section 3.12.2.4 for qualification.

b. The implementation of this option needs prior approval by the procuring agency and the appropriate launch and/or test range approval authority.

3.12.4.5 Flight Hardware Heat Pipe Requirements

3.12.4.5.1 Factor of Safety.

REFERENCED DOCUMENTS

a. Unless otherwise specified, the minimum burst factors for heat pipes with a diameter greater than 1.5 in. shall be 2.5.

b. For heat pipes with a diameter less than or equal to 1.5 in., the minimum burst factor shall be 4.0.

3.12.4.5.2 Qualification Test Requirements. Pressure testing shall be conducted to demonstrate no failure at the design burst pressure.

3.12.4.5.3 Acceptance Test Requirements.

a. All fusion joints or full penetration welds on the heat pipes that contain hazardous fluids shall be inspected using an acceptable surface and volumetric NDI technique.

b. A proof pressure test shall be conducted to a minimum level of 1.5 times MEOP on all heat pipes.

3.12.4.5.4 Recertification Test Requirements.

a. All refurbished heat pipes shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight.

b. Heat pipes that have exceeded the approved storage environment (temperature, humidity, time, and other environments) shall also be recertified by the acceptance test requirements for new hardware.

3.12.4.5.5 Special Requirements. The heat pipe material shall satisfy the material compatibility requirements defined in Section 3.12.1.17.2 for the contained fluid at both the proof test temperature and operational temperature.

3.12.4.6 Flight Hardware Sealed Containers

3.12.4.6.1 Sealed Containers with Non-Hazardous LBB Failure Mode. The LBB failure mode shall be demonstrated as defined in Section 3.12.2.2. *EXCEPTION: Those containers made of aluminum, stainless steel, or titanium sheets that are acceptable as LBB designs do not have to demonstrate LBB failure mode.*

a. Factor of Safety. Unless otherwise specified, the minimum burst factor shall be 1.5.

b. Qualification Test Requirements

1. Sealed containers containing non-electronic equipment shall only be subjected to pressure testing.

2. For sealed containers containing electronic equipment, other qualification tests including functional, thermal vacuum, thermal cycling, random vibration, and pyro shock shall be conducted per MIL-STD-1540 or equivalent.

c. Acceptance Test Requirements. Sealed containers shall be proof pressure tested to a minimum level of 1.25 times maximum design pressure differential or MAWP.

d. Recertification Test Requirements

1. All refurbished sealed containers shall be recertified after each refurbishment by the acceptance test requirements for new hardware to verify their structural integrity and to establish their suitability for continued service before commitment to flight.

2. Sealed containers that have exceeded the approved storage environment (temperature, humidity, time, and others) shall also be recertified by the acceptance test requirements for new hardware.

3.12.4.6.2 Sealed Containers with Brittle Fracture or Hazardous LBB Failure Mode.

a. Sealed containers that exhibit a brittle fracture failure mode or contain hazardous fluid, or both, shall meet the requirements of Section 3.12.2.3.

b. For sealed containers containing electronic equipment, qualification tests including functional, thermal vacuum, thermal cycling, and pyro shock shall be conducted in addition to random vibration and pressure testing.

3.12.5 Flight Hardware Pressure System Component Design and Test Requirements

This section describes the requirements for the design and testing of flight hardware pressure system components. Included are hydraulic, pneumatic, hypergolic, and cryogenic system components.

3.12.5.1 Flight Hardware Pneumatic and Hydraulic Pressure System Components

3.12.5.1.1 Factor of Safety Requirements. Flight hardware pneumatic and hydraulic pressure system components shall be designed to the minimum factor shown in Table 3-2.

REFERENCED DOCUMENTS

e. Safety critical actuation of pneumatic systems shall not be adversely affected by any back pressure resulting from concurrent operations of any other parts of the system under any set of conditions.

f. Components that can be isolated and contain residual pressure shall be equipped with gage reading and bleed valves for pressure safety check.

g. Bleed valves shall be directed away from operating personnel.

h. Fittings or caps for bleeding pressure are not acceptable.

i. Pressurized reservoirs that are designed for gas/fluid separation with provisions to entrap gas that may be hazardous to the system or safety critical actuation and prevent its recirculation in the system shall be specified. This shall include the posting of instructions adjacent to the filling point for proper bleeding when servicing.

j. Compressed gas emergency systems shall be bled directly to the atmosphere away from the vicinity of personnel, rather than to reservoir.

k. If the gas is combustible, consideration shall be given to the selection of safety critical components and methods for reducing the potential for accidental ignition or explosion.

l. Where necessary to prevent a hazardous sequence of operations and provide a fail-safe capability at all times, interlocks shall be specified. For example, the OPEN position of remotely controlled valves that can hazardously pressurize lines leading to remotely controlled (or automatic) disconnect couplings shall be interlocked to preclude the OPEN valve position coincident with the disconnected condition of the couplings.

m. Pressure systems that combine several safety critical functions shall have sufficient controls for isolating failed functions, for the purpose of safety operating the remaining functions.

n. All pressure systems shall have pressure indicating devices to monitor critical flows and pressures marked to show safe upper and lower limits of system pressure.

o. The pressure indicators shall be located to be readily visible to the operating crew.

p. All systems shall be protected for pressure above 500 psi in all areas where damage can occur during servicing or other operational hazards.

q. Pressure lines and components of 500 psi or higher that are adjacent to safety critical equipment shall be shielded to protect such equipment in the event of leakage or burst of the pressure system.

r. Automatic disengagement of by-pass shall be provided for pneumatic systems that provide for manual takeover in the event of a hazardous situation.

s. Positive indication of disengagement shall be provided.

t. Safety Critical pneumatic actuators shall have positive mechanical stops at the extremes of safe motion.

u. Adjustable orifice restrictor valves shall not be used in safety critical pneumatic systems.

3.12.5.1.6 Pneumatic Components.

a. Pneumatic components (other than tanks) for safety critical systems shall exhibit safe endurance against hazardous failure modes for not less than 400 percent of the total number of expected cycles including system test.

b. The configuration of pneumatic components shall permit bleeding of entrapped moisture, lubricants, particulate material, or other foreign matter hazardous to this system.

c. Compressors that are designed to sustain not less than 2.5 x delivery pressure after allowance for loss of strength of the materials equivalent to not less than that caused by 1,000 hours aging at 275EF shall be selected.

3.12.5.1.7 Design Loads.

a. Installation of all lines and components to withstand all expected acceleration and shock loads shall be specified.

b. Shock isolation mounts may be used if necessary to eliminate destructive vibration and interference collisions.

c. The mounting of components, including valves, on structures having sufficient strength to withstand torque and dynamic loads and not supported by the tubing shall be specified.

d. Light-weight components that do not require adjustment after installation (for example, check valves), may be supported by the tubing, provided that a tube clamp is installed on each such tube near the component.

e. Tubing shall be supported by cushioned steel tube clamps or by multiple-block type clamps

that are suitably spaced to restrain destructive vibration.

3.12.5.1.8 Electrical/Electronic Devices.

a. Electrical components for use in potentially ignitable atmospheres shall be demonstrated to be incapable of causing an explosion in the intended application.

b. Electrically energized hydraulic components shall not propagate radio-frequency energy that is hazardous to other subsystems in the total system, or interfere in the operation of safety critical electronic equipment (Reference MIL-STD-464).

c. Grounding. Pressure system components and lines shall be electrically grounded to metallic structures.

d. All solenoids shall be capable of safely withstanding a test voltage of not less than 1500 V rms at 60 cps for 1 min between terminals and case at the maximum operating temperature of the solenoid in the functional envelope.

e. Electric Motor Driven Pumps. Electric motor driven pumps used in safety critical systems shall not be used for ground test purposes unless the motor is rated for reliable continuous and safe operation. Otherwise, the test parameters may perturb reliability calculations.

3.12.5.1.9 Pressure Relief Devices.

a. Pressure relief devices shall be specified on all systems having a pressure source that can exceed the maximum allowable pressure of the system, or where the malfunction/failure of any component can cause the maximum allowable pressure to be exceeded.

b. Relief devices are required downstream of all regulating valves and orifice restrictors unless the downstream system is designed to accept full source pressure.

c. On space systems, where operational or weight limitations preclude the use of relief valves, and systems will operate in an environment not hazardous to personnel, they can be omitted if the ground or support system contains such devices and they cannot be isolated from the airborne system during the pressurization cycle and the space vehicle cannot provide its own protection.

d. Where a ground system is specifically designed to service an unmanned flight vehicle,

pressure relief protection may be provided within the ground equipment, if no capability exists to isolate the pressure relief protection from the flight vehicle during the pressurization cycle.

e. Where safety factors of less than 2.0 are used in the design of flight hardware pressure vessels, provide a means for automatic relief, depressurization, and pressure verification of a safety critical vessels in the event of launch abort.

f. Whenever any pressure volume can be confined and/or isolated by system valving, provide an automatic pressure relief device.

g. Pop-values, rupture discs, blow-out plugs, armoring, and construction to contain the greatest possible overpressure that may develop are examples of corrective measures for system safety in cases not covered by the above paragraphs.

h. Pressure relief devices shall be vented for toxic or inert gases to safe areas or scrubbers, away from the vicinity of personnel.

i. Shut-off valves for maintenance purposes on the inlet side of pressurized relief valves are permissible if a means for monitoring and bleeding trapped pressure is provided and the requirements of ASME Code for unfired pressure vessels, Appendix M, paragraph UA-354. It is mandatory that the valve be locked open when the system is repressurized.

j. Hydrostatic testing systems for vessels that are not designed to sustain negative internal pressure shall be equipped with fail-safe devices for relief of hazardous negative pressure during the period of fluid removal. Check valves and valve interlocks are examples of devices that can be used for this purpose.

k. Vessels that can be collapsed by a negative pressure shall have negative pressure relief and/or prevention devices for safety during storage and transportation.

l. Pressurized reservoirs shall be designed so that all ullage volumes are connected to a relief valve that shall protect the reservoir and power pump from hazardous overpressure or back pressure of the system.

m. The air pressure control for pressurized reservoirs shall be an externally nonadjustable pressure regulating device. If this unit also contains a reservoir pressure relief valve, it shall be designed so that no failure in the unit will permit overpressurization of the reservoir.

3.12.5.1.10 System Contamination Related Considerations.

REFERENCED DOCUMENTS

a. The following contamination related considerations shall be addressed in the design of pressurized systems. NOTE: Contamination includes solid, liquid, and gaseous material.

1. Contamination shall be prevented from entering or developing within the system.

2. The system shall be designed to include provisions to detect contamination.

3. The system shall be designed to include provisions for removal of contamination and provisions for initial purge with fluid or gas that will not degrade future system performance.

4. The system shall be designed to be tolerant of contamination.

b. All pressurizing fluids entering safety critical system shall be filtered through a 10 micron filter, or finer, before entering the system.

c. All pressure systems shall have fluid filters in the system, designed and located to reduce the flow of contaminant particles to a safe minimum.

d. All of the circulating fluid in the system shall be filtered downstream from the pressure pump, or immediately upstream from safety critical actuators.

e. Entrance of contamination at test points or vents shall be minimized by downstream filters.

f. The bypass fluid or case drain flow on variable displacement pumps shall be filtered.

g. When the clogging of small orifices could cause a hazardous malfunction or failure of the system, they shall be protected by a filter element designed to prevent clogging of the orifice. Note that this includes servo valves.

h. Filters or screens shall not be used in suction lines of power pumps or hand pumps of safety critical systems.

i. Air filters shall be specified for hydraulic reservoir air pressurization circuits and locate air filters to protect the pressure regulating equipment from contamination.

j. Dry compressed air shall be specified for hydraulic reservoir pressurization.

k. A moisture removal unit shall be specified to protect the pressure regulation lines and equipment.

l. Unpressurized Reservoirs. Unpressurized hydraulic reservoirs shall have filters and desiccant units at the breather opening to preclude introduction of moisture and contaminants into the reservoir.

3.12.5.1.11 Bleed Ports.

a. Where necessary, bleed ports shall be provided to remove accumulations of residue or contaminants.

b. High point bleed ports shall be provided where necessary for removal of trapped gases.

c. The bleed valve shall be directed away from operating personnel and possible ignition sources.

d. Components, cavities, or lines that can be isolated shall be equipped with bleed valves that can be used to release retained pressure, or will indicate that continued pressure exists in the system.

e. Bleed valves used for reducing pressure on systems containing hazardous fluids shall be routed to a safe disposal area.

f. Auxiliary Bleed Ports

1. Auxiliary bleed ports shall be provided where necessary to allow bleed off for safety purposes.

2. Bleeder valves shall be located so that they can be operated without removal of other components, and shall permit the attachment of a hose to direct the bleed-off fluid into a container.

g. Filler Cap Bleed. Reservoir filler caps shall include design provisions that shall automatically bleed the reservoir on opening, so that possible ullage pressure cannot impart hazardous kinetic energy to either the filler caps, the fluid in the reservoir, or the system.

3.12.5.1.12 Control Devices.

a. Safety critical pressure systems incorporating two or more directional control valves shall be designed to preclude the possibility of inadvertently directing the flow or pressure from one valve into the flow path or pressure path intended for another valve, with any combination of valve settings possible in the total system.

b. Control devices shall be designed to prevent overtravel or undertravel that may contribute to a hazardous condition, or damage to the value.

c. All pressure and volume controls shall have stops, or equivalent, to prevent settings outside their nominal safe working ranges.

d. Control components that have integral manually operated levers and stops capable of withstanding the following limit torques.

<u>Lever Radius (R)</u>	<u>Design Torque</u>
Less than 3 in.	50 x R lb-in.
3 to 6 in.	75 x R lb-in.
Over 6 in.	150 x R in-in.

3.12.5.1.13 Manually Operated Levers.

a. Components that have integrated manually operated levers shall provide levers and stops capable of withstanding the limit torques specified by MIL-STD-1472.

b. Levers and stops shall be provided on remote controls capable of withstanding a limit torque of 1800 lb-in.

c. Because jamming is possible, sheathed flexible actuators shall not be used for valve controls in safety critical pressure systems; for example, push-pull wires, torque wires that are sheathed are not acceptable.

3.12.5.1.14 Accumulators.

a. Accumulators shall be designed in accordance with the pressure vessel standards for ground systems and locate for minimal probability of mechanical damage and for minimum escalation of material damage or personnel injury in the event of a major failure such as tank rupture.

b. Accumulator gas pressure gauges shall not be used to indicate system pressure for operational or maintenance purposes.

c. Gas type and pressure level shall be posted on, or immediately adjacent to the accumulator.

3.12.5.1.15 Flex Hose.

a. Flex hose shall be used between any two connections where relative motion can be expected to fatigue metal tube or pipe.

b. Flex hose installation shall be designed to avoid abrasive contact with adjacent structure or moving parts.

c. Rigid supports shall not be used on flex hose.

d. Flex hose installation that are six feet long or greater shall be included so that restraint is provided on both the hose and adjacent structure at no greater than six-foot intervals and at each end to prevent whiplash in the event of a burst.

e. Restraining devices shall be designed and demonstrated to contain a force not less than 1.5 x open line pressure force. (See Table 3-3)

f. The design safety factor shall not be less than 3.

g. Sand or shot bags placed on top of flexible hose is not an acceptable restraint.

h. Hose clamp-type restraining devices shall not be used.

i. Flex hose installations shall be designed to produce no stress or strain of any nature in the hard lines or components.

j. Stresses induced because of dimensional changes caused by pressure or temperature variations or torque forces induced in the flex hose shall be included.

k. Temporary installations using chains or cables anchored to substantial fixed points, lead ingots, or other weights, are acceptable if they meet the requirements of Section 3.12.5.1.2.a.

l. Flex hose shall be protected from kinking or abrasive chafing from the restraining device or damage from adjacent structure or moving parts that may cause reduction in strength.

3.12.5.1.16 Qualification Test Requirements. Qualification tests are not required on lines and fittings. Internal/external pressure testing shall be conducted on all other pressure components to demonstrate no failure at the design burst pressure. Seamless lines, tubing and pipe are exempt.

3.12.5.1.17 Acceptance Test Requirements.

a. Testing Flight Hardware Pneumatic Components Prior to Assembly

Table 3-3
Open Line Force Calculation Factor

Diameter Opening (inch)	Calculated Force Factor for each psi of Source Pressure (lb)
1/8	0.18506
1/5	0.2832
3/8	0.3814
1/2	0.4796
5/8	0.5777
3/4	0.6759
7/8	0.7741
1	0.8723

Note: To calculate the force acting on line opening, select applicable diameter and multiply right-hand column by the source pressure (psi).

REFERENCED DOCUMENTS

1. All other pressurized components such as valves, pipe, tubing, and pipe and tube fittings shall be hydrostatically proof tested to a minimum of 1.5 times the component MAWP for a minimum of 5 min.

2. Proof testing shall demonstrate that the components will sustain proof pressure levels without distortion, damage, or leakage.

3. Both the inlet and discharge sides of a relief valve shall be proof tested. **NOTE:** When the discharge side has a lower pressure rating than the inlet, they are to be proof tested independently.

4. The following inspections shall be performed after proof testing:

(a) Mechanical components such as valves and regulators shall be inspected for external deformation, deterioration, or damage.

(b) Damaged, distorted, or deteriorated parts shall be rejected and replaced and the test repeated.

5. Functional and leak tests shall be performed at the component MAWP after the proof test.

6. Pneumatic pressure system components shall undergo sufficient qualification and acceptance testing to demonstrate that the system and components meet design and safety requirements when subjected to prelaunch and launch environments such as vibration, shock, acceleration, and temperature.

7. Test plans and test reports shall be made available to Range Safety.

8. Pressure relief valves shall be tested for proper setting and flow capacity prior to installation and first use on the Ranges.

9. Pressure gauges and transducers shall be hydrostatically tested to a minimum of 1.5 times the system MOP/MEOP.

10. Pressure gauges and transducers shall be calibrated prior to installation and periodically thereafter.

11. Components may be initially hydrostatically proof tested after being assembled into a subsystem or system to 1.5 times the system MOP. **NOTE:** This approach shall be approved by Range Safety.

12. Pneumatic proof testing to a proof pressure of 1.25 times MAWP is permissible only if hydrostatic proof testing is impractical, impossible, or will jeopardize the integrity of the system

or system element. **NOTE:** Prior approval for pneumatic proof testing at the Ranges shall be obtained from Range Safety.

b. Testing Flight Hardware Pneumatic Systems After Assembly. All newly assembled pneumatic pressure systems shall be hydrostatically tested to 1.5 times MOP/MEOP prior to use. **NOTE 1:** MOP here refers to the maximum operating pressure that personnel are exposed to. **NOTE 2:** Where this is not possible, Range Safety will determine the adequacy of component testing and alternate means of testing the assembled system.

c. Leak Tests. All newly assembled pressure systems shall be leak tested at the system MOP/MEOP prior to first use at the Ranges. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained. Minimum test requirements are as follows:

1. The gas used during the leak test shall be the same as the system fluid media except that for hazardous gas systems, a system compatible non-hazardous gas may be used that has a density as near as possible to the system fluid; for example, helium should be used to leak test a gaseous hydrogen system.

2. Mechanical connections, gasketed joints, seals, and weld seams, and other items shall be visually bubble tight for a minimum of 1 min when an approved leak test solution is applied.

3. Alternate methods of leak testing such as the use of portable mass spectrometers may be specified when required on a case-by-case basis.

d. System Validation and Functional Tests. All newly assembled pressure systems shall have a system validation test and a functional test of each component at system MOP prior to first use at the Ranges. **NOTE:** These tests shall be conducted at the Ranges unless prior approval from Range Safety has been obtained. Minimum test requirements are as follows:

1. These tests shall demonstrate the functional capability of all non-passive components such as valves, regulators, and transducers.

2. All prelaunch operational sequences for the system shall be executed.

3. All parallel or series redundant components shall be individually tested to ensure single fault tolerant capabilities are functional prior to launch.

4. All shutoff and block valves shall be leak checked downstream to verify their shutoff capability in the CLOSED position.

e. Bonding and Grounding Tests. All newly assembled pressure systems containing flammable and combustible fluids shall be tested to verify that the requirements of the **Flight Hardware Pressure System Bonding and Grounding** section of this Chapter have been met.

f. Test Requirements for Modified and Repaired Flight Hardware Pneumatic Systems

1. Any pressure system element, including fittings or welds, that has been repaired, modified, or possibly damaged subsequent to having been proof tested, shall be retested at proof pressure prior to its normal use.

2. A modified or repaired pressure system shall be leak tested at the system MOP/MEOP prior to its normal use. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

g. A modified or repaired pressure system shall be revalidated and functionally tested at the system MOP prior to its normal use.

h. If any pressure system element such as valve, regulator, gauges, or tubing has been disconnected or reconnected for any reason, the affected system or subsystem shall be leak tested at MOP/MEOP.

3.12.5.2 Hazardous Fluid Systems Component Requirements, including Hypergolic, Cryogenic, and Hydraulic Systems

Hypergolic and cryogenic components are required to meet the requirements in Sections 3.12.6, 3.12.7, 3.12.8 and 3.12.9 in addition to the following:

a. Cycling capability for safety critical components shall be not less than 400 percent of the total number of expected cycles, including system tests, but not less than 2,000 cycles.

b. For service above a temperature of 160EF, an additional cycling capability equivalent to the above shall be required as a maximum.

c. Safety critical actuators shall have positive mechanical stops at the extremes of safe motion.

d. Fluid reservoirs and supply tanks shall be equipped with shutoff valves, operable from a

relatively safe location in the event of a hydraulic system emergency.

e. Shuttle valves shall not be used in safety critical hydraulic systems where the event of a force balance on both inlet ports may occur, causing the shuttle valve to restrict flow from the outlet port.

f. Systems incorporating accumulators shall be interlocked to either vent or isolate accumulator fluid pressure when power is shutoff.

g. Adjustable orifice restrictor valves shall not be used in safety critical systems.

h. When two or more actuators are mechanically tied together, only one lock valve shall be used to lock all the actuators.

i. Lock valves shall not be used for safety critical lockup periods likely to involve extreme temperature changes, unless fluid expansion and contraction effects are safely accounted for.

j. Reservoir

1. Whenever possible, the hydraulic reservoir should be located at the highest point in the system.

2. If this is not possible in safety critical systems, procedures shall be developed to detect air in actuators or other safety critical components and to ensure that the system is properly bled prior to each use.

k. Systems installations shall be limited to a maximum pressure of 15,000 psig. **NOTE:** There is not intent to restrain development of systems capable of higher pressures, however, the employment of such systems must be preceded by complete development and qualification that includes appropriate safety tests.

l. The inlet pressure of pumps in safety critical systems shall be specified to prevent cavitation effects in the pump passages or outlets.

m. Fluid Column. Safety critical systems shall have positive protection against breaking the fluid column in the suction line during standby.

n. Systems for primary flight control of manned vehicles shall have redundant features for all major aspects of operation and control and be essentially independent of systems non-critical to safety. **NOTE:** Provision may be made for a safety critical systems to draw power from a non-critical system, provided that no single failure can cause loss of both systems because of this connection.

o. Systems that provide for manual takeover shall automatically disengage or allow by-pass of the act of manual takeover.

REFERENCED DOCUMENTS

p. Safety critical systems or alternate by-pass systems provided for safety shall not be rendered inoperative because of back pressure under any set of conditions.

q. The system shall be designed so that a lock resulting from an unplanned disconnection of a self-seating coupling or other component shall not cause damage to the system or to adjacent property, or injury to personnel.

r. Systems employing power operated pumps shall include a pressure regulating device and an independent safety relief valve.

s. Thermal Pressure Relief.

1. Thermal expansion relief valves shall be installed as necessary to prevent system damage from thermal expansion of hydraulic fluid, as in the event of gross overheating.

2. Internal valve leakage not be considered an acceptable method of providing thermal relief.

3. Thermal relief valve setting shall not exceed 150 psi above the value for system relief valve setting.

4. Vents shall outlet only to areas of relative safety from fire hazard.

5. Hydraulic blow-out fuses (soft plugs) shall not be used in systems having temperatures above 160EF.

t. Pressure relief valves shall be located in the systems wherever necessary to ensure that the pressure in any part of a power system shall not exceed the safe limit above the regulated pressure of the system.

3.12.6 Flight Hardware Pneumatic System Design Requirements

This section presents specific requirements for the design of flight hardware pneumatic systems and specific pneumatic system components.

3.12.6.1 Flight Hardware Pneumatic System Piping

a. NPT connectors shall not be used in hazardous pressure system piping.

b. Socket welded flanges shall not be used in hazardous pressure system piping.

c. All piping and fitting welds shall be 100 percent radiographically inspected.

3.12.6.2 Flight Hardware Pneumatic System Tubing

All tubing and fitting welds shall be 100 percent radiographically inspected before and after the proof test.

3.12.6.3 Flight Hardware Pneumatic System Regulators

a. Regulators shall be selected so that their working pressure falls within the center 50 percent of their total pressure range if it is susceptible to inaccuracies or creep at either end of its pressure range.

b. Pressure regulator actuators shall be capable of shutting off the fluid when the system is at the maximum possible flow and pressure.

c. Designs using uncontained seats are unacceptable.

d. Systems that contain regulators that are remotely operated during prelaunch operations shall be designed to be fail-safe if pneumatic or electric control power to the regulator is lost.

3.12.6.4 Flight Hardware Pneumatic System Valves

a. Valve actuators shall be operable under maximum design flow and pressure.

b. Manually operated valves shall be designed so that overtightening the valve stem cannot damage soft seats to the extent that seat failure occurs.

c. Designs using uncontained seats are prohibited.

d. Valves that are not intended to be reversible shall be designed or marked so that they will not be connected in a reverse mode.

e. All electrical control circuits for remotely actuated valves shall be shielded or otherwise protected from hazardous stray energy.

f. Remotely controlled valves shall provide for remote monitoring of OPEN and CLOSED positions during prelaunch operations.

g. Systems that contain remotely operated valves shall be designed to be fail-safe if pneumatic or electric control power to the valve is lost during prelaunch operations.

h. Check valves shall be provided where back flow of fluids would create a hazard.

i. Special care shall be taken in the design of oxygen systems to minimize the heating effect due to rapid increases in pressure. **NOTE:** Fast opening valves that can produce high velocity kinetic effects

and rapid pressurization shall be avoided.

j. Valve stem travel on manual valves shall be limited by a positive stop at each extreme position.

k. The application or removal of force to the valve stem positioning device shall not cause disassembly of the pressure containing structure of the valve.

3.12.6.5 Flight Hardware Pneumatic System Pressure Indicating Devices

a. A pressure indicating device shall be located on the downstream side of each pressure regulator, and on any storage system.

b. These pressure indicating devices shall be designed to be remotely monitored during prelaunch operations.

3.12.6.6 Flight Hardware Pneumatic System Flexible Hoses

a. Hoses shall be used only when required to provide for movement between interconnecting gas lines when no other feasible means is available.

b. Flex hose installation shall be designed to avoid abrasive contact with adjacent structures or moving parts.

c. Flex hose assemblies shall not be installed in a manner that will place a mechanical load on the hose or hose fittings to the extent that will degrade hose strength or cause the hose fitting to loosen.

d. Flexible hose shall not be supported by rigid lines or components if excessive loads from flex hose motion can occur.

e. Flex hoses shall not be exposed to temperatures that exceed the rated temperature of the hose.

f. Flex hoses that are permitted to pass close to a heat source shall be protected.

g. The bend radius of flex hoses shall be designed to be no less than the safe minimum bend radius recommended in authoritative specifications for the particular hose.

h. All flexible hoses that are not lined shall be subjected to a flow induced vibration analysis. **NOTE:** A guidance document for performing this analysis is MSFC 20MO2540.

3.12.6.7 Flight Hardware Pneumatic System Pressure Relief Devices

a. Pressure relief devices shall be installed on all

systems having an on-board pressure source that can exceed the MAWP of any component downstream of that source unless the system is single fault tolerant against overpressurization during prelaunch operations.

b. Flight systems that require on-board pressure relief capability shall be designed to the following minimum requirements:

1. The pressure relief device shall be installed as close as is practical downstream of the pressure reducing device or source of pressure such as compressor and gas generator.

2. Pressure relief devices should be set to operate at a pressure not to exceed 110 percent of the system MOP.

3. The relieving capacity of the relief device shall be equal to or greater than the maximum flow capability of the upstream pressure reducing device or pressure source and should prevent the pressure from rising more than 20 percent above the system MOP.

4. The relief device vent outlet piping shall be sized to prevent excessive back pressure from adversely affecting the function of the relief device.

5. All relief devices and associated piping shall be structurally restrained to minimize any thrust effects on the pressure system vessels or piping.

6. The effects of the discharge from relief devices shall be assessed and analyzed to ensure that operation of the device will not be hazardous to personnel or equipment. **NOTE:** Items to be analyzed are thrust loads, noise, impingement of high velocity gas or entrained particles, toxicity, oxygen enrichment, and flammability.

7. All pressure relief devices shall be vented separately unless the following can be positively demonstrated:

(a) The creation of a hazardous mixture of gases in the vent system and the migration of hazardous substances into an unplanned environment is impossible.

(b) The capacity of the vent system is adequate to prevent a pressure rise of more than 20 percent above MOP when all attached pressure relief devices are wide open and the system is at full pressure and volume generating capacity.

8. No obstructions shall be placed downstream of the relief device.

9. Relief devices shall be located so that other components cannot render them inoperative.

REFERENCED DOCUMENTS

3.12.6.8 Flight Hardware Pneumatic System Vents

a. Pressure systems shall be designed so that pressure cannot be trapped in any part of the system without vent capability.

b. Vent system outlets should be in a location normally inaccessible to personnel or shall be conspicuously identified.

c. Vent outlets shall be protected against rain intrusion and entry of birds, insects, and animals.

d. Oxidizer and fuel vent outlets to the atmosphere shall be separated sufficiently to prevent mixing of vented fluids.

e. All vent outlets shall be designed to prevent accumulation of vented gases in dangerous concentrations (oxygen rich) in areas frequented by unprotected personnel.

f. Hydrogen vents shall discharge to atmosphere through an approved burner.

g. Special attention shall be given to the design of vent line supports at vent outlets due to potential thrust loads.

a. Each line venting into a multiple use vent system shall be protected against back pressurization by means of a check valve if the upstream system cannot withstand the back pressure or where contamination of the upstream system cannot be tolerated.

3.12.6.9 Flight Hardware Pneumatic System Quick Disconnect Couplings

NOTE: The quick disconnect assembly includes both the ground-half and air-half couplings.

a. All quick disconnect couplings shall be designed with a factor of safety of no less than 2.5.

b. Quick disconnect coupling bodies and appropriate parts shall be constructed of 300 series stainless steel. All parts that contact the fluid shall be compatible with the fluid.

c. The quick disconnect ground-half couplings shall withstand being dropped from a height of 6 ft on to a metal deck/grating or concrete floor without leaking or becoming disassembled.

d. When uncoupled, the quick disconnect shall seal the air-half and ground-half couplings and shall not permit external leakage. Both halves of the coupling shall seal under both low and high pressure.

e. When coupled, the quick disconnect shall permit fluid flow in either direction.

f. The quick disconnect shall not permit external leakage during any phase of coupling or uncoupling. (See paragraph 3.11.2.11. f.2.)

g. The quick disconnect shall be designed so that coupling and uncoupling can be performed with simple motions.

h. It shall be possible to determine that the quick disconnect is completely coupled by visual inspection.

i. The quick disconnect shall not have any partially coupled position in which the coupling can remain stable and permit fluid flow.

j. Special care shall be taken in the quick disconnect design to ensure that the possibility of inadvertent uncoupling and/or coupling external leakage due to side and axial loads is minimized.

k. The quick disconnect shall be designed to couple/uncouple without imparting adverse loads on the vehicle fluid lines that could cause flight hardware damage.

All quick disconnect ground-half couplings shall be identified in accordance with paragraph 3.11.1.16.1.f.

3.12.7 Flight Hardware Hydraulic System Design Requirements

Flight Hardware Hydraulic Systems shall meet the minimum design fabrication and test requirements of Section 3.12.5.2 in addition to the following.

3.12.7.1 Flight Hardware System General Design Requirements

a. Where necessary, hydraulic system low-points shall be provided a drain fitting (bleed ports) to allow draining of condensates or residue for safety purposes. **NOTE:** Entrapped air, moisture, and cleaning solvents are examples of foreign substances that may be hazardous to the system, component, or control equipment.

b. Bleed ports shall be located so that they can be operated without removal of other components and will permit the attachment of a hose to direct the bleed off material into a container away from the positions of the operators.

c. Test points shall be provided on hydraulic systems so that disassembly for test is not required.

d. Test points shall be easily accessible for the attachment of ground test equipment.

e. For all power-generating components, pump pulsations shall be controlled to a level that does not adversely affect system tubing, components, and

support installation.

f. Where system leakage can expose hydraulic fluid to potential ignition sources, fire resistant or flameproof hydraulic fluid shall be used.

3.12.7.2 Flight Hardware Hydraulic Accumulators and Reservoirs

All accumulators and reservoirs that are pressurized with gas to pressures greater than 100 psig shall be designed in accordance with Section 3.12.2.

3.12.7.3 Flight Hardware Hydraulic System Pressure Indicating Devices

a. A pressure indicating device shall be located on any pressurized storage system with a pressure greater than 100 psig.

b. These devices shall be designed to be remotely monitored during prelaunch operations.

3.12.7.4 Flight Hardware Hydraulic System Pressure Relief Devices

a. Pressure relief devices shall be installed on all hydraulic systems having an on-board pressure source that can exceed the MAWP of any component downstream of that source unless the system is single fault tolerant against overpressurization during prelaunch operations.

b. Flight systems that require on-board pressure relief capability shall meet the following minimum requirements:

1. The pressure relief device shall be installed as close as practical downstream of the pressure sources such as pumps, turbines, or gas generators.

2. Pressure relief devices should be set to operate at a pressure not to exceed 110 percent of the system MOP.

3. The relieving capacity of the relief device shall be equal to or greater than the maximum flow capability of the upstream pressure source and should prevent the pressure from rising more than 20 percent above the system MOP.

4. The effects of discharge from relief devices shall be assessed and analyzed to ensure that operation of the device will not be hazardous to personnel or equipment. **NOTE:** Items to be analyzed include thrust loads, toxicity, combustibility, flammability, and others as necessary.

5. Relief devices shall be located so that other components cannot render them inoperative.

6. No obstructions shall be placed downstream of the relief valve or burst disk outlet.

3.12.7.5 Flight Hardware Hydraulic Vent and Drain Systems

Hydraulic systems shall be designed so that pressure and fluids cannot be trapped in any part of the system without vent and/or drain capability.

3.12.7.6 Flight Hardware Hydraulic System Quick Disconnect Couplings

NOTE: The quick disconnect assembly includes both the ground-half and air-half couplings.

a. All quick disconnect couplings shall be designed with a factor of safety of no less than 2.5.

b. Special care shall be taken in the quick disconnect design to minimize air inclusion into the hydraulic fluid during coupling and uncoupling of the quick disconnect.

c. The quick disconnect ground-half couplings shall withstand being dropped from a height of 6 ft on to a metal deck/grating or concrete floor without leaking or becoming disassembled.

d. When uncoupled, the quick disconnect shall seal the air-half and ground-half couplings and shall not permit external leakage. Both halves of the coupling shall seal under both low and high pressure.

e. When coupled, the quick disconnect shall permit fluid flow in either direction.

f. The quick disconnect shall not permit external leakage during any phase of coupling or uncoupling. (See paragraphs 3.12.7.8.2 and 3.12.7.8.3)

g. The quick disconnect shall be designed so that coupling and uncoupling can be performed with simple motions.

h. The quick disconnect coupling shall contain a positive locking device that will automatically lock the connection of the coupling halves.

i. It shall be possible to determine that the quick disconnect is completely coupled and locked by visual inspection.

j. The quick disconnect shall not have any partially coupled unlocked position in which the coupling can remain stable and permit fluid flow.

k. Special care shall be taken in the quick disconnect design to ensure that the possibility of inadvertent uncoupling and/or coupling external leakage due to side and axial loads is minimized.

l. The quick disconnect shall be designed to couple/uncouple without imparting adverse loads on the vehicle fluid lines that could cause flight hardware damage.

m. All parts of the quick disconnect that contact fluid shall be compatible with the fluid.

REFERENCED DOCUMENTS

All quick disconnect ground-half couplings shall be identified in accordance with paragraph 3.11.1.16.1.f.

3.12.7.7 Testing Flight Hardware Hydraulic Systems After Assembly

a. All accumulators and reservoirs pressurized with gas to pressures greater than 100 psig shall be qualification tested in accordance with Section 3.12.2.4.1 and acceptance tested in accordance with Section 3.12.2.4.2.

b. All other hydraulic system components such as valves, pipe, tube, quick disconnects, and pipe and tube fittings shall be hydrostatically proof tested to a minimum of 1.5 times the component MAWP for a minimum of 5 min.

c. Proof testing shall demonstrate that the components will sustain proof pressure levels without distortion, damage, or leakage.

d. Both the inlet and discharge sides of a relief valve shall be proof tested.

e. When the discharge side of a relief valve has a lower pressure rating than the inlet side, they shall be proof tested independently.

f. Pressure relief valves shall be tested for proper setting and flow capacity prior to installation and first use on the Ranges.

g. Pressure gauges and transducers shall be hydrostatically tested to a minimum of 1.5 times the system MOP.

h. Pressure gauges and transducers shall be calibrated prior to installation and periodically thereafter.

i. Components may be initially hydrostatically proof tested after being assembled into a subsystem or system to 1.5 times the system MOP. **NOTE:** This approach shall be approved by Range Safety.

3.12.7.8 Testing Flight Hardware Hydraulic Systems After Assembly

3.12.7.8.1 Hydrostatic Tests. All newly assembled hydraulic pressure systems shall be hydrostatically tested to 1.5 times the system MOP prior to use. **NOTE 1:** MOP here refers to the maximum operating pressure that personnel are exposed to. **NOTE 2:** Where this is not possible, Range Safety will determine the adequacy of component testing and alternate means of testing the assembled system.

3.12.7.8.2 Leak Tests. All newly assembled hydraulic systems shall be leak tested at the system MOP after the proof test and prior to first use at the Ranges. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained. Minimum test requirements are as follows:

a. The fluid used during the leak test shall be the same as the system fluid media.

b. All mechanical joints such as gasketed joints, seals, threaded joints, quick disconnects, and weld seams shall be inspected for leaks while monitoring for any pressure decay.

c. All shutoff and block valves shall be leak checked downstream to verify their shutoff capability in the CLOSED position.

3.12.7.8.3 System Validation and Functional Tests.

a. All newly assembled hydraulic systems shall have a system validation test and a functional test of each component at system MOP prior to first use at the Ranges. **NOTE:** These tests shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

b. Minimum test requirements are as follows:

1. These tests shall demonstrate the functional capability of all components.

2. All prelaunch operational sequences for the system shall be executed.

3.12.7.9 Testing Modified and Repaired Flight Hardware Hydraulic Systems

a. Any hydraulic system element, including fittings or welds, that has been repaired, modified, or possibly damaged subsequent to having been proof tested shall be retested at proof pressure prior to its normal use.

b. A modified or repaired hydraulic system shall be leak tested at the system MOP prior to its normal use. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

c. A modified or repaired hydraulic system shall be revalidated and functionally tested at the system MOP prior to its normal use.

d. If any hydraulic system element such as valves, regulators, gauges, or tubing has been disconnected or reconnected for any reason, the affected system or subsystem shall be leak tested at MOP.

3.12.8 Flight Hardware Hypergolic Propellant System Design and Test Requirements

3.12.8.1 Flight Hardware Hypergolic Propellant System General Design Requirements

- a.* Propellant systems shall have low point drain capability.
- b.* Low point drains shall be accessible and located in the system to provide the capability of removing propellant from the tanks, piping, lines, and components at all times after loading.
- c.* Propellant systems shall be designed to be flushed and purged with inert fluids.
- d.* For prelaunch failure modes that could result in a time-critical emergency, provision shall be made for automatic switching to a safe mode of operation. **NOTE:** Caution and warning signals shall be provided for these time-critical functions.
- e.* Hypergolic propellant systems shall also comply with the pneumatic system requirements of Section 3.12.6.
- f.* Items used in any fuel or oxidizer system shall not be interchanged after exposure to the respective media.
- g.* Bi-propellant systems shall have the capability of loading the fuel and oxidizer system one at the time.
- h.* Hypergolic propellant (liquid or gas) migration into an associated pneumatic system shall be controlled. **NOTE:** The pneumatic system should be compatible with all of the hypergolic propellants served by the pneumatic supply.

3.12.8.2 Flight Hardware Hypergolic Propellant System Piping and Tubing

- a.* NPT connectors shall not be used in hypergolic system piping and tubing.
- b.* Socket weld flanges shall not be used in hypergolic system piping.
- c.* All pipe and tube welded joints shall be 100 percent radiographically inspected before and after the acceptance proof test.

3.12.8.3 Flight Hardware Hypergolic Propellant System Valves

- a.* Valve actuators shall be operable under maximum design flow and pressure.
- b.* Flow control valves shall be designed to be fail-safe if pneumatic or electric control power is lost during prelaunch operations.
- c.* Check valves shall be provided where back

flow of fluids would create a hazard.

d. Valve connectors and connections shall be designed, selected, or located, (or as a last resort, marked) to prevent connection to an incompatible system.

e. Remotely controlled valves shall provide for remote monitoring of OPEN and CLOSED positions during prelaunch operations.

f. All electrical control circuits for remotely actuated valves shall be shielded or otherwise protected from hazardous stray energy.

g. Designs using uncontained seats are prohibited.

h. Valves that are not intended to be reversible shall be designed or marked so that they will not be connected in a reverse mode.

i. Manually operated valves shall be designed so that overtightening the valve stem cannot damage soft seats to the extent that seat failure occurs.

j. Valve stem travel on manual valves shall be limited by a positive stop at each extreme position.

k. The application or removal of force to the stem positioning device shall not cause disassembly of the pressure containing structure of the valve.

3.12.8.4 Flight Hardware Hypergolic Propellant System Pressure Indicating Devices

a. A pressure indicating device shall be located on any hypergolic storage vessel and on any section of the system where pressurized fluid can be trapped.

b. These pressure indicating devices shall be designed to be remotely monitored during prelaunch operations.

3.12.8.5 Flight Hardware Hypergolic Propellant System Flexible Hoses

a. Hoses shall be used only when required to provide movement between interconnecting fluid lines when no other feasible means is available.

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b. Flex hose installation shall be designed to avoid abrasive contact with adjacent structures or moving parts.

c. Flexible hose shall not be supported by rigid lines or components if excessive loads from flex hose motion can occur.

d. Flex hose assemblies shall not be installed in a manner that will place a mechanical load on the hose or hose fittings to an extent that will degrade hose strength or cause the hose fitting to loosen.

e. The bend radius of flex hoses shall be designed to be no less than the safe minimum bend radius recommended in authoritative specifications for the particular hose.

f. Flex hoses shall not be exposed to temperatures that exceed the rated temperature of the hose.

g. Flex hoses that are permitted to pass close to a heat source shall be protected.

h. All flexible hoses that are not lined shall be subjected to a flow induced vibration analysis. **NOTE:** A guidance document for performing this analysis is MSFC 20MO2540.

3.12.8.6 Flight Hardware Hypergolic Propellant System Pressure Relief Devices

a. Pressure relief devices shall be installed on all systems having an on-board pressure source that can exceed the MAWP or MEOP of any component downstream of that source unless the system is single fault tolerant against overpressurization during prelaunch operation.

b. Flight systems that require on-board pressure relief capability shall be designed to the following minimum requirements:

1. The pressure relief device shall be installed as close as is practical downstream of the pressure reducing device or source of pressure such as a compressor or gas generator.

2. Pressure relief devices should be set to operate at a pressure not to exceed 110 percent of the system MOP/MEOP.

3. The relieving capacity of the relief device shall be equal to or greater than the maximum flow capability of the upstream pressure reducing device or pressure source and should prevent the pressure from rising more than 20 percent above the system MOP/MEOP.

c. The relief device vent outlet piping shall be sized to prevent excessive back pressure from adversely affecting the relief device function.

d. All relief devices and associated piping shall be

structurally restrained to minimize any thrust effects to the pressure system vessels or piping.

e. The effects of the discharge from relief devices shall be assessed and analyzed to ensure that operation of the device will not be hazardous to personnel or equipment. **NOTE:** Items to be analyzed are thrust loads, toxicity, and flammability.

f. All pressure relief devices shall be vented separately unless the following criteria can be positively demonstrated:

1. The creation of a hazardous mixture of gases in the vent system and the migration of hazardous substances into an unplanned environment is impossible.

2. The capacity of the vent system is adequate to prevent a pressure rise more than 20 percent above MOP when all attached pressure relief devices are wide open and the system is at full pressure and volume generating capacity.

g. No obstructions shall be placed downstream of the relief device.

h. Relief devices shall be located so that other components cannot render them inoperative.

3.12.8.7 Flight Hardware Hypergolic Propellant Vent Systems

a. All hypergolic vent effluent resulting from routine operations shall be scrubbed and/or incinerated prior to venting to the atmosphere through vent stacks.

b. Hypergolic systems shall be designed so that vapors or liquids cannot be trapped in any part of the system without vent and/or drain capability.

c. Vent system outlets shall be in a location normally inaccessible to personnel and shall be conspicuously identified.

d. Vent outlets shall be protected against rain intrusion and entry of birds, insects, and animals.

e. Oxidizer and fuel vent outlets to the atmosphere shall be separated sufficiently to prevent mixing of vented fluids.

f. Special attention shall be given to the design of vent line supports at vent outlets due to potential thrust loads.

g. Each line venting into a multiple use vent system shall be protected against back pressurization by means of a check valve if the upstream system cannot withstand the back pressure or where contamination of the upstream system cannot be tolerated.

h. Pressure relief vents shall be designed and lo-

cated so that vapors will not enter any inhabited areas.

i. Incompatible fluids shall not be discharged into the same vent or drain system.

j. Fuel and oxidizer vent systems shall be equipped with a means of purging the system with an inert gas to prevent explosive mixtures.

3.12.8.8 Flight Hardware Hypergolic Propellant System Quick Disconnect Couplings

NOTE: The quick disconnect assembly includes both the ground-half and air-half couplings.

a. All quick disconnect couplings shall be designed with a factor of safety of no less than 2.5.

b. Quick disconnect coupling bodies and appropriate parts shall be constructed of 304, 304L, 316, or 316L series stainless steel. All parts that contact the fluid shall be compatible with the fluid.

c. The quick disconnect ground-half couplings shall withstand being dropped from a height of 6 ft on to a metal deck/grating or concrete floor without leaking or becoming disassembled.

d. When uncoupled, the quick disconnect shall seal the air-half and ground-half couplings and

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shall not permit external leakage. Both halves of the coupling shall seal under both low and high pressure.

e. When coupled, the quick disconnect shall permit fluid flow in either direction.

f. The quick disconnect shall not permit external leakage during any phase of coupling or uncoupling. (See paragraphs 3.12.8.9 f., 3.12.8.10.2, and 3.12.8.10.3.)

g. The quick disconnect shall be designed so that coupling and uncoupling can be performed with simple motions.

h. The quick disconnect shall contain a positive locking device that will automatically lock the connection of the coupling halves.

i. It shall be possible to determine that the quick disconnect is completely coupled and locked by visual inspection.

j. The quick disconnect shall not have any partially coupled unlocked position in which the coupling can remain stable and permit fluid flow.

k. Special care shall be taken in the quick disconnect design to ensure that the possibility of inadvertent uncoupling and/or coupling external leakage due to side and axial loads is minimized.

l. The quick disconnect shall be designed to couple/uncouple without imparting adverse loads on the vehicle fluid lines that could cause flight hardware damage.

m. Hypergolic quick disconnects shall be designed to ensure that all incompatible fuel and oxidizer couplings cannot be inadvertently connected, causing mixing of propellants.

n. All quick disconnect ground-half couplings shall be identified in accordance with paragraph 3.11.1.16.1.f.

3.12.8.9 Testing Flight Hardware Hypergolic Propellant System Components Prior to Assembly

a. All hypergolic vessels shall be qualification tested in accordance with Section 3.12.2.2.3 and acceptance tested in accordance with Section 3.12.2.2.4.

b. All other pressurized components such as valves, pipe, tubing, quick disconnects, and pipe and tube fittings shall be hydrostatically proof tested to a minimum of 1.5 times the component MAWP for a minimum of 5 min.

c. Proof testing shall demonstrate that the components will sustain proof pressure levels without distortion, damage, or leakage.

d. Both the inlet and discharge sides of a relief valve shall be proof tested. **NOTE:** When the discharge side of a relief valve has a lower pressure rating than the inlet, they shall be proof tested independently.

e. The following inspections shall be performed after proof testing.

1. Mechanical components such as valves, regulators, and quick disconnects shall be inspected for external deformation, deterioration, or damage.

2. Damaged, distorted, or deteriorated parts shall be rejected and replaced and the test repeated.

f. Functional and leak tests shall be performed at the component MAWP or MEOP after the proof test.

g. Pressure gauges and transducers shall be hydrostatically tested to a minimum of 1.5 times the system MOP.

h. Pressure gauges and transducers shall be calibrated prior to installation and periodically thereafter.

i. Pressure relief valves shall be tested for proper setting prior to installation and first use on the Ranges.

j. Components may be initially hydrostatically proof tested after being assembled into a subsystem or system to 1.5 times the system MOP/MEOP. **NOTE:** This approach shall be approved by Range Safety.

k. Pneumatic proof testing to a proof pressure of 1.25 times MAWP or MEOP is permissible only if hydrostatic proof testing is impractical, impossible, or will jeopardize the integrity of the system or system element. **NOTE:** Prior approval for pneumatic proof testing at the Ranges shall be obtained from Range Safety.

l. All hypergolic valves shall be tested for both internal and external leakage at their MAWP.

1. The normal leakage rate shall not exceed that detected by a volumetric bubble leak test conducted with a minimum 10 percent helium mixture.

Certain critical system components may require further elaborate testing (mass spectrometer) to verify leak rates not to exceed 1×10^{-6} cc/sec at standard temperature and pressure (STP) of helium gas.

3.12.8.10 Testing Flight Hardware Hypergolic Propellant Systems After Assembly

3.12.8.10.1 Hydrostatic Tests. All newly assembled hypergolic propellant pressure systems shall be hydrostatically tested to 1.5 times MOP prior to use. **NOTE 1:** MOP here refers to the maximum operating pressure that personnel are exposed to. **NOTE 2:** Where this is not possible,

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Range Safety will determine the adequacy of component testing and alternate means of testing the assembled system.

3.12.8.10.2 Leak Tests.

a. Pneumatic leak testing at system MOP/MEOP of all completely assembled and cleaned vessel pipe and tubing sections, with components installed, shall be completed prior to introduction of propellant.

b. Minimum test requirements are as follows:

1. Test gas should use a minimum volume of 10 percent helium.

2. All mechanical joints such as gasket joints, seals, quick disconnects, and threaded joints and weld seams shall be visually bubble tight, using approved soap solution and techniques.

3. The functional validity of installed block valves should be checked by incrementally venting downstream sections and pin hole leak checking. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

c. When required, alternate methods of leak testing such as the use of portable mass spectrometers may be specified on a case-by-case basis.

3.12.8.10.3 System Validation and Functional Tests.

a. All newly assembled pressure systems shall have a system validation test and a functional test of each component performed at system MOP/MEOP prior to first use on the Ranges. **NOTE:** These tests shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

b. Minimum test requirements are as follows:

1. These tests shall demonstrate the functional capability of all non-passive components such as valves, regulators, and transducers.

2. In addition, all prelaunch operational sequences for the system shall be executed.

3. All parallel or series redundant components shall be individually tested to ensure single fault tolerant capabilities are functional prior to launch.

4. All shutoff and block valves shall be leak checked downstream to verify their shutoff capability in the CLOSED position.

3.12.8.10.4 Bonding and Grounding. All newly assembled pressure systems containing flammable

and combustible fluids shall be tested to verify that the bonding and grounding requirements of the **Flight Hardware Pressure System Bonding and Grounding** section of this Chapter have been met.

3.12.8.11 3.12.8.11 Testing Modified and Repaired Flight Hardware Hypergolic Propellant Systems

a. Any hypergolic system elements including fittings or welds that have been repaired, modified, or possibly damaged after having been proof tested shall be retested at proof pressure prior to their normal use.

b. A modified or repaired hypergolic system shall be leak tested at the system MOP/MEOP prior to its normal use. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

c. A modified or repaired hypergolic system shall be revalidated and functionally tested at the system MOP/MEOP prior to its normal use.

If any hypergolic system elements such as valves, gauges, and tubing have been disconnected or reconnected for any reason, the affected system or subsystem shall be leak tested at MOP/MEOP

3.12.9 Flight Hardware Cryogenic Systems Design and Test Requirements

3.12.9.1 Flight Hardware Cryogenic System General Design Requirements

a. Propellant systems shall have low point drain capability.

1. Low point drains shall be accessible and located in the system to provide the capability of removing propellant from the tanks, piping, lines, and components.

2. In addition, the LH₂ system shall be designed to be purged with inert fluids.

b. Bi-propellant systems shall have the capability of loading the fuel and oxidizer one at the time.

c. For prelaunch failure modes that could result in a time-critical emergency, provision shall be made for automatic switching to a safe mode of operation. **NOTE:** Caution and warning signals shall be provided for these time-critical functions.

d. Pneumatic systems servicing cryogenic systems shall comply with the pneumatic pressure system requirements of the **Flight Hardware Pneumatic Systems** section of this Chapter.

e. Cryogenic systems shall be designed to control

liquefaction of air.

f. For systems requiring insulation, nonflammable materials shall be used in compartments or spaces where fluids and/or vapors could invade the area.

g. Vacuum-jacketed systems shall be capable of having the vacuum verified.

h. Purge gas for LH₂ and cold GH₂ lines should be gaseous helium (GHe).

i. Precautions shall be taken to prevent cross mixing of media through common purge lines by use of check valves to prevent back flow from a system into a purge distribution manifold.

j. Titanium and titanium alloys shall not be used where exposure to GOX (cryogenic) or LOX is possible.

3.12.9.2 Flight Hardware Cryogenic System Vessels and Tanks

Cryogenic vessels and tanks shall be designed in accordance with the requirements identified in paragraph 3.12.2.

3.12.9.3 Flight Hardware Cryogenic System Piping and Tubing

a. The amount and type of thermal insulation (insulation material or vacuum-jacketed) shall be determined from system thermal requirements.

b. The use of slip-on flanges shall be avoided.

c. Flanged joints in LH₂ systems shall be seal welded.

d. Flanged joint gaskets are not to be reused.

e. Cryogenic systems shall provide for thermal expansion and contraction without imposing excessive loads on the system. **NOTE:** Bellows, reactive thrust bellows, or other suitable load relieving flexible joints may be used.

f. All pipe and tube welds shall be 100 percent radiographically inspected before and after the acceptance proof test. **NOTE:** The accept and reject criteria shall be submitted to Range Safety for review and approval.

3.12.9.4 Flight Hardware Cryogenic System Valves

a. Cryogenic systems shall be designed to ensure icing does not render the valve inoperable.

b. Remotely controlled valves shall provide for remote monitoring of OPEN and CLOSED position.

c. Remotely operated valves shall be designed to be fail-safe if pneumatic or electric control power is lost during prelaunch operations.

d. All electrical control circuits for remotely actuated valves shall be shielded or otherwise protected from hazardous stray energy.

e. Manually operated valves shall be designed so that overtightening the valve stem cannot damage seats to the extent that seat failure occurs.

f. Valve stem travel on manual valves shall be limited by a positive stop at each extreme position.

g. The application or removal of force to the stem positioning device shall not cause disassembly of the pressure containing structure of the valve.

h. Manual or remote valve actuators shall be operable under maximum design flow and pressure.

i. Valves that are not intended to be reversible shall be designed or marked so that they will not be connected in a reverse mode.

j. Stem position local or remote indicators shall sense the position of the stem directly, not the position of the actuating device.

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3.12.9.5 Flight Hardware Cryogenic System Pressure Indicating Devices

a. A pressure indicating device shall be located on any cryogenic vessel and/or tank and on any section of the system where cryogenic liquid can be trapped.

b. These pressure indicating devices shall be designed to be remotely monitored during prelaunch operations.

3.12.9.6 Flight Hardware Cryogenic System Flexible Hoses

a. Hoses shall be used only when required to provide for movement between interconnecting cryogenic lines if no other feasible means are available.

b. Flex hose installation shall be designed to avoid abrasive contact with adjacent structures or moving parts.

c. Flexible hose shall not be supported by rigid lines or components if excessive loads from flex hose motion can occur.

d. Flex hose assemblies shall not be installed in a manner that will place a mechanical load on the hose or hose fittings to an extent that will degrade hose strength or cause the hose fitting to loosen.

e. The bend radius of flex hoses shall be designed to be no less than the safe minimum bend radius recommended in authoritative specifications for the particular hose.

f. All flexible hoses that are not lined shall be subjected to a flow induced vibration analysis. **NOTE:** A guidance document for performing this analysis is MSFC 20MO2540.

3.12.9.7 Flight Hardware Cryogenic System Pressure Relief Devices

a. All cryogenic vessels and tanks shall be protected against overpressure by means of at least one pressure relief valve.

b. Minimum design requirements are as follows:

1. The pressure relief device shall be installed as close as practical to the cryogenic vessel or tank.

2. Pressure relief valves shall be set to operate at pressures determined on a case-by-case basis by the Range User.

3. The relieving capacity of the relief valve shall be determined on a case-by-case basis by the Range User.

c. All pressure relief devices shall be vented separately unless the following can be positively dem-

onstrated:

1. The creation of a hazardous mixture of gases in the vent system and the migration of hazardous substances into an unplanned environment is impossible.

2. The capacity of the vent system is adequate to prevent a pressure rise more than 20 percent above MOP when all attached pressure relief devices are wide open and the system is at full pressure and volume generating capacity.

d. All relief devices and associated piping shall be structurally restrained to eliminate any deleterious thrust effects on cryogenic system vessels or piping.

e. The effects of the discharge from relief devices shall be assessed and analyzed to ensure that operation of the device will not be hazardous to personnel or equipment. **NOTE:** Items to be analyzed are thrust loads, impingement of high velocity gas or entrained particles, toxicity, oxygen enrichment, and flammability.

f. No obstructions shall be placed downstream of the relief valves.

g. Relief valves shall be located so that other components cannot render them inoperative.

3.12.9.8 Flight Hardware Cryogenic System Vents

a. GH₂ shall be vented to atmosphere through a burner system.

b. Cryogenic systems shall be designed so that fluids cannot be trapped in any part of the system without drain or vent (relief valve or vent valve) capability.

c. Each line venting into a multiple use vent system shall be protected against back pressurization by a check valve if the upstream system cannot withstand the back pressure or where contamination of the upstream system cannot be tolerated.

d. Vents shall be placed in a location normally inaccessible to personnel and at a height or location where venting will not normally be deposited into habitable spaces.

e. Each vent shall be conspicuously identified using appropriate warning signs, labels, and markings.

f. Vent outlets shall be located far enough away from incompatible propellant systems and incompatible materials to ensure no contact is made during vent operations.

g. Incompatible fluids shall not be discharged into the same vent or drain system.

h. Fuel vent systems shall be equipped with a means of purging the system with an inert gas to prevent explosive mixtures.

i. Vent outlets shall be protected against rain intrusion and entry of birds, insects, and animals.

j. Special attention shall be given to the design of vent line supports at vent outlets due to potential thrust loads.

3.12.9.9 3.12.9.9 Flight Hardware Cryogenic System Quick Disconnect Couplings

NOTE: The quick disconnect assembly includes both the ground-half and air-half couplings.

a. All quick disconnect couplings shall be designed with a factor of safety of no less than 2.5.

b. Quick disconnect coupling bodies and appropriate parts shall be constructed of 304, 304L, 316, or 316L series stainless steel. All parts that contact the fluid shall be compatible with the fluid.

c. Cryogenic quick connect couplings shall be of the following types: Type I-supply coupling assemblies; Type II-vent coupling assemblies.

d. When uncoupled, Type I couplings shall seal the air-half and ground-half couplings and shall not permit external leakage. Both halves of the coupling shall seal under both low and high pressure. When the coupling is connected, liquid cryogenic fluid shall flow. When the coupling is disconnected, the flow shall be checked automatically. Type II couplings shall allow gaseous cryogenic fluid flow through the coupling whether connected or disconnected.

e. When coupled, the quick disconnect shall permit fluid flow in either direction.

f. Type I quick disconnect ground-half couplings shall withstand being dropped from a height of 6 ft on to a metal deck/grating or concrete floor

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without leaking or becoming disassembled.

g. Type I quick disconnects shall not permit external leakage during any phase of coupling or uncoupling. (See paragraph 3.12.9.10 f.)

h. The quick disconnect shall be designed so that coupling and uncoupling can be performed with simple motions.

i. The quick disconnect coupling shall contain a positive locking device that will automatically lock the connection of the coupling halves.

j. It shall be possible to determine that the quick disconnect is completely coupled and locked by visual inspection.

k. Type I quick disconnects shall not have any partially coupled unlocked position in which the coupling can remain stable and permit fluid flow.

l. Special care shall be taken in the quick disconnect design to ensure that the possibility of inadvertent uncoupling and/or coupling external leakage due to side and axial loads is minimized.

m. The quick disconnect shall be designed to couple/uncouple without imparting adverse loads on the vehicle fluid lines that could cause flight hardware damage.

n. Cryogenic quick disconnects shall be designed to ensure that all incompatible fuel and oxidizer couplings cannot be inadvertently connected, causing mixing of propellants.

o. All quick disconnect ground-half couplings shall be identified in accordance with paragraph 3.11.1.16.1.f.

3.12.9.10 3.12.9.10 Testing Flight Hardware Cryogenic System Components Prior to Assembly

a. All cryogenic vessels and tanks shall be qualification tested in accordance with Section 3.12.2.2.3 and acceptance tested in accordance with Section 3.12.2.2.4.

b. All other cryogenic components such as valves, pipe, tubing, quick disconnects, and pipe and tube fittings shall be hydrostatically proof tested to a minimum of 1.5 times the component MAWP or MEOP at ambient temperatures for a minimum of 5 min.

c. Proof testing shall demonstrate that the components will sustain proof pressure levels without distortion, damage, or leakage.

d. Both the inlet and discharge sides of a relief valve shall be proof tested. **NOTE:** When the discharge side of a relief valve has a lower pressure

rating than the inlet side, they are to be proof tested independently.

e. The following inspections shall be performed after proof testing:

1. Mechanical components such as valves and quick disconnects shall be inspected for deformation, deterioration, or damage.

2. Damaged, distorted, or deteriorated parts shall be rejected and replaced and the test repeated.

f. Functional and leak tests shall be performed at the component MAWP or MEOP after the proof test.

g. Pressure relief valves shall be tested for proper setting and flow capacity prior to installation and first use on the Ranges.

h. Pressure gauges and transducers shall be hydrostatically tested to a minimum of 1.5 times the system MOP/MEOP.

i. Pressure gauges and transducers shall be calibrated prior to installation.

j. Components may be initially hydrostatically proof tested after being assembled into a subsystem or system to 1.5 times the system MOP/MEOP. **NOTE:** This approach shall be approved by Range Safety.

k. Pneumatic proof testing to a proof pressure of 1.25 times MAWP/MEOP is permissible only if hydrostatic proof testing is impractical, impossible or will jeopardize the integrity of the system or system element. **NOTE:** Prior approval for pneumatic proof testing at the Ranges shall be obtained from Range Safety.

3.12.9.11 3.12.9.11 Testing Flight Hardware Cryogenic Systems After Assembly

a. All newly assembled pressure systems shall be hydrostatically tested to 1.5 times MOP/MEOP prior to use. **NOTE 1:** MOP here refers to the maximum operating pressure that personnel are exposed to. **NOTE 2:** Where this is not possible, Range Safety will determine the adequacy of component testing and alternate means of testing the assembled system.

b. All newly assembled cryogenic systems shall be leak tested.

c. The system shall be pressurized to the system MOP using gaseous helium for LH₂ systems and gaseous nitrogen for LOX systems.

d. Following the leak test, all newly assembled cryogenic systems shall have a system validation

test performed at system MOP prior to first operational use at the Ranges.

e. Minimum test requirements are as follows:

CHAPTER 3

LAUNCH VEHICLE, PAYLOAD, AND GROUND SUPPORT EQUIPMENT DOCUMENTATION, DESIGN, AND TEST REQUIREMENTS

1. The intended service fluid (LO₂, LH₂) shall be used as the validation test fluid.
2. The functional capability of all components and subsystems shall be validated.
3. All prelaunch operational sequences for the system shall be exercised, including emergency shutdown, safing, and unloading procedures.
4. Vacuum readings shall be taken and recorded of all vacuum volumes before, during, and after the test.
5. No deformation, damage, or leakage is allowed.

3.12.9.12 Testing Modified and Repaired Flight Hardware Cryogenic Systems

- a. Any cryogenic system element, including fittings or welds, that has been repaired, modified, or possibly damaged subsequent to system leak test shall be retested.
- b. The component retest sequence shall be as follows:
 1. The component shall be hydrostatically proof test at ambient temperature to 1.5 times the component MAWP or MEOP.
 2. The component shall be reinstalled into the cryogenic system and a leak check performed at system MOP or MEOP.
 3. The functional capability of the modified and/or repaired component shall be revalidated using the intended service fluid at system MOP or MEOP.
- c. If any cryogenic system elements such as valves, regulators, gauges, or pipes have been disconnected or reconnected for any reason, the affected connection shall be leak checked at MOP.

3.12.10 Flight Hardware Pressure Systems Data Requirements

This section lists the minimum data required to certify compliance with the design, analysis, and test requirements of the **Flight Hardware Pressure Systems and Pressurized Structures** section of this Chapter.

- a. Data required by Sections 3.12.10.1 through 3.12.10.4 shall be incorporated into the MSPSP or submitted as a separate package when appropriate.
- b. Data required by paragraph 3.12.10.5 shall be placed in a certification file to be maintained by the hazardous pressure system operator.
- c. This data shall be reviewed and approved by Range Safety prior to the first operational use of hazardous pressure systems at the Ranges.

3.12.10.1 Flight Hardware Pressure Systems General Data Requirements

The following general flight hardware pressure systems data is required:

- a. Hazard analysis of hazardous pressure systems in accordance with a jointly tailored Systems Safety Program (See Appendix 1B.)
- b. The material compatibility analysis in accordance with the **Flight Hardware Pressure Systems Material Compatibility and Selection and Metallic Materials** sections of this Chapter
- c. Physical and chemical properties and general characteristics of the propellant, test fluid, and gases. **NOTE:** Data shall be provided to both Range Safety, Bioenvironmental Engineering, Environmental Planning, 30 CEG and 30 SW/ET, as appropriate.
- d. For hazardous propellants, fluids, and gases, the following data shall be submitted:

1. Specific health hazards such as toxicity and physiological effects
2. TLV, MAC for 8-hr day, 5-day week of continuous exposure
3. Emergency tolerance limits including length of time of exposure and authority for limits, such as the Surgeon General, NIOSH, or independent study
4. Maximum credible spill (volume and surface area) and supporting analyses
5. Description of hazards other than toxicity, such as flammability and reactivity
6. Identification of material incompatibility problems in the event of a spill
7. Personal protective equipment to be used in handling and using the propellants when this equipment will be used during an operation, and the manufacturer, model number, and other identifying data
8. Manufacturer, model number, specifications, operating limits, type of certification, and general description of vapor detecting equipment
9. Recommended methods and techniques for decontamination of areas affected by spills or vapor clouds and hazardous waste disposal procedures

3.12.10.2 Flight Hardware Pressure System Design Data Requirements

- a. A schematic that presents the system in a clear and easily readable form, with complete subsystems grouped and labeled accordingly; nomenclature of each element should be made adjacent to or in the vicinity of each element.
- b. The schematic or corresponding data sheet shall contain the following information:
 1. Identification of all pressure system components such as valves, regulator, tubes, hoses, vessels, and gauges using standard symbols. **NOTE:** A legend is recommended and the original mechanical drawings should be referenced
 2. MOP of all systems and subsystems at expected operating temperatures and identification of expected source pressures and expected delivery pressures
 3. All relief valve pressure settings and flow rates
 4. System fluid and maximum expected temperature
 5. Pressure ranges of all pressure gauges
 6. Pressure settings of pressure regulators
 7. Charging pressure of reservoirs and vessels, their nominal capacities, and wall thickness
 8. Pressure setting of all pressure switches

9. Nominal outside diameter and wall thickness of all tubing and piping

10. Flowpath through all components. **NOTE:** When the system is to be used in several operating modes, it is easier to provide a separate schematic that depicts flowpaths for each operating mode.

11. Identification of each component (reference designations) so that cross-reference between schematics and drawings and a pressure system component list or other documentation is possible

12. End-to-end electrical schematics of electrical and electronic components giving full functional data and current loads

13. Connections for testing or servicing

14. A narrative that provides the following information:

- (a) Description of the system and its operating modes
- (b) Discussion of operational hazards
- (c) Discussion of accessibility of components

15. A sketch and/or drawing of the system that shows physical layout and dimensions shall be provided.

16. System information shall be placed in tables. (See Appendix 3A for guidance.)

3.12.10.3 Flight Hardware Pressure System Component Design Data

- a. Identification of each component with a reference designation permitting cross-reference with the system schematic
- b. MAWP for all pressure system components and the MOP the component shall see when installed in the system
- c. Safety factors or design burst pressure for all pressure system components and identification of actual burst pressures, if available
- d. Proof pressure for each system component and identification of the proof pressure the component will see after installation in the system, if applicable
- e. Materials used in the fabrication of each element within the component including soft goods and other internal elements
- f. Cycle limits if fatigue is a factor of the component
- g. Temperature limits of each system component
- h. Component information shall be placed in tables. (See Appendix 3A for guidance.)

3.12.10.4 Flight Hardware Pressure System Test Procedures and Reports

- a. All test plans, test procedures and test reports

required to be performed by the **Flight Hardware Pressure Systems** section of this Chapter shall be submitted to Range Safety for review and approval.

b. A list and synopsis of all hazardous pressure system operational procedures to be performed at the Ranges shall be provided.

3.12.10.5 Flight Hardware Pressure System Certification Files

a. Certification files shall be maintained and updated by the hazardous pressure system operator.

b. These files shall be located at the Ranges.

c. The certification file for each hazardous pressure system shall contain the data required in Sections 3.12.10.1 through 3.12.10.4 in addition to the following:

1. As applicable, stress, safe-life, fatigue, fracture mechanics analysis in accordance with sections 3.12.1.4.3, 3.12.1.5.4 and 3.12.1.5.5.

2. Specification drawings and documents for all components

3. If necessary, a cross-sectional assembly drawing of the component to assess the safety aspects of the internal elements

4. Certification that welding and weld NDE meet applicable standards and have been performed by certified personnel

5. Qualification and acceptance test plans and test reports

6. Certification documentation showing that vessels are designed, fabricated, and tested in accordance with Sections 3.12.1, 3.12.2 and 3.12.3.

7. Certification that all components, including pipe and tube fittings, have successfully passed a hydrostatic proof test

3.13 ORDNANCE SYSTEMS

3.13.1 Ordnance Hazard Classification

3.13.1.1 Ordnance General Classification

a. Ordnance items shall be assigned the appropriate DoD and United Nations (UN) hazard classification and storage compatibility group in accordance with DoD 6055.9-STD.

b. Items that have not previously been classified and cannot be classified based on similarity with previously classified items shall be tested in accordance with AFTO 11A-1-47/(NAVSEAINST 8020.3/TB700-2/DLAR 8220.1) and classified accordingly.

c. Ordnance items shall also have a DOT classification. **NOTE:** The Range User is responsible for obtaining DOT classification.

d. The Range User shall provide the DoD and DOT documentation demonstrating proper classification to Range Safety for review and approval prior to delivering ordnance to the Ranges.

3.13.1.2 Range Safety Ordnance Device and System Categorization

a. In addition to the requirements noted above, each ordnance device and system shall be classified as category A (hazardous) or B (non-hazardous) and the proposed classifications submitted to Range Safety for review and approval prior to delivering ordnance to the Ranges.

b. The following criteria shall be used to determine ordnance device and system hazard category:

1. Handheld Mode

(a) At least 1 percent of an ordnance item qualification lot or at 10 units shall be functioned to determine if the ordnance produces fragments, if the temperature rises above 260°C, if the ordnance produces flame, or if the ordnance produces pressure in excess of 150 psig at the output end. **NOTE:** It is not the intention of this document to impose excessive test requirements. Similarities with previously tested items is often sufficient for categorization. If testing or analogy is not accomplished, the initiating device shall be treated as category A.

(b) If one or more of the tested units violate the criteria, the ordnance shall be considered category A in the handheld mode.

2. Assembled Mode

(a) An analysis of the ordnance system shall be performed to determine if its initiation is capable of causing injury or damage to DoD property on the Ranges.

(b) Tests will not be required for the assembled mode.

3.13.2 Ordnance System General Requirements

All the remaining parts of section 3.13 establish the design requirements for category A ordnance and ordnance systems during transportation, handling, storage, installation, testing, and connection on the Ranges. Category B ordnance and ordnance systems do not have to meet requirements of EWR 127-1.

3.13.2.1 Ordnance Subsystem Identification

Ordnance systems include the following subsystems. All of these subsystems are subject to the design requirements in this section.

a. Power Source: The power source may be a

battery, a dedicated power bus, or a capacitor.

b. Firing Circuit (the path between the power source and the initiating device): The firing circuit includes the electrical path and the optical path for laser initiated ordnance.

c. Control Circuit: The control circuit activates and deactivates the safety devices in the firing circuit.

d. Monitor Circuit: The monitor circuit monitors status of the firing circuits.

e. Initiating Device: The initiating device converts electrical, mechanical, or optical energy into explosive energy.

f. Receptor Ordnance: Receptor ordnance includes all ordnance items such as the explosive transfer system (ETS), separation charge, explosive bolt installed downstream of the initiating devices.

3.13.2.2 Preclusion of Inadvertent Firing

Ordnance devices and systems shall be designed to preclude inadvertent firing of any explosive or pyrotechnic components when subjected to environments such as shock, vibration, and static electricity encountered during ground processing.

3.13.2.3 Failure Mode Effects and Criticality Analysis

A Failure Mode Effects and Criticality Analysis (FMECA) shall be performed on all ordnance systems in accordance with the requirements of a jointly tailored MIL-STD-1543.

3.13.3 Ordnance Electrical and Optical Circuits

3.13.3.1 Ordnance Electrical and Optical Circuit General Design Requirements

a. Ordnance system circuitry shall be shielded, filtered, grounded, or otherwise isolated to preclude energy sources such as electromagnetic energy or stray light from the Ranges and/or launch vehicle from causing undesired output of the system.

b. Category A ordnance systems shall be designed so that the initiating devices can be installed in the system just prior to final electrical and/or optical hookup on the launch pad. **NOTE:** It is understood that this requirement cannot always be met. Exceptions shall be handled on a case-by-case basis where the Range User has demonstrated compliance with the intent.

1. Initiating device locations shall be accessible to facilitate installation and removal and electrical and/or optical connections as late as possible in the

launch countdown.

2. Launch complexes shall be designed to accommodate this accessibility requirement.

c. Separate power sources and/or busses are required for ordnance initiating systems.

d. RF energy shall not be used to ignite initiating devices.

e. Electrical firing circuits shall be isolated from the initiating ordnance case, electronic case, and other conducting parts of the vehicle.

1. If a circuit is grounded, there shall be only one interconnection (single ground point) with other circuits. **NOTE:** Static bleed resistors of 10 kilohms to 100 kilohms are not considered to violate the single point ground.

2. This interconnection shall be at the power source only.

3. Other ground connections with equivalent isolation shall be handled on a case-by-case basis.

f. Ungrounded circuits capable of building up static charge shall be connected to the structure by static bleed resistors of between 10 kilohms and 100 kilohms.

g. Firing circuit design shall preclude sneak circuits and unintentional electrical paths due to such faults as ground loops and failure of solid state switches.

h. Redundant circuits are required if loss of power or signal may result in injury to personnel or be a detriment to safety critical systems.

1. The elements of a redundant circuit shall not be terminated in a single connector where the loss of such connector will negate the redundant feature.

2. Redundant circuits should be separated to the maximum extent possible.

3.13.3.2 Ordnance Electrical and Optical Circuit Shielding

a. Shields shall not be used as intentional current-carrying conductors.

b. Electrical firing circuits shall be completely shielded or shielded from the initiating ordnance or LFU back to a point in the firing circuit at which filters or absorptive devices eliminate RF entry into the shielded portion of the system.

c. RF shielding shall provide a minimum of 85 percent of optical coverage ratio. (Optical coverage ratio is the percentage of the surface area of the cable core insulation covered by a shield). A solid shield rather than a mesh shield would have 100 percent coverage.

d. There shall be no gaps or discontinuities in the termination at the back faces of the connectors or

apertures in any container that houses elements of the firing circuit.

e. Electrical shields terminated at a connection shall be joined around the full 360° circumference of the shield.

f. All metallic parts of the initiating ordnance subsystem that are physically connected shall be bonded with a DC resistance of less than 2.5 milliohms.

g. Firing, control, and monitor circuits shall all be shielded from each other.

3.13.3.3 Ordnance Electrical and Optical Circuits Wiring

a. Twisted shielded pairs shall be used unless other configurations such as coaxial leads can be shown to be more effective.

b. For low voltage circuits, insulation resistance between the shield and conductor at 500 volts DC minimum shall be greater than 2 Megohms.

c. For high voltage circuits, insulation resistance between the shield and conductor at 150 percent of rated output voltage or 500 volts, whichever is greater, shall be greater than 50 Megohms.

d. Wires shall be of sufficient size to adequately handle 150 percent of the design load for continuous duty signals (100 sec or more) on the safety critical circuit.

e. Splicing of firing circuit wires or overbraid shields is prohibited.

f. The use of wire wrap to connect wire shields is prohibited.

3.13.3.4 Ordnance Electrical and Optical Connectors

a. The outer shells of electrical connectors shall be made of metal.

b. Electrical and optical connectors shall be selected to eliminate the possibility of mismating. **NOTE:** Mismating includes improper installation as well as connecting wrong connectors.

c. Electrical and optical connectors shall be of the self-locking type or lock wiring shall be used to prevent accidental or inadvertent demating.

d. The design shall ensure that the shielding connection for an electrical connector is complete before the pin connection.

e. Shields need not be carried through a connector if the connector can provide RF attenuation and electrical conductivity at least equal to that of the shield.

f. Circuit assignments and the isolation of firing pins within an electrical connector shall be so that

any single short circuit occurring as a result of a bent pin shall not result in more than 10 percent of the all-fire current. **NOTE:** Unless otherwise agreed to by Range Safety, a bent pin analysis shall be performed on all electrical connectors.

g. There shall be only one wire per pin and in no case shall an electrical connector pin be used as a terminal or tie-point for multiple connections.

h. Spare pins are allowed in electrical connectors except where a broken spare pin may have an adverse effect on a firing or control circuit.

i. Source circuits shall terminate in an electrical connector with female contacts.

j. Electrical connectors relying on spring contact shall not be used on safety critical circuits.

k. Electrical connectors shall be capable of adequately handling 150 percent of the designed electrical load continuous duty signal (100 sec or more) on safety critical circuits.

l. Optical connectors and receptacles shall be provided with self-locking protective covers or caps that shall be installed except when the connector or receptacle is in use.

m. Separate cables and connectors shall be used when redundant circuits are required.

3.13.3.5 Ordnance Electrical and Optical Circuits Switches and Relays

a. Switches and relays shall be designed to function at expected operating voltage and current ranges under worst case ground environmental conditions, including maximum expected cycle life.

b. Switches and relays used for inhibits shall not be considered adequate for RF isolation and absorption unless demonstrated by analysis and test for the specific environment of use.

3.13.3.6 Ordnance Electrical and Optical Monitoring, Checkout, and Control Circuits

a. All circuits used to arm or disarm the firing circuit shall contain means to provide remote electrical indication of their armed or safe status.

1. These inhibits shall be directly monitored.

2. GSE shall be provided to electrically monitor ARM and SAFE status of the firing circuit at all processing facilities including launch complexes up to launch.

b. Monitoring, control, and checkout circuits shall be completely independent of the firing circuits and shall use a separate and non-interchangeable electrical connector.

c. Monitoring, control, and checkout circuits shall not be routed through arm or safe plugs except when approved by Range Safety.

d. The electrical continuity of one status circuit (SAFE or ARM) shall completely break prior to the time that electrical continuity is established for the other status circuit (ARM or SAFE).

e. The safety of the ordnance system shall not be affected by the external shorting of a monitor circuit or by the application of any positive or negative voltage between 0 and 35 volts DC to a monitor circuit.

f. Monitoring and checkout current in a low voltage electroexplosive system firing line shall not exceed 1/10 the no-fire current of the EED or 50 milliamperes, whichever is less.

g. Monitor circuits shall be designed so that the application of the operational voltage will not compromise the safety of the firing circuit nor cause the ordnance system to be armed.

h. Tolerances for monitor circuit outputs shall be specified for both RF and hardline and shall be submitted to Range Safety for review and approval.

i. Maximum and minimum values for monitor circuit outputs shall be specified and submitted to Range Safety for review and approval.

j. No single point failure in monitoring, checkout, or control circuitry and equipment shall compromise the safety of the firing circuit.

k. Control circuits shall be electrically isolated from the firing circuit so that a stimulus in these circuits does not induce a stimulus greater than 20 dB of the activation level in the firing circuit.

l. The monitor circuit that applies current to the EED shall be defined to limit the open circuit output voltage to 1 volt.

3.13.4 Initiator Electrical and Optical Circuits

3.13.4.1 Electrical and Optical Low Voltage Electromechanical Circuits Design Requirements

a. All solid rocket motor ignition circuits and other high hazard ordnance systems (as determined by Range Safety) using low voltage initiators shall provide an electromechanical safe and arm (S&A) device.

b. EED ordnance systems other than solid rocket motor ignition circuits and other high hazard ordnance systems shall provide two independent circuit interrupts such as ENABLE and FIRE switches in the power side of the initiator and one safe plug that interrupts both the power and return side.

c. The safe plug shall provide interruption of the circuit after the ENABLE and FIRE switches and as close to the end item ordnance as possible.

d. The final electrical connection of an EED to the firing circuit shall be as close to the EED as possible.

e. EEDs shall be protected from electrostatic hazards by the placement of resistors from line-to-line and line-to-ground (structure). **NOTE:** The placement of line-to-structure static bleed resistances is not considered to violate the single point ground requirement as long as the parallel combination of these resistors are 10 kilohms or more.

f. The system circuitry shall be designed and/or located to limit RF power at each EED (produced by Range and/or vehicle transmitter) to a level at least 20 dB below the pin-to-pin DC no-fire power of the EED. **NOTE 1:** Electromagnetic environment evaluation shall either be by analysis or electromagnetic compatibility (EMC) testing. **NOTE 2:** Computer RF power density levels for Range facilities are available from Range Safety.

3.13.4.2 High Voltage Exploding Bridgewire Circuits

a. All solid rocket motor ignition circuits for all launch vehicles and payloads using exploding bridgewire (EBW) systems shall include a manual arming and safing plug in addition to an EBW-Firing Unit (EBW-FU).

b. An EBW-FU is required on all other EBW systems. **NOTE:** A manual arming and safing plug may also be required depending on the degree of hazard as determined by Range Safety on a case-by-case basis.

3.13.4.3 Laser Initiated Ordnance Circuits

a. The optic system design shall preclude stray energy sources such as photostrobe, magnified sunlight, arc welding, xenon strobe, lightning, static electricity, and RF from causing an undesired output. **NOTE:** This requirement shall be demonstrated during development and qualification testing.

b. Laser power sources shall have a minimum of two independent and verifiable inhibits. One of these inhibits for the main laser shall be a power interrupt plug that removes all airborne and ground power to the laser firing unit (LFU).

c. High voltage laser systems used for solid rocket motor ignition circuit shall use one of the following safety devices:

1. An LFU used in conjunction with two optical barriers capable of being armed and safed and locked and unlocked remotely. A manual safe plug capable of interrupting power to the barrier control circuits shall also be provided.

2. An optical S&A

3. An ordnance S&A

d. Low voltage laser systems such as the Diode Laser used for the solid rocket motor ignition circuit shall use one of the following safety devices:

1. An optical S&A

2. An ordnance S&A

e. Specific safety device requirements for systems other than solid rocket motor ignition circuits shall be determined on a case-by-case by Range Safety based on the degree of hazard.

f. If a low energy level end-to-end test is to be performed by the Range User when LIOS is connected to the receptor ordnance, the following requirements shall be met:

1. The energy level shall be less than 1/10,000 of the no-fire level of the LID.

2. The single failure mode maximum energy level of the test system shall be less than 1/100 of no-fire level of the LID.

3. The test source shall emit a different wave length than the main firing unit laser.

4. One of the following inhibit options shall be implemented during a low energy level test:

- (a) An ordnance S&A device and a safe plug that interrupts power to the main laser shall be provided.

- (b) Three independent verifiable inhibits shall be in place to preclude inadvertent initiation of the LID by the main firing unit laser during the low level energy test. **NOTE:** One of these inhibits shall

be a safe plug that interrupts power to the main laser.

- (c) The explosive train shall be disconnected anywhere between the LID and the receptor ordnance.

- g. If a main laser subsystem firing test is performed by the Range User when LIOS is connected to the receptor ordnance, a minimum of three independent, verifiable inhibits shall be in place.

1. Two of the inhibits shall be optical barriers capable of being independently locked in place.

2. The third inhibit shall be a safe plug that interrupts the power control circuits to the optical barriers.

- h. Lasers shall be completely enclosed during checkout or provided with GSE that can enclose the laser emission path at all times the system is powered.

3.13.5 Ordnance Safety Devices

3.13.5.1 Ordnance Safety Device General Design Requirements

a. Ordnance safety devices are electrical, electromechanical, optoelectronic, optical, or mechanical devices used in all ordnance subsystems to provide isolation between the power source to firing circuits and firing circuits to initiating devices or receptor ordnance. Examples include S&A devices, Arm/Disarm devices, relays, switches, EBW-FUs, Laser Firing Units (LFUs) and manual arming/safing plugs.

b. Electrical and electronic safety devices shall remain or transfer back to their safe state in the event of input power loss.

c. All safety devices shall be capable of being functionally tested by ground test equipment.

d. Manual safety devices on the launch vehicle and payload shall be accessible up to launch. Remotely activated safety devices shall remain operable up to launch and after launch abort. **NOTE:** It is understood that this requirement cannot always be met. Exceptions shall be handled on a case-by-case basis where the Range User has demonstrated compliance with the intent.

e. The arrangement of safety devices shall maximize safety by placing the most positive and reliable form of interruption closest to the initiating device; for example, a safe plug would be located downstream of a solid state switch.

f. Ordnance and optical mechanical barriers used for safety devices shall demonstrate a reliability of 0.999 at the 95 percent confidence level to prevent

initiation of the receptor ordnance or the laser initiated device LID for LIOS. **NOTE:** The test method shall be a Bruceton procedure or other statistical testing method acceptable to Range Safety.

g. Safety devices shall not require adjustment throughout their service life.

h. Each safety device shall be designed for a service life of at least 10 years after passing the acceptance test.

3.13.5.2 Ordnance Arming and Safing Plugs

a. Safing plugs shall be designed to be manually installed to provide electrical isolation of the input power from the EBW-FU or LFU.

b. Arming plugs shall be designed to be manually installed to provide electrical continuity from the input power to the EBW-FU or LFU.

c. The design of the arming and safing plugs and their location shall ensure easy access for plug installation and removal during assembly and check-out in all prelaunch processing facilities, including the launch complexes.

d. Arming and safing plugs shall be designed to be positively identifiable by color, shape, and name.

e. The design of arming and safing plugs and their location shall ensure easy access for plug installation and removal just prior to final launch complex clear. **NOTE:** It is understood that this requirement cannot always be met. Exceptions shall be handled on a case-by-case basis where the Range User has demonstrated compliance with the intent.

f. For low voltage systems (EED) that use a safing plug instead of an electromechanical S&A, the safing plug shall be designed to electrically isolate and short the initiator side of the firing circuit. **NOTE:** Isolation shall be a minimum of 10 kilohms.

3.13.5.3 Low Voltage EED Electromechanical S&As

a. Electromechanical S&As shall provide mechanical isolation of the EED from the explosive train and electrical isolation of the firing circuit from the EEDs.

b. When the S&A is in the SAFE position, the power and return lines of the firing circuit shall be disconnected. The bridgewire shall be shorted and grounded through a 10 kilohm to 100 kilohm resistor and the explosive train shall be interrupted by a mechanical barrier capable of containing the EED output energy without initiating the explosive.

c. Transition from the SAFE to ARM position shall require 90E of rotation of the mechanical bar-

rier for rotating S&As containing ordnance in the barrier. **NOTE:** SAFE to ARM transition tolerances for other electromechanical S&A devices require specific Range Safety approval.

d. The S&A device shall not be capable of propagating the detonation with the barrier rotated at least 50E from SAFE for a 90E rotational barrier. **NOTE:** This position shall be 50 percent of the travel distance between ARM and SAFE for sliding barriers.

e. The mechanical lock within the S&A shall prevent inadvertent transfer from the ARM to SAFE position (or vice versa) under all ground operational environments without the application of any electrical signal.

f. S&A design shall incorporate provisions to safe the ordnance train from any rotor and/or barrier position.

g. S&As shall be capable of being remotely safed and armed. They shall not be capable of being manually armed, but shall be capable of being manually safed.

h. Remote and manual safing shall be accomplished without passing through the ARM position.

i. The S&A SAFE signal shall not be indicated visually or remotely unless the device is less than 10E from the SAFE position for rotating systems or 10 percent from the SAFE position for sliding barriers.

j. No visual indication of SAFE or ARM shall appear if the device is in between the SAFE and ARM positions. **NOTE:** The S&A will be considered "not safe" or ARMED if the indicator does not show SAFE.

k. The electrical continuity of one status circuit of the S&A device (SAFE or ARM) shall completely break prior to the time that the electrical continuity is established for the other status circuit (ARM or SAFE).

l. A remote status indicator shall be provided to show the armed or safed condition.

1. The device shall also indicate its ARM or SAFE status by visual inspection.

2. There shall be easy access to this visual indication throughout ground processing.

m. S&A device locations on the vehicle shall be accessible to facilitate installation and removal and electrical and ordnance connections during final vehicle closeout.

n. A safety pin shall be used in the S&A to prevent movement from the SAFE to the ARM position when the arming signal is applied.

1. Rotation and/or transition of the mechanical barrier to align the explosive train and electrical

continuity of the firing circuit to the EEDs shall not be possible with the safety pin installed.

2. Removal of the safety pin shall not be possible if the arming circuit is energized.

3. The retention mechanism shall be capable of withstanding an applied force of at least 100 lb tension or a torque of at least 100 in. lb without failure.

4. Removal of the safety pin shall not cause the S&A to automatically arm.

5. Removal of the safety pin shall be inhibited by a locking mechanism requiring 90° rotation of the pin. **NOTE:** The removal force shall be 3 to 10 in. lb of torque.

6. When inserted, the pin shall manually safe the device.

7. The safing pin shall be accessible through final launch complex clear.

8. The force required for safing pin insertion shall be between 20 and 40 lb and/or 20 to 40 in. lb of torque.

9. The safing pin shall provide a means of attaching warning streamers.

10. When installed, each safing pin shall be marked by a red streamer.

o. All S&A devices shall be designed to withstand repeated cycling from ARM to SAFE for at least 1000 cycles, or at least five times the expected number of cycles, whichever is greater, without any malfunction, failure, or deterioration in performance.

p. A constant 1 hr application of S&A arming voltage with the safing pin installed shall not cause the explosive in the unit to function or degrade to a point that it will no longer function if such a failure could create a hazard.

q. The time required to arm or safe an S&A device shall not exceed 1 sec after application of the actuation signal.

r. The S&A shall not initiate and shall be safe to handle for subsequent disposal after being subjected to a 20-ft drop on to a steel plate.

s. The S&A shall have shielding caps attached on the firing connectors during storage, handling, transportation, and installation up to firing line connection.

t. The shielding cap shall have a solid metal outer shell that makes electrical contact with the firing circuit case in the same manner as the mating connector.

3.13.5.4 Mechanical S&As

a. Electrically actuated S&As shall be used unless justification for mechanical S&As is provided to

and approved by Range Safety.

b. Range Safety approved mechanical S&As shall incorporate the same features as electrically actuated devices except that arming and safing is performed mechanically. **NOTE:** Normally, these devices are armed by a liftoff lanyard or by stage separation.

c. These S&As shall be designed to withstand repeated cycling from the ARM to the SAFE position for at least 300 cycles without malfunction, failure, or deterioration in performance.

3.13.5.5 EBW Firing Units

a. The EBW-FU shall provide circuits for capacitor charging, bleeding, charge interruption, and triggering.

b. The charged capacitor circuit shall have a dual bleed system with either system capable of independently bleeding off the stored capacitor charge.

c. EBW-FU design shall provide a positive remotely controlled means of interrupting the capacitor charging circuit.

d. A gap tube shall be provided that interrupts the EBW trigger circuit.

e. EBW-FUs shall be designed to be discriminatory to spurious signals in accordance with MIL-STD-461.

f. At a minimum, EBW-FU monitor circuits shall provide the status of the trigger capacitor, high voltage capacitor, arm input, inhibit input (if used), and power.

g. The insulation resistance between each EBW-FU high voltage output circuit and the case shall be designed to be not less than 50 Megohms at 500 Vdc.

h. The isolation resistance between EBW-FU output circuits and any other circuits shall be not less than 50 megohms.

i. Remote discharged indicators for EBW-FUs shall not appear unless the capacitor bank voltage is one-half or less of the no-fire voltage of the EBW. The EBW-FU shall be considered not safe if the indicator does not show DISCHARGED.

j. The EBW-FU shall be capable of being remotely safed and armed.

3.13.5.6 Laser Firing Units, Optical Barriers, Optical S&As, and Ordnance S&As

a. The following laser firing unit, optical barrier, optical S&A, and ordnance S&A design requirements shall be applied according to the device used.

b. The conceptual configuration of the devices to be used and their planned prelaunch testing shall be coordinated with Range Safety as early as possible to ensure the configuration is acceptable.

3.13.5.6.1 Laser Firing Units.

a. LFU General Design Requirements.

1. LFUs shall provide a positive, remotely controlled means of interrupting the power to the firing circuit.

2. Capacitor charging circuits shall have a dual bleed system with each system capable of independently bleeding off the stored charge.

3. A gap tube shall be provided that interrupts the trigger circuit in a high voltage LFU.

4. LFUs shall be designed to be discriminatory to spurious signals in accordance with MIL-STD-461.

5. Low voltage LFUs shall provide a continuous spurious energy monitor and/or detection circuit on the input firing line capable of indicating when 1/10 of the minimum input firing voltage or current firing is exceeded.

b. LFU Monitor Circuits.

1. At a minimum, LFU monitor circuits shall provide the status of the trigger capacitor, high voltage capacitor, arm input, barrier position, barrier locked/unlocked, inhibit input, and power as applicable.

2. The electrical continuity of one status circuit shall completely break prior to the time that the electrical continuity is established for the other status circuit.

c. **LFU CHARGED and DISCHARGED Indicators.** A remote DISCHARGED indicator for LFUs that use a capacitor bank shall not appear unless the capacitor bank voltage is 50 percent or less of the no-fire voltage of the LID. **NOTE:** The LFU shall be considered "not safe" if the indicator does not show DISCHARGED.

3.13.5.6.2 Optical Barriers.

a. Optical Barrier General Design Requirements.

1. The SAFE position of the optical barrier shall be capable of absorbing or redirecting the

complete optical energy source to a safe receiver.

(a) The barrier shall be capable of absorbing and/or redirecting 100 times the maximum energy that the laser can generate.

(b) Depending on barrier design, the safety factor shall be calculated using several possible variables such as distance from nominal beam spot to the edge of the barrier or the edge of the aperture, distance and/or degrees between ARM and SAFE, laser energy deflected, and mechanical tolerances.

2. The optical barrier shall maintain the safety margin and function nominally after being pulsed by the main laser a minimum of four times the expected lifetime number of pulses or 10 pulses, whichever is greater, at the maximum firing rate and power of the laser.

3. The control of barriers, mechanical locks, and monitors shall be independent of the firing circuit.

4. A constant 5-min application of arming voltage with the mechanical lock of the barriers engaged shall not cause the optical train to go to the ARM position.

5. All optical barriers shall be designed to withstand repeated cycling from the ARM to the SAFE positions for at least 1,000 cycles without any malfunction, failure, or deterioration in performance. **NOTE:** If the device is to be used for a program with a known operating life cycle, Range Safety may accept a design cycle life of at least five times the expected number of cycles.

b. Optical Barrier Status Indicators.

1. A remote status indicator for the optical barriers located in LFU or optical S&A shall be provided.

2. A visual status indicator of optical barrier status shall also be provided on the device or at a nearby location so that it is easily seen by operating personnel.

(a) If a visual status indicator is provided on the barrier, it shall be readily accessible to personnel on the complex and/or facility.

(b) The design solution for a visual indicator shall not result in an external light source path for hazardous light energy to enter the LIOS system.

(c) If a visual status indicator on the LFU or S&A device is not provided, redundant electronic remote status indicators shall be provided at the launch pad and launch control center to show the armed or safe status of the LFU or S&A barriers.

3. The SAFE signal shall only be indicated when the optical barriers are in a position that will

not align the optical train and not allow initiation of the LID with a reliability of 0.999 at the 95 percent confidence level.

4. Bruceton-type testing or other statistical methods acceptable to Range Safety shall be performed to establish reliability.

5. The optical barrier will be considered "not safe" or armed if the indicator does not show SAFE.

3.13.5.6.3 Optical S&As.

a. When an optical S&A device is in the laser SAFE position, the following criteria shall be met:

1. The optical transfer assembly shall be interrupted by a minimum of two mechanical barriers that can be mechanically locked in place.

2. The main laser power circuit shall be electrically disconnected. **NOTE:** This main laser power interrupt capability is not required if the power circuit to the mechanical barriers is interrupted by an arm and/or safe plug.

3. Optical S&As shall be capable of being remotely safed and armed.

4. Optical S&As shall not be capable of being manually armed but they shall be capable of being manually safed.

5. Remote and manual safing shall be accomplished without passing through the armed position.

b. Optical S&A barriers shall meet the requirements of the **Optical Barriers** section of this Chapter.

c. The electrical continuity of one status circuit shall completely break prior to the time that the electrical continuity is established for the other status circuit.

d. The S&A shall provide status of the optical barriers (ARM, SAFE), barriers locked/ unlocked, and electrical inhibits.

e. The insulation resistance between each S&A circuit and the case shall not be less than 2 megohms at 500 Vdc.

f. All S&A devices shall be designed to withstand repeated cycling from ARM to SAFE for at least 1000 cycles or at least five times the expected number of cycles, whichever is greater, without any malfunction, failure, or deterioration in performance.

g. A constant 5 min application of S&A arming voltage shall not cause malfunction, failure, or deterioration in performance.

h. The time required to ARM or SAFE an S&A device shall not exceed 1 sec after application of the actuation signal.

3.13.5.6.4 Ordnance S&As.

a. *Ordnance S&A General Design Requirements.*

1. Ordnance S&As shall provide mechanical isolation of the explosive train.

2. When the device is in the SAFE position, the explosive train shall be interrupted by a mechanical barrier capable of containing the explosive.

3. SAFE to ARM Transition

(a) Transition from the SAFE to ARM position shall require 90° of rotation of the mechanical barrier for rotating S&As containing ordnance in the barrier.

(b) SAFE to ARM transition tolerances for other electromechanical S&A devices shall be approved by Range Safety.

4. Detonation Propagation

(a) The device shall not be capable of propagating the detonation with the barrier rotated less than 50° from SAFE for a 90° rotational barrier.

(b) The device shall not be capable of propagating the detonation with the barrier at 50 percent of the travel distance between ARM and SAFE for sliding barriers.

5. Ordnance S&A device locations on the vehicle shall be accessible to facilitate installation and/or removal of ordnance connections during final vehicle closeout.

6. The S&A shall not initiate and shall be safe to handle for subsequent disposal after being subjected to a 20-ft drop on to a steel plate.

b. *Ordnance S&A ARM and SAFE Mechanisms*

1. The S&A device shall be designed to incorporate provisions to safe the ordnance train from any rotor or barrier position.

2. The time required to ARM or SAFE an S&A device shall not exceed 1 sec after application of the actuation signal.

3. All S&A devices shall be designed to withstand repeated cycling from ARM to SAFE for at least 1,000 cycles or at least five times the expected number of cycles, whichever is greater, without any malfunction, failure, or deterioration in performance.

4. A mechanical lock in the S&A shall prevent inadvertent transfer from the ARM to SAFE position or the SAFE to ARM position under all operating environments without the application of any electrical signal.

5. S&As shall be capable of being remotely safed and armed.

6. Ordnance S&As shall not be capable of

being manually armed but they shall be capable of being manually safed.

7. Remote and manual safing shall be accomplished without passing through the armed position.

c. Ordnance S&A Status Indicators

1. The electrical continuity of one status circuit of the S&A device (SAFE or ARM) shall completely break prior to the time that the electrical continuity is established for the other status circuit (ARM or SAFE).

2. Ordnance S&A Remote and Visual Status Indicators:

(a) A remote status indicator shall be provided to show the armed or safed condition.

(b) A visual status indicator shall be provided to show the armed or safed condition by simple visual inspection.

(c) Easy access to the visual status indicator shall be provided throughout ground processing.

3. The S&A SAFE signal shall not be indicated visually or remotely unless the device is less than 10° from the SAFE position for rotating systems or 10 percent from the SAFE position for sliding barriers.

4. No visual indication of SAFE or ARM shall appear if the device is in between SAFE and ARM positions. **NOTE:** The S&A will be considered "not safe" or armed if the indicator does not show SAFE.

d. Ordnance S&A Safing Pins

1. A safing pin shall be used in the S&A device to prevent movement from the SAFE to the ARM position when an arming signal is applied.

2. Rotation and/or transition of the mechanical barrier to the aligned explosive train shall not be possible with the safing pin installed.

3. When inserted and rotated, the safing pin shall manually safe the device.

4. The safing pin shall be accessible through final launch complex clear.

5. Removal of the safing pin shall not be possible if the arming circuit is energized.

6. The retention mechanism of the safing mechanism shall be capable of withstanding an applied force of at least 100 lb tension or a torque of at least 100 in. lb without failure.

7. Removal of the safing pin shall not cause the device to automatically arm.

8. Removal of the safing pin shall be inhibited by a locking mechanism requiring 90° rotation of the pin. The removal force shall be 3 to 10 in. lb of torque.

9. The force required for safing pin insertion shall be between 20 and 40 lb and/or 20 to 40 in. lb of torque.

10. A constant 1 h application of S&A arming voltage, with the safing pin installed, shall not cause the explosive in the unit to function.

3.13.6 Ordnance Initiating Devices

3.13.6.1 Ordnance Initiating Device General Design Requirements

a. The explosive or pyrotechnic mix shall not degrade, decompose, or change chemically over its life causing a more sensitive device.

b. Periodic testing of ordnance to verify that no sensitivity changes have occurred shall be in accordance with DoD-E-83578, unless it can be shown that sensitivity with aging is not a credible concern with the specific explosive composition.

c. Ordnance should be designed for a service life of at least 10 years, with a design goal of 15 years.

d. The decomposition, cook-off, and melting temperatures of all explosives shall be at least 30°C higher than the maximum predicted environmental temperature to which the material will be exposed during storage, handling, transportation, and launch.

3.13.6.2 Low Voltage EEDs

a. One amp/one watt no-fire survivability of low voltage EEDs is required, as determined from the 0.1 percent firing level of the EED with 95 percent confidence using the Bruceton test or other statistical testing methods acceptable to Range Safety.

b. EEDs shall be designed to withstand a constant direct current firing pulse of 1 ampere and 1 watt power for a period of 5 min duration without initiation or deterioration of performance.

c. The EED main body shall not rupture or fragment when the device is fired. **NOTE:** Displacement or deformation of the connector and main housing is permissible; rupture or deformation of the outer end is permissible.

d. The autoignition temperature shall not be less than 150°C.

e. Carbon bridgewires and conductive mixes without bridgewires are prohibited.

f. EEDs shall not fire or deteriorate in performance (if failure can create a hazard) as a result of being subjected to an electrostatic discharge of 25 kV from a 500 picofarad capacitor applied in the pin-to-case mode without a series resistor, and in the pin-to-pin mode with a 5 kilohms resistor in

series.

g. The EED shall not initiate and will perform to specification (if failure can create a hazard) after being subjected to a 6-ft drop on to a steel plate.

h. The EED shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop on to a steel plate.

i. Insulation resistance between pin-to-case shall not be less than 2 megohms at 500 Vdc.

j. The outer case of the EED main body shall be made of conductive material, preferably metal.

k. RF survivability shall meet the testing criteria described in MIL-STD-1576.

l. Shielding caps shall be provided and placed on the EED during shipment, storage, handling, and installation up to the point of electrical connection.

1. The shielding cap shall have an outer shell made of conductive material that provides an RF shield and makes electrical contact with the EED case.

2. There shall be no RF gaps around the full 360° mating surface between the shielding cap and EED case.

3. The shielding cap shall be designed to accommodate the torquing tool during installation.

4. Shorting plugs (caps) shall not be used as a substitute for shielding caps.

3.13.6.3 High Voltage Exploding Bridgewires

a. Explosive materials shall be a secondary explosive such as Pentaerythritoltetranitrate (PETN) or Cyclotrimethylenetrinitramine (RDX).

b. Insulation resistance pin-to-case shall be designed to be not less than 50 megohms at 500 Vdc.

c. A voltage blocking gap shall be provided.

1. The gap breakdown voltage shall not be less than 650 Vdc when discharged from a 0.025 \pm 10 percent microfarad capacitor.

2. The nominal gap breakdown voltage tolerance shall be specified and approved by Range Safety.

d. The EBW shall not fire or deteriorate in performance (if failure can create a hazard) upon being subjected to a voltage of 125 to 130 Volts root mean square (Vrms) at 60 Hz applied across the terminals or between the terminals and the EBW body for 5 min \pm 10 sec.

e. The EBW shall not fire or degrade to the extent that it is unsafe to handle when 230 \pm 10 Vrms at 60 Hz is applied across the terminals or between the terminals and EBW body for 5 min \pm 10 sec.

f. The EBW shall not fire or deteriorate in performance (if failure can create a hazard) upon being

subjected to a source of 500 \pm 25 Vdc having an output capacitance of 1.0 \pm 10 percent microfarads applied across the terminals or between the terminals and the EBW body for 60 to 90 sec.

g. The EBW shall not fire or deteriorate in performance (if failure can create a hazard) after exposure to that level of power equivalent to absorption by the test item of 1.0 watt average power at any frequency within each RF energy range, as specified in Table 3-4. The frequency shall be applied across the input terminals of the EBW detonator for 5.0 to 6.0 sec.

**Table 3-4
RF SENSITIVITY**

Frequency (in Mhz)	Type
5 - 100	Continuous Wave
250 - 300	Continuous Wave
400 - 500	Continuous Wave
800 - 1000	Continuous Wave
2000 - 2400	Continuous Wave
2900 - 3100	Continuous Wave
5000 - 6000	Continuous Wave
9800 - 10000	Continuous Wave
16000 - 23000	Pulse Wave ^a
32000 - 40000	Pulse Wave ^a

^a Pulsed repetition frequency shall be not less than 100 Hz and the pulse width shall be a minimum of 1.0 micro-sec.

h. The EBW shall not fire or deteriorate in performance (if failure can create a hazard) as a result of being subjected to an electrostatic discharge of 25 kV from a 500 picofarad capacitor applied in the pin-to-case mode without a series resistor and in the pin-to-pin mode with a 5 kilohm resistor in series.

i. The autoignition temperature of the EBW shall not be less than 150°C.

j. The EBW shall not initiate and shall perform to specification (if failure can create a hazard) after being subjected to a 6-ft drop on to a steel plate.

k. The EBW shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop on to a steel plate.

3.13.6.4 Laser Initiated Devices

a. Laser initiated devices (LIDs) shall have specific energy density, spot size, pulse width, and wave length characteristics with a specified tolerance level for each characteristic.

b. LIDs shall not use primary explosives.

1. If modified secondary (composition) explosives are used, their sensitivity characteristics shall be established by test in accordance with MIL-STD-

1751, ADA 086259, or the equivalent.

2. The test requirements and test report shall be reviewed and approved by Range Safety.

c. Flight configuration LIDs shall be tested to determine their susceptibility to all stray energy sources such as strobe, sunlight, arc welder, flash-lamps, lightning, RF, AC, and DC electrical energy present during prelaunch processing up to the launch environment. **NOTE:** This susceptibility applies to both inadvertent firing and dudding if dudding can create a hazard.

1. At a minimum, the sensitivity characteristics to these energy sources will be established by functioning a minimum of 45 LIDs per the Bruceton test or other statistical testing method acceptable to Range Safety in terms of spot size, pulse width, energy density, and wave length.

2. A correlation between the above test and the no-fire level established for the LID shall be provided to Range Safety for review and approval. At a minimum, the LID no-fire energy shall be 10^4 greater than any credible stray energy source.

3. If the above LID sensitivity requirements are not met, the explosive train (LID to explosive transfer assembly [ETA] or ETA to receptor ordnance interface) shall remain disconnected until just prior to final pad evacuation for launch, or an ordnance S&A device shall be provided between the LID and the ETA.

d. No-fire level survivability is required as determined from the 0.1 percent firing level of the LID with 95 percent confidence using the Bruceton test or other statistical methods acceptable to Range Safety.

1. The test shall take into account the effects of the temperature of the explosive as well as effects caused by manufacturing variations in explosive grain size and pressure.

2. The no-fire level shall be applied for a minimum of 5 min without firing or dudding the LID if dudding can create a hazard.

e. The minimum all-fire level shall be at least 10 times the no-fire level.

f. LIDs shall not be exposed to energy density levels greater than 1/10,000 the no-fire level of the ordnance initiator during prelaunch processing, shipment, storage, handling, installation, and testing. **NOTE:** This energy constraint is to be applied at the end of the fiber optic cable just prior to the cable entering the laser ordnance initiator reflective coating.

g. LIDs shall dissipate heat faster than single failure conditions can input into the device without ini-

tiating or dudding (if dudding can create a hazard).

NOTE 1: An analysis shall be provided to demonstrate compliance with this requirement. **NOTE 2:** This does not include full laser firing energy output.

h. Optical shielding and protective caps shall be provided for LIDs during prelaunch processing, including shipment, storage, handling, installation, and testing.

1. Shielding and protective cap devices shall prevent exposure of the LID to energy density levels greater than 1/10,000 of the no-fire level of the LID.

2. Reflective coatings of the LID shall not be considered part of the shield.

i. The shielding cap shall be designed to accommodate the tool used during installation without the removal of the cap.

j. Autoignition temperature of the LID shall not be less than 150°C.

k. LIDs shall not initiate and shall perform to specification (if failure can create a hazard) after being subjected to a 6-ft drop test on to a steel plate.

l. The LID shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop test on to a steel plate.

m. LIDs shall not fire or deteriorate in performance (if failure can create a hazard) as result of being subjected to an electrostatic discharge of 25 kV from a 500 picofarad capacitor. **NOTE:** The test configuration shall be approved by Range Safety.

3.13.6.5 Percussion Activated Devices

a. Stab initiation of percussion activated devices (PADs) is prohibited.

b. Each initiator shall have a positive safety interrupter feature that can be mechanically locked in place.

c. The initiator and its interrupter shall be designed to withstand all transportation, handling, and installation environments.

d. The interrupter safety lock shall be designed to remain in place during and after installation.

e. The interrupter safety lock shall be designed to be removed after installation.

f. The design shall ensure the PAD cannot be assembled without the interrupter.

g. Percussion initiators shall be designed so that the operating energy is at least twice the all-fire energy.

h. Percussion initiator no-fire energy shall be such that the percussion initiator shall not fire when subjected to an energy of 50 percent of the

all-fire energy.

3.13.6.6 Non-Explosive Initiators

Non-explosive initiators (NEIs) shall be handled on a case-by-case basis to ensure safety of the system design and shall be classified as either Category A or B.

3.13.7 Receptor Ordnance

Explosive transfer systems (ETS) are used to transmit the initiation reaction from the initiator to the receptor ordnance. Most ETS harnesses contain flexible confined detonation cord (FCDC), mild detonating cord (MDC), or mild detonating fuse (MDF) terminated by end booster caps or manifolds. ETSs shall be designed to meet the applicable safety sections of DoD-E-83578 and this section.

a. The explosive or pyrotechnic mix shall not degrade, decompose, or change chemically over its life causing a more sensitive device.

b. Periodic testing of ordnance to verify no sensitivity changes shall be in accordance with DoD-E-83578 unless it can be shown that the sensitivity with aging is not a credible concern with the specific explosive composition.

c. Explosives used in ETS lines shall be secondary explosives.

d. FCDC shall not fragment or separate from end fittings upon initiation. **NOTE:** Gaseous emission is permissible.

e. The ETS shall not detonate and shall be capable of performing its function (if failure can create a hazard) after being subjected to a 6-ft drop on to a steel plate.

f. The ETS shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop on to a steel plate.

g. All ETS interconnections shall provide for safety (lock) wiring or a Range Safety approved equivalent.

h. An electrically conductive path shall exist between ETS components and their attachment fittings. The bonding resistance should be designed to be 2.5 milliohms but in no case shall the resistance exceed 5 ohms.

i. ETS fittings shall be designed and located to facilitate installation of the end receptor ordnance components in the launch vehicle as late as practical.

j. Fittings that should not be reversed or interchanged (because they may cause a hazard) shall be designed so that reverse installation or interchange is not possible.

k. Exposed end fittings shall be equipped with protective caps.

l. Receptor ordnance shall be designed to meet the applicable safety sections of DoD-E-83578 and this section and shall use secondary high explosives such as PETN, RDX, Cyclotetramethylenetetranitramine (HMX), or 2,2,4,4,6,6 Hexanitrostilbene (HNS).

1. Explosives shall be non-hygroscopic.

2. Specific approval from Range Safety is required for all explosive compositions.

m. The receptor ordnance shall not detonate after being subjected to a 6-ft drop test on to a steel plate.

n. The receptor ordnance shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate.

3.13.8 Ordnance Test Equipment

3.13.8.1 Ordnance Test Equipment General Design Requirements

a. All test equipment shall be designed to meet standard industry safety requirements such as those established by ANSI, OSHA, and NFPA.

b. All ordnance test equipment such as continuity and bridgewire resistance measurement devices shall be inspected and tested for voltage and optical isolation and limitation. **NOTE:** These tests can be accomplished at the Range Calibration Laboratory.

1. These devices shall be designed so that they will not pass greater than 1/10 of the no-fire energy across an EED bridgewire.

2. These devices shall be analyzed to verify that rough handling, dropping, or single component failure will not result in negating the current-limiting feature.

3. Clear cases of unacceptable energy or current for a particular resistance range or ranges shall be excluded from use by disablement by the manufacturer or local authority before certification.

4. Certification of each device shall include a tabular listing (to be kept with or marked on each meter) of the energy level and current levels available at each of the selectable ranges for the meter.

c. The test results shall be submitted to Range Safety for approval prior to equipment use on the Ranges.

3.13.8.2 Stray Current Monitors

a. A stray current monitor shall be provided for all low voltage (EED) solid rocket motor ignition circuits and other high hazard ordnance systems as determined by Range Safety.

b. The stray current monitor shall be installed and remain connected until the electrical connection of the actual initiators is accomplished. **NOTE:** The monitor will be installed at a time during vehicle processing mutually agreeable to Range Safety and the Range User.

c. The stray current monitor shall provide a stray current device such as a fuse or automatic recording system capable of detecting 1/10 of the maximum safe no-fire current.

d. The monitoring device shall be installed in the firing line.

3.13.8.3 Ground Support Test Equipment

The design of test equipment used to test ground support equipment shall be reviewed and approved by Range Safety.

3.13.8.4 Laser Test Equipment

a. All laser test equipment that has the capability to directly or indirectly fire the LID shall be assessed and approved by Range Safety.

b. Laser test equipment shall meet the following design criteria:

1. The energy level shall be less than 1/10,000 of the no-fire level of the LID.

2. The single failure mode energy level of the test equipment shall be less than 1/100 of the no-fire level of the LID.

3. The test source shall emit a different wave length from that of the firing unit laser.

3.13.9 Ordnance Data Requirements

The following ordnance data requirements shall be incorporated in the MSPSP: (See Appendix 3A for guidance.)

3.13.9.1 Ordnance General Design Data

a. Data to verify compliance with the design and test requirements of the **Ordnance Systems** section of this Chapter shall be submitted to Range Safety for review and approval prior to the arrival of ordnance at the Ranges.

b. All schematics and functional diagrams shall have well defined, standard Institute of Electrical and Electronics Engineers (IEEE) or military specification terminology and symbols.

3.13.9.2 Ordnance Hazard Classifications and Categories

a. DoD/UN hazard classifications (class, division, and compatibility group) in accordance with DoD 6055.9-STD.

b. DOT classification

c. The Range Safety ordnance device and system hazard category for each ordnance item and system.

d. Test results and/or analysis used to classify the ordnance devices and systems as Category A or B

3.13.9.3 Ordnance System Design Data

a. A block diagram of the entire ordnance system

b. A complete line schematic of the entire ordnance system from the power source to the receptor ordnance, including telemetry pick-off points and ground (umbilical) interfaces

c. Diagrams showing the location of all ordnance components on the vehicle

d. A description of wiring, ETS, and Fiber Optic Cable (FOC) routing

e. A description of electrical, ETS, and optical connections and connectors

f. Detailed, complete schematics of the entire ordnance system showing component values such as resistance and capacitance, tolerances, shields, grounds, connectors, and pin outs. **NOTE 1:** The schematics shall include all other vehicle components and elements that interface or share common usage with the ordnance system. **NOTE 2:** All pin assignments shall be accounted for.

g. Detailed narrative description of the operation of the ordnance system, including all possible scenarios

h. FMECA for each ordnance system

i. A summary list of all noncompliances, both meets intent and waiver

j. An operational flow of the ordnance system processing and checkout, including time lines and summaries of each procedure to be used

k. A sketch showing the accessibility of manual arming and safing devices

l. Specification drawings and documents for all airborne and ground ordnance systems

3.13.9.4 Ordnance Component Design Data

a. A complete and detailed description of each ordnance system component and how it functions

b. Specification drawings and documents for all airborne and ground ordnance components

c. Illustrated breakdown of all mechanically operated ordnance components

d. Part number, manufacturer, and net explosive weight for each ordnance item

e. Temperature and humidity requirements for each ordnance item

f. Bridgewire resistance, maximum safe-no-fire current, and minimum all-fire current for each low voltage EED

g. Maximum no-fire voltage and minimum all-fire voltage for each EBW

a. Maximum no-fire energy and minimum all-fire energy for each LID and PAD

b. 8 x 10 inch color photographs of all ordnance items. The photographs should be of sufficient detail to identify individual ordnance items as well as to show the ordnance items in installed configuration on the vehicle. **NOTE:** These photographs are intended to ensure the safety of EOD personnel who may be directed to render the ordnance safe.

3.13.9.5 Ordnance Ground Systems Design Data

a. A complete description of the ground test equipment that will be used in the checkout of ordnance devices and systems, including general specifications and schematics for all test equipment

b. Specifications, schematics, and a complete functional description of the low voltage stray current monitor

c. Schematics of all ordnance system monitor circuits from the ordnance component pick-off points to the OSC termination

d. Calibration data for all monitor circuit terminations that will be provided to the OSC

e. A complete and detailed description of the airborne and ground ordnance telemetry system and how it functions, including general specifications and schematics

f. The following information is required for ordnance continuity and bridgewire resistance measurement devices:

1. Maximum safe no-fire energy of the ordnance being tested

2. A declaration of any certification currently in effect for the instrument along with the manufacturer's specifications including:

- (a) Range
- (b) Accuracy
- (c) Power supply and recharge capability
- (d) Self-test features
- (e) Schematics

3. Failure analysis including the outcome of the energy analysis (open circuit or maximum terminal voltage) and current limit analysis (short circuit or maximum output current)

4. Instrument description including any modifications required for operational use and details of safety design features such as interlocks

5. Description of intended operations

3.14 ELECTRICAL AND ELECTRONIC EQUIPMENT

3.14.1 Electrical and Electronic Ground Support Equipment and Flight Hardware General Design Requirements

3.14.1.1 Electrical and Electronic Ground Support Equipment and Flight Hardware Power Cut Off

All electrical and electronic ground support equipment (EGSE) and flight hardware shall have a means to cut off power prior to installing, replacing, or interchanging units, assemblies, or portions thereof.

3.14.1.2 EGSE and Flight Hardware Power Transient

Safety critical systems shall be protected against power transients from facility power.

3.14.1.3 EGSE and Flight Hardware Connectors

a. If a hazardous condition can be created by mismatching or reverse polarity, connectors shall have alignment pins, keyway arrangements, or other means to make it impossible to incorrectly mate. **NOTE:** Mismatching includes improper installation as well as connecting wrong connectors.

b. Color coding may be used in addition to, but not in lieu of, the more positive means of mismatch prevention.

c. If a hazardous event can occur, the following precautions shall be taken:

1. Power and signal leads shall not be terminated on adjacent pins of a connector.

2. Wiring shall be isolated so that a single short circuit occurring in a connector cannot affect other components.

3. Pin locations shall be assigned to prevent inadvertent pin-to-pin and pin-to-case shorts.

4. Spare pins should not be used in connectors controlling hazardous operations or safety critical functions.

d. Connectors used in safety critical or hazardous systems shall be of the locking type.

e. Connectors relying on spring contact shall not be used in safety critical or hazardous systems.

f. Where possible, plug and socket type connectors shall be used in safety critical or hazardous systems.

g. A bent pin analysis shall be performed on all

safety critical or hazardous system connectors that cannot be verified as a good mate after final connection.

3.14.1.4 EGSE and Flight Hardware Grounding, Bonding, and Shielding

a. Equipment shall be designed and constructed to ensure that all external parts, shields and surfaces, exclusive of radiating antennas and transmission line terminals, are at ground potential.

b. Shields shall not be used as current carrying ground connections, except for coaxial cables.

c. Circuits that operate safety critical or hazardous functions shall be protected from the electromagnetic environment to preclude inadvertent operation.

3.14.1.5 EGSE and Flight Hardware Cables

a. Cables shall be supported and protected against abrasion or crimping.

b. Cables shall be located or protected so as not to present a tripping hazard.

c. Cables in hazardous areas shall be designed so that they do not, in and of themselves, create a hazard.

d. Cables shall be selected according to the following criteria:

1. Toxicity
2. Combustibility and smoke production
3. Offgassing
4. Compatibility with liquids in the area
5. Environmental exposure

3.14.1.6 EGSE and Flight Hardware Batteries

3.14.1.6.1 EGSE and Flight Hardware Battery General Design Requirements.

a. All batteries shall be capable of being easily electrically disconnected and/or removed.

b. Battery connectors shall be designed to prevent reverse polarity.

c. Diodes shall be used to prevent reverse current. **NOTE:** Diodes may be placed in the battery or in external circuitry.

d. If a battery is not connected to the system, the battery terminals or connector plug shall be taped, guarded, or otherwise given positive protection against shorting.

e. Identification. Each battery shall be permanently identified with the following information:

1. Component name
2. Type of construction
3. Manufacturer identification
4. Part number

5. Lot and serial number

6. Date of manufacture

3.14.1.6.2 EGSE and Flight Hardware Lithium Batteries. The following requirements are applicable to lithium batteries used in flight hardware and EGSE:

a. All lithium battery designs shall be reviewed and approved by Range Safety prior to arrival, usage, packing, storage, transportation, or disposal on the Ranges. **NOTE:** Batteries that have an Underwriter's Laboratory (UL) listing and are intended for public use are exempt from these requirements.

b. The following safety devices shall be incorporated into the lithium battery design:

1. Thermistors or fuses shall be used for each battery output.

2. Internal diodes shall be placed between each cell, unless proven by test that any single cell cannot be driven into reversal by the remaining cells.

3. Cells in series shall have shunt diode protection.

4. Parallel rows of cells shall have blocking diodes.

c. Each electrical safety device shall have a specific quality control program approved by Range Safety.

d. Safety critical steps and processes shall be identified during development for the manufacturing process. **NOTE:** These points in manufacturing shall be reviewed by Range Safety and a determination made of what points require Range Safety approval prior to change and what points the Range User can approve with just notification to Range Safety after the fact.

e. Batteries shall be designed not to create a catastrophic hazard when the safety tests described in the **Ordinance Systems** section of this Chapter are performed.

3.14.2 EGSE Design Requirements

3.14.2.1 EGSE Design Standards

The following requirements supplement the requirements specified in the **Electrical and Electronic Ground Support Equipment and Flight Hardware General Design Requirements** of this Chapter, NFPA 70, and MIL-HDBK-454, Requirement 1.

3.14.2.2 EGSE Switches and Controls

a. A clearly labeled main power switch and power indicator light located on ground support equipment

shall cut off power to all circuits in the equipment. A power indicator light shall be provided. If fault isolation switches are incorporated, they shall not operate independently of the main power switch.

b. Power switches shall be located so that accidental contact by personnel will not place equipment in operation.

c. All switches and controls shall be clearly marked.

d. Switches and controls shall be sufficiently separated and protected if they could be inadvertently mistaken and actuated, creating a hazardous condition.

e. Critical switches that can produce or induce hazardous conditions, if inadvertently activated, shall have a protective cover over them.

3.14.2.3 EGSE Circuit Protection

a. Fuses, circuits breakers, and other protective devices are required for EGSE primary circuits.

b. Protective devices shall be connected to the load side of the main power switch unless neutral power sensing is essential for proper protection of the equipment.

c. Protection shall be provided in each of the three ungrounded conductors of all 3-phase EGSE motors so that failure of one conductor shall result in de-energizing all three conductors.

d. All fuses, circuit breakers, resets, or other safety devices shall be located for easy access.

e. Circuit breaker trips shall be detectable by visual inspection.

f. Replaceable components and test points shall be easily accessible.

g. Electrical fuse and switch boxes shall be marked on the outside or inside cover to show the voltage present, rated fuse capacity, and EGSE that the circuit controls.

h. Each redundant EGSE circuit shall have its own circuit breaker or fuse.

i. Each circuit shall not have the capability to inhibit by loss of control more than one safety critical control device.

j. Megohm meter (megger high voltage resistance meters) shall be current limited by the use of fuses or equivalent devices depending on application.

3.14.2.4 EGSE Cables

EGSE cables shall not share the same trench as propellant lines.

3.14.2.5 EGSE Batteries

a. Sufficient ventilation shall be provided for EGSE batteries to ensure concentrations of vapor do not reach 25 percent of the LEL.

b. Polarity of EGSE battery terminals shall be marked.

3.14.2.6 EGSE Battery Charging Equipment

a. Battery charging EGSE shall be current limited by design.

b. The battery charging rate shall not be able to initiate or sustain a run-away failure of the battery.

c. A temperature monitoring system shall be used in addition to other methods of charge control.

d. Analysis or testing shall be conducted to demonstrate compliance with the above requirement.

3.14.2.7 Fixed and Portable EGSE in Hazardous Locations

a. At a minimum, electrical equipment and its installation shall comply with the requirements of the most recent edition of the NFPA 70 or the regulations of OSHA, whichever are more restrictive.

b. Any electrical equipment that is not specifically labeled for the purpose or conditions of operation intended by a recognized testing agency, or that is not manufactured or installed to meet the electrical classification of the area in which the equipment is to be operated shall be approved by Range Safety prior to putting the equipment in service.

3.14.2.7.1 Definition of Hazardous (Classified) Locations. Hazardous (classified) locations are defined in Article 500 of the NEC; however, some explosives and propellants are not covered. For Range installations, the following paragraphs define the minimum requirements to be applied in the definition of locations in which explosives, pyrotechnics, or propellants are or are expected to be present. These requirements shall be followed unless less stringent classifications are justified and approved as part of the design data submittal process. Range Safety and the Fire Marshal shall approve all potential critical facility hazardous location designations. (See Appendix 3C for hazardous area classifications.)

***a.* Class 1, Division 1**

1. Locations in which flammable liquids, vapors, or gases may be present in air during normal operations

2. Locations in which ignitable concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage

3. Locations in which the breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases or vapors and might also cause simultaneous failure of electrical equipment

4. As a baseline, these include the following locations:

(a) Within 25 ft of any vent opening unless the discharge is normally incinerated or scrubbed to non-flammable conditions (less than 25 percent of LEL). This distance may be increased if the vent flow rate creates a flammability concern at a distance greater than 25 ft.

(b) Below grade locations in a Class 1, Division 2 area.

b. Class 1, Division 2

1. Locations in which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined in closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or system or in case of abnormal operation of equipment

2. Locations in which ignitable concentrations of gases or vapors are normally prevented by positive mechanical ventilation and which might become hazardous through failure of abnormal operations of ventilation equipment

3. Locations adjacent to a Class 1, Division 1 location and to which ignitable concentrations of gases or vapors might occasionally be communicated unless communication is prevented by adequate positive pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided. **NOTE 1:** This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used but, in the judgment of Range Safety and the Fire Marshal, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of an accident, the adequacy of ventilating equipment, the total area involved, and the record of the Range User with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location. **NOTE 2:** Piping without valves, checks, meters, and similar devices would not ordinarily

introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions. **NOTE 3:** As determined by Range Safety and the Fire Marshal, locations may actively change classification depending upon the flammable fluid system activity and configuration. For these types of locations, fixed or permanently installed electrical equipment shall be designed for the worst case hazardous environment. **NOTE 4:** Portable electrical equipment shall be designed for the worst case hazardous environment in which it will be used. Portable equipment that is not designed for use in a particular hazardous environment shall not be in that environment or shall be locked out from use in that environment.

4. As a baseline, Class 1, Division 2 locations include the following equipment or areas:

(a) Storage vessels (including carts and drums) - 25 ft horizontally and below to grade and 4 ft vertically above the vessel (25 ft in any direction for hydrogen)

(b) Transfer lines - 25 ft horizontally and below to grade and 4 ft above the line (25 ft in any direction for hydrogen)

(c) Launch vehicle (liquid fueled vehicle, stages, or payloads) - 100 ft radius horizontally from and 25 ft vertically above (100 ft for hydrogen) the highest leak or vent source and below the vehicle to grade

(d) Enclosed locations such as rooms, work bays, and launch complex clean rooms that are used to store and handle flammable and combustible propellants when the concentration of vapors inside the room resulting from a release of all fluids stored and handled equals the lowest explosive limit. **NOTE:** The quantity of fluids used in the analysis shall be the maximum amount allowed in the explosives site plan.

c. Hazardous Commodity Groups. Hazardous commodities are grouped by similar characteristics. These fuels shall be categorized as follows:

1. Group B - Liquid or gaseous hydrogen

2. Group C - Hypergolic fuels such as Hydrazine (N_2H_4), Monomethyl Hydrazine (MMH), Unsymmetrical Dimethyl Hydrazine (UDMH), Aerozine 50 (A50)

3. Group D - Hydrocarbon fuels Rocket Propellant (RP) and Jet Propellant (JP)

4. Group D - Oxidizers. Oxidizers shall be considered Group D hazardous substances in addi-

tion to the fluids listed in Section 500-3 of the NEC

d. Exposed Solid Propellants. The atmosphere within 10 ft of exposed solid propellant shall be classified as a Class 1, Division 2, Group D location. Solid rocket motors are considered exposed in the following situations:

1. The motor nozzle is not attached and the aft end of the motor does not have a cover
2. The motor nozzle is attached but does not have a nozzle plug
3. The unassembled motor segments do not have front and rear covers
4. The igniter is removed from the motor and cover is not provided

3.14.2.7.2 Electrical Systems and Equipment Hazard Proofing. Electrical systems and equipment used in hazardous locations shall be designed and listed for the locations in accordance with the following requirements:

a. Explosion proof apparatus shall meet the requirements of the NEC for Class I, Division 1 or Class I, Division 2, and be listed and labeled by a nationally recognized testing laboratory, such as UL, Factory Mutual Corporation (FM), or those accredited by OSHA under the Nationally Recognized Testing Laboratory accreditation program (29 CFR 1910.7).

b. Non-incendive apparatus shall meet the requirements of NEC Article 501 and are restricted to installations in Class I, Division 2 locations only. They shall be listed and labeled by a nationally recognized testing laboratory such as UL or FM.

c. Intrinsically safe equipment and systems intended for Class I, Division 1 or Class I, Division 2 locations shall meet the requirements of NEC Article 504 and UL 913 and be listed and labeled by a nationally recognized testing laboratory such as UL, FM, or those accredited by OSHA under the Nationally Recognized Testing Laboratory accreditation program (29 CFR 1910.7).

d. The use of purged and pressurized electrical enclosures designed in accordance with NFPA 496 for the purpose of eliminating or reducing the hazardous location classification as defined in Article 500 of the NEC is acceptable with the following additional requirements:

1. The purged and pressurized enclosure shall be maintained at a nominal 1/2 in. of water unless a lower pressure is approved by Range Safety. In no case shall the pressure in the enclosures be less than 1/10 in. of water.
2. Rooms into which unprotected personnel

may enter shall be purged with air only.

3. Purged rooms and enclosures shall be provided with an audible alarm set to trigger when the pressure drops below 1/4 in. water.

e. Equipment inspected and tested to other government standards such as MIL-STD-810 may be used if approved by Range Safety in coordination with Civil Engineering.

f. Exterior Interconnecting Cable

1. Exterior interconnecting cable installed in the "open" is acceptable for interconnecting electrical equipment in a hazardous location. **NOTE:** *Open* refers to open trays or raceways that cannot trap gases when installing exterior-type to interconnect electrical equipment in a hazardous location

2. Cable installation shall comply with the requirements of Article 501-4 of the NEC.

3.14.3 Electrical and Electronic Flight Hardware

3.14.3.1 Electrical and Electronic Flight Hardware Design Standards

Airborne electrical and electronic equipment shall be designed to meet the intent of NEC 501 to the maximum extent possible. **NOTE:** The intent of NEC 501 is normally provided by hermetic sealing.

3.14.3.2 Flight Hardware Electromechanical Initiating Devices and Systems

a. Electromechanical initiating devices and systems, including NEIs, are used for such purposes as structure deployment or actuation release mechanisms.

b. Electromechanical initiating devices and systems shall be evaluated to determine the severity of the hazard (Category A or B).

c. Design, test, and data requirements shall be determined by Range Safety on a case-by-case basis.

d. At a minimum, the system safety fault tolerances described in the **System Design Policy** section of this Chapter and the initiating ordnance design requirements shall be addressed.

3.14.3.3 Flight Hardware Batteries

a. Flight battery cases shall be designed to an ultimate safety factor of 3 to 1 with respect to worst case pressure build-up for normal operations.

1. This pressure build-up shall take into account hydraulic and temperature extremes.

2. Batteries that have chemically limited pressure increases such as nickel-hydrogen chemistries

and whose battery/cell case can be designed to withstand worst case pressure build-up in abnormal conditions such as direct short and extreme temperatures, can reduce the safety factor to 2:1 (ultimate) and 1.5:1 yield. Lower factors of safety determined by an Range Safety approved fracture mechanics analysis can be used on a case-by-case basis for nickel-hydrogen chemistries.

b. Sealed batteries shall have pressure relief capability unless the battery case is designed to a safety factor of at least 3 to 1 based on worst case internal pressure.

1. Pressure relief devices shall be set to operate at a maximum of 1.5 times the operating pressure and sized so that the resulting maximum stress of the case does not exceed the yield strength of the case material.

2. Nickel-hydrogen batteries and/or cells that are proven by test to withstand worst case pressure build-up in abnormal conditions such as direct short and thermal extremes that can be experienced when installed with no reliance on external controls such as heaters and air conditioning are not required to have pressure relief capability.

3.14.4 Test Requirements for Lithium Batteries

Unless otherwise agreed to by Range Safety, the following tests shall be performed prior to the use or storage of lithium batteries at the Ranges. **NOTE:** These tests are likely to cause violent reactions, so all possible safety precautions shall be observed.

3.14.4.1 Lithium Battery Constant Current Discharge and Reversal Test

a. The constant current discharge and reversal test shall determine if the pressure relief mechanism functions properly or case integrity is sustained under circumstances simulating a high rate of discharge.

b. The test shall be performed according to the following criteria:

1. The test shall consist of a constant current discharge using a DC power supply.

2. The fusing of the battery shall be bypassed (shorted).

3. The discharge shall be performed at a level equal to the battery fuse current rating and the voltage of the battery.

4. After the battery voltage reaches zero volts, the discharge shall be continued into voltage reversal at the same current for a time equivalent to 1.5

times the stated ampere-hour capacity of the battery pack.

5. Voltage, pressure, and temperature shall be continuously monitored and recorded.

3.14.4.2 Lithium Battery Short Circuit Test

a. The short circuit test shall determine if the pressure relief mechanism functions properly under conditions simulating a battery short circuit failure mode; or if a pressure relief mechanism is not provided, case integrity shall be determined under conditions simulating a battery short circuit failure mode.

b. The test shall be performed according to the following criteria:

1. After all internal electrical safety devices have been bypassed, the battery shall be shorted through a load of 0.01 ohm or less, leaving the load attached for not less than 24 h.

2. Voltage, current, pressure, and temperature shall be continuously monitored and recorded.

3.14.4.3 Lithium Battery Drop Test

A drop test shall be performed according to the following criteria:

a. The battery in the activated state shall be dropped from a 3-ft height to a concrete pad on the edge of the battery, on the corner of the battery, and on the terminals of the battery.

b. The battery shall not vent or start a hazardous event when dropped.

c. A physical analysis shall be performed after the drop test to determine what handling procedures are required to safely dispose of the batteries if dropped on the Ranges.

NOTE: Other tests may be required by Range Safety depending upon design, storage, operating environments and other criteria. If required, additional tests shall be identified by Range Safety during the cDR and PDR. Manufacturing lot acceptance tests may be required of safety devices in the battery design to ensure safety critical functions have not been altered.

3.14.5 Electrical and Electronic Equipment Data Requirements

The following electrical and electronic equipment design data shall be incorporated in the MSPSP: (See Appendix 3A for guidance.)

3.14.5.1 EGSE and Flight Hardware Battery Design Data

a. Design versus actual operating parameters of

cells and battery

- b. Cell chemistry and physical construction
- c. Cell vent parameters
- d. Toxic chemical emission of cells and evaluation of hazards
- e. EPA classification of battery
- f. DOT classification of battery
- g. Physical and electrical integration of cells to form the battery
- h. Description of safety devices
- i. Case design including vent operation and cell and battery case housing yield point
- j. A description of all Range operations including packing, transportation, and storage configuration; activation; installation; checkout; charging; usage; removal; and disposal
- k. Identification of the hazards associated with each activity in *j* above and the safety controls that shall be in effect
- l. Manufacturing qualification and acceptance testing results that are considered safety critical
- m. Battery size and weight
- n. Specification of the system that uses the battery
- o. A description of the EGSE used for packing, transportation, and storage; activation; installation; checkout; charging; usage; removal; and disposal of the battery
- p. Lithium battery test results

3.14.5.2 EGSE Design Data

- a. Identification of EGSE and its use
- b. A description of how faults in the EGSE circuitry that can create a hazardous condition are prevented from propagating into the flight system
- c. A description of how inadvertent commands that can cause a hazardous condition are prevented
- d. Identification of potential shock hazards
- e. A description of how the intent of the NFPA is met with respect to hazardous atmospheres
- f. Identification of all non-explosion proof equipment powered up during and after propellant loading
- g. For explosion proof and intrinsically safe equipment approved by a nationally recognized testing laboratory, the following information shall be provided:
 - 1. Manufacturer
 - 2. Model number
 - 3. Hazardous location class and group
 - 4. Operating temperature
- h. For any explosion proof equipment or component not having a fixed label from a nationally recognized testing laboratory, the data and certification

shall be available for inspection in the facility of use.

i. Test data and certification on custom or modified equipment that can not be certified by a nationally recognized testing laboratory for explosion proof equipment

j. Test results for all Range User designed, built, or modified intrinsically safe apparatus as required by a nationally recognized testing laboratory in accordance with UL 913, *Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1 Hazardous (Classified) Locations*

k. Results of the bent pin analysis performed on all safety critical or hazardous system connectors that cannot be verified as a good mate after final connection.

3.14.5.3 Electrical and Electronic Flight Hardware Data Requirements

a. A brief description of power sources and the power distribution network, including schematics and line drawings of the distribution network

b. A description of how faults in electrical circuitry are prevented from propagating into hazardous subsystems, including such information as dedicated power sources and buses, use of fuses, and wiring sizing

c. A description of how inadvertent commands that can cause a hazardous condition are prevented

d. Identification of potential shock hazards

e. A description of how the intent of hazard proofing is met for electrical and electronic systems

f. Complete grounding and bonding methodology

g. Results of the bent pin analysis performed on all safety critical or hazardous system connectors that cannot be verified as a good mate after final connection.

3.15 MOTOR VEHICLES

This section provides the design, test, and documentation requirements for motor vehicles, tankers, and trailers used to transport critical hardware or bulk hazardous materials such as toxics, flammables, and combustibles and explosives on CCAS/VAFB roads and tracks. It also applies to all forklifts, regardless of the loads being handled on the Ranges.

3.15.1 Motor Vehicles, Tankers, and Trailers

3.15.1.1 Motor Vehicle, Tanker, and Trailer General Design Requirements

a. Motor vehicles, tankers, and trailers shall

comply with applicable DOT and DoD requirements for transportation on public highways and rails.

b. Motor vehicles, tankers, and trailers that do not meet DOT and DoD public transportation requirements shall not be permitted to transport hazardous materials on the Ranges unless the vehicle is covered by a formal DOT and/or DoD exemption.

c. If the motor vehicle, tanker, or trailer is not exempted from DOT requirements, the following data shall be submitted to Range Safety for review and approval prior to using the vehicles on the Ranges:

1. Design, test, and NDE inspection requirements for vehicles
2. Stress analysis
3. Single failure point analysis
4. FMECA in accordance with MIL-STD-1543
5. Clear identification of areas of compliance and non-compliance with similar, DOT approved, vehicles
6. Engineering documentation such as analyses, tests, and inspections that justifies acceptance of these DOT noncompliances based on "equivalent safety" or "meets DOT intent" criteria

3.15.1.2 Trailers Used to Transport Critical Flight Hardware Design

a. Trailers and their ancillary support equipment such as outriggers and support stands shall be designed with a yield factor of safety of at least 2.

b. Load test tags shall be attached to the trailer and marked with the following minimum information:

1. Part number
2. Date of most recent load test (or date of next load test)
3. Weight of test load
4. Rated load
5. Date of most recent NDE (or date of next NDE)

c. Load test tags shall be accessible for inspection.

d. A single failure point (SFP) analysis shall be performed.

3.15.1.3 Trailers Used to Transport Critical Flight Hardware Tests

3.15.1.3.1 Critical Flight Hardware Trailer Initial Tests. At a minimum, the following critical tests shall be performed on trailers used to transport critical flight hardware on Range roads. These tests shall be performed prior to first operational use at

the Ranges:

a. The trailer shall be static proof tested to 125 percent of rated load. **NOTE:** The rated load shall include the dynamic load.

b. A road test shall be taken over an actual Range route at maximum allowable speed with 100 percent of rated load on the trailer. **NOTE:** Trailers will be instrumented to verify the proper dynamic loading was taken into account.

c. Volumetric and surface NDI shall be performed on all SFP components and SFP welds prior to the proof load test and after the road test.

d. Volumetric and surface NDI shall be performed on 10 percent of non-SFP welds located in load path.

3.15.1.3.2 Critical Flight Hardware Trailer Periodic Tests. At a minimum, the following tests shall be performed on trailers used to transport flight hardware (hazardous or non-hazardous) on the Ranges every four years. Unless otherwise agreed to by Range Safety, these tests shall also be performed after a trailer has been modified or repaired:

a. The trailer shall be proof tested to 125 percent of rated load.

b. Visual and surface NDE shall be performed on all SFP components and SFP welds after the proof load test.

c. Volumetric NDE shall be performed on all modified and/or repaired SFP components and SFP welds prior to and after the load test.

3.15.1.4 Motor Vehicles, Tankers, Trailers, and Critical Flight Hardware Trailer Data Requirements

The following initial and recurring data requirements shall be submitted to Range Safety for review and approval as part of the MSPSP:

3.15.1.4.1 Motor Vehicle, Tanker, and Trailer Initial Data. The following data shall be submitted to Range Safety for review and approval prior to the first operational use of vehicles used to transport hazardous material or flight hardware on the Ranges:

a. Documentation certifying that motor vehicles and tankers comply with DOT requirements or are formally exempted by DOT.

b. If the DOT certification or exemption documentation is not available, the following information is required:

1. Design, test, inspection requirements
2. Stress analysis
3. Single failure point analysis

4. FMECA

5. Comparison analysis with similar DOT approved vehicle

6. "Equivalent safety" (meets DOT intent) analysis

3.15.1.4.2 Critical Flight Hardware Trailer Initial Data. The following data shall be submitted for trailers used to transport critical flight hardware (hazardous or non-hazardous):

- a. Stress analysis
- b. SFP analysis
- c. Initial proof load test plan and test results
- d. Initial road test plan and test results
- e. NDE plan and test results for SFPs

3.15.1.4.3 Critical Flight Hardware Trailer Recurring Data. The following data shall be submitted to Range Safety for review and approval prior to the first periodic testing of trailers used to transport critical flight hardware:

- a. Periodic proof load test plan and test results
- b. NDE plan and test results for SFPs

3.15.2 Forklifts

NOTE: Before using a forklift to lift or move critical loads, consideration shall be given to the use of facility cranes.

3.15.2.1 Forklift Design Standards

a. All forklifts shall be designed in accordance with ANSI/ASME B56.1 and 29 CFR 1920.178.

b. Additional requirements:

1. Forklifts with internal combustion engines shall meet UL 558.

2. Electric battery operated forklifts shall meet UL 583.

3. Forklifts to be used in locations classified by Article 500 of the NEC shall meet the requirements of NFPA 505. Tires and other components shall not be replaced with tires and other components not approved for the specific application and/or environment.

4. Forklifts used to transport explosives and propellants or operate in explosive and propellant locations shall also meet the requirements of AFMAN 91-201 and DoD 6055.9-STD.

3.15.2.2 Forklift General Design Requirements

a. All forklifts shall be equipped with overhead guards.

b. All forklifts shall be designed with shoulder-high wing safety seats with seat belts.

c. All forklifts shall be designed with dead-man

controls.

d. Personnel platforms attached to forklifts shall be designed and tested in accordance with the **Personnel Platforms** section of this Chapter.

e. All forklifts shall be clearly marked with 2-in. letters indicating maximum load capacity at maximum elevation.

f. Critical loads shall not exceed 75 percent of the forklift rated capacity.

3.15.2.3 Gasoline and Diesel Powered Forklifts

a. Deflector plates shall be installed to prevent overflow from the fuel tank from reaching the engine or exhaust system.

b. Flash screens shall be installed in the fuel line of both gasoline and diesel powered forklifts.

c. Diesel powered forklifts shall have an emergency shutoff valve installed in the fuel line at a convenient and visible location.

3.15.2.4 Battery Powered Forklifts

a. All electrical cables shall be mounted so that they cannot catch or snag on stationary objects.

b. Battery boxes shall be securely fastened and ventilated to ensure explosive gas mixture buildup does not occur.

c. The main service switch shall be located so that it can be reached from the driver position.

3.15.2.5 Forklift Tests

All forklifts shall be tested in accordance with ANSI/ASME B56.1.

3.15.2.6 Forklift Data Requirements

The following data shall be submitted to Range Safety for review and approval prior to the first use of a forklift at the Ranges. The data shall be incorporated in the MSPSP:

a. Certification that the forklift has been designed and tested in accordance with applicable national standards such as ANSI/ASME B56.1, UL 558, and UL 583

b. For personnel platforms on forklifts:

1. Stress analysis

2. SFP analysis

3. NDI plan and test results for SFP components and welds

4. Proof load test plan and test results

5. For forklifts used to lift or move critical loads, maintenance plans shall be submitted for review and approval.

3.16 COMPUTING SYSTEMS AND SOFTWARE

This section provides safety design requirements and guidelines for the design and development of all systems such as flight and ground in which computing systems have or potentially have safety critical applications. Unless specifically excluded and approved by Range Safety, all safety critical computing systems associated with the handling, checkout, test, or launch of missiles or space vehicles at the Ranges shall be designed in accordance with the requirements in this section. These requirements include safety critical computing systems used in prelaunch assembly operations such as software controlled cranes.

3.16.1 Determination of Software Safety Critical Functions

a. Software used to control or monitor the functioning of safety critical hardware shall be considered a software safety critical function (SSCF).

b. Software used to or having the capability to monitor or control hazardous systems shall be considered an SSCF.

c. Software associated with fault detection of safety critical hardware and/or software shall be considered an SSCF. **NOTE:** *Fault* is defined as the manifestation of an error in software. The term *fault detection* includes software associated with fault signal transmission.

d. Software responding to the detection of a safety critical fault shall be considered an SSCF.

e. Flight Termination System (FTS) software shall be considered an SSCF.

f. Processor interrupt software associated with previously designated SSCF shall be considered an SSCF.

g. Computation of safety critical data used in a previously designated SSCF shall be considered and SSCF.

NOTE: It is recommended that SSCFs are identified and agreed to with Range Safety early in the program. Boundaries defining what is included and excluded from each SSCF should be documented.

3.16.2 General Safety Design Requirements

The following requirements shall apply to all SSCFs.

3.16.2.1 Central Processing Unit/Firmware

a. Central Processing Unit (CPU) functionality shall be validated for intended use and environment. Such validation may be based upon experience and/or testing.

b. CPU utilization shall not exceed 80 percent (not exceeding 70 percent is desirable).

c. CPUs shall either separate instruction and data memories and busses or separate program memory and data memory through memory protection hardware, segment protection, or page protection.

d. SSCF flight architecture shall protect against CPU Single Event Upset (SEU) at altitudes of 30,000 ft and above. This may be accomplished

through redundancy, error correcting memory, voting between parallel CPUs, or other approved approaches.

e. Design of firmware and installation procedures should minimize the potential for damage to the circuits due to mishandling, electrostatic discharge, or normal or abnormal storage environments.

3.16.2.2 Power

a. The system shall power up in a safe state.

b. The system shall not enter an unsafe or hazardous state after an intermittent power transient or fluctuation.

c. The system shall gracefully degrade to a secondary mode of operations or shutdown in the event of a total power loss so that potentially unsafe states are not created.

3.16.2.3 Failure Detection

a. An initialization test that verifies the following shall be incorporated in the design:

1. The system is in a safe state and functioning properly prior to initiation of hazardous activities

2. Continuity and proper functioning of SSCF circuits, components, inhibits, interlocks, exception limits, and safing logic are tested to ensure safety operation

3. Memory integrity

4. Program loads

b. The system shall periodically verify:

1. That safety critical hardware and SSCF, including safety data transmission are operating correctly

2. That safety data transmission has not been corrupted

3. The validity of real-time SSCF data

c. The software shall be capable of detecting the following input/output errors:

1. Improper entries

2. Improper sequences of entries

3. Improper sequences of operations

4. Invalid output

5. Timing

3.16.2.4 Failure Response

a. If a failure or error is detected within a ground/prelaunch processing SSCF or associated safety critical hardware, the system shall:

1. Be designed to revert to a safe state

2. Provide provisions for safing hardware subsystems under the control of software

3. Reject erroneous input

4. Ensure the logging of all detected SSCF related system errors

5. Notify the operator if an ARM and SAFE logic error pattern, other than the ARM and SAFE codes, is present.

6. Initiate Anomaly Alerts

(a) Anomalies shall be prioritized; for example, warning/caution/advisory.

(b) Anomalies of the same priority should be grouped together; for example, all warnings displayed first, cautions next, and advisories last.

(c) The most recent anomaly should be displayed at the top of the priority subgroup.

(d) The display shall support reporting multiple anomalies. Details of each anomaly may be accessed with a single action; in other words, expand each anomaly summary into full write-up delineating actions automatically taken and recommended actions for the operator to take.

(e) The display shall differentiate between read and unread anomaly alerts.

(f) Anomaly alerts shall be cleared after predefined operator input. Such inputs shall provide feedback of the corrective actions taken and confirm corrective action states.

b. If a failure or error is detected within a flight SSCF or associated safety critical hardware, the system shall:

1. Maintain the FTS in an ARMED state throughout the flight even if errors are detected

2. Reject erroneous input

3. Ensure all detected SSCF (FTS) related system errors are transmitted via telemetry to the range

4. Notify the operator if an ARM or SAFE logic pattern other than ARM or SAFE code is present.

3.16.2.5 Testing and Maintenance

3.16.2.5.1 Non-Operational Hardware and Software.

a. If non-operational hardware, such as test sets and simulators, or software is required for testing or maintenance, the system shall be designed so that identification of such equipment is fail-safe.

b. Operational hardware or software identification shall not be inadvertently identified as non-operational.

3.16.2.5.2 Interlocks and Inhibits.

a. Interlocks shall be provided to preclude hazards to personnel maintaining or testing the system.

b. Provisions shall prevent interlocks from being inadvertently overridden.

c. Where interlocks must be overridden, disabled, removed, or bypassed to perform tests, they shall:

1. Not be left in overridden state once the system is restored to operational use
2. Not be autonomously controlled by a computing system
3. Display the status of the interlocks on the safety console and/or the test/launch conductor console
4. Verify the restoration of the interlocks prior to resuming normal operations.

3.16.2.6 EMI/ESD

The system design shall provide protection against harmful effects from electromagnetic radiation, or electrostatic discharge for the sensitive components of the SSCF computer system.

3.16.2.7 Operator Console

a. The system shall be designed so that the operator may cancel current processing with a single action and have the system revert to a known safe state. **NOTE 1:** The action may consist of pressing two keys at the same time. **NOTE 2:** In-flight FTS “safe state” may either be in a SAFE or ARMED mode.

b. The system shall be designed so that the operator may exit potentially unsafe states to a known safe state with a single action. **NOTE:** The action may consist of pressing two keys at the same time.

c. Two or more unique operator actions shall be required to initiate any potentially hazardous function or sequence of functions.

d. Actions required shall be designed to minimize the potential for inadvertent actuation.

e. Operator displays, legends, and other interactions shall be clear, concise, and unambiguous.

f. The software shall provide positive confirmation of valid data entry or actions taken; for example, the system shall provide visual and/or aural feedback to the operator so the operator

knows that the system has accepted the action and is processing it.

g. The system shall provide feedback for SSCF actions not executed.

h. The system shall provide a real-time indication that it is functioning.

i. Real-time processing functions requiring several seconds or longer shall provide a status indicator to the operator during processing. **NOTE:** Indication should confirm that the commanded action has occurred thus providing the operator with a closed-loop indication. This should not merely be a “signal has been sent” status.

j. Multiple devices and logical paths shall be provided to ensure that a single failure/error cannot prevent the operator from taking safing actions.

k. Error messages that distinguish safety critical states/errors from non-safety critical states/errors shall be provided.

3.16.3 Software Development

The following requirements are applicable to all SSCFs.

3.16.3.1 Software Development Process

a. Desk audits, peer reviews, static analysis, and dynamic analysis tools and techniques shall be used to verify implementation of SSCF design requirements in the source code and system.

b. Reviews of the software source code shall ensure that the code and comments within the code agree.

c. Object code patches shall be prohibited.

3.16.3.2 Coding Standards

3.16.3.2.1 Timers.

a. Watchdog timers or similar devices shall be provided to ensure that the microprocessor or computer is operating properly.

b. Watchdog timers or similar devices shall be designed so that SSCF software cannot enter an inner loop and reset the timer or similar device as part of that loop sequence.

c. SSCF timing functions shall be controlled by the computer.

d. SSCF timing values shall not be modifiable by the operator from system consoles.

e. SSCF timer values shall be verified and shall be examined for reasonableness for the intended function.

3.16.3.2.2 Modular Code.

a. SSCF software design and code shall be modular.

b. The number of program modules containing SSCF shall be minimized where possible within the constraints of operational effectiveness, computer resources, and good software design practices.

c. Modules shall have one entry and one exit point.

d. SSCF software should be segregated from non-SSCF software.

3.16.3.2.3 Loops.

a. Loops shall not exceed a predefined constant maximum execution time.

b. Feedback loops shall be designed so that the software cannot cause a runaway condition due to the failure of a feedback sensor.

c. Branches into loops shall not be used.

d. Branches out of loops shall lead to a single exit point placed after the loop within the same module.

3.16.3.2.4 Object Code.

a. STOP instructions shall not be used in operational SSCF object code.

b. HALT instructions shall not be used in non-executive operational SSCF object code.

c. After a task has been HALTED, the executive shall restart CPU task processing no later than the start of the next computing frame.

d. WAIT instructions may be used where necessary to synchronize input/output where appropriate handshake signals are not available.

e. The system design shall prevent unauthorized or inadvertent access to or modification of SSCF software (source or assembly) and SSCF object code.

f. The system design shall prevent self-modification of the SSCF object code.

g. SSCF operational program loads shall not contain unused executable codes; in other words, Dead Code.

h. SSCF operational program loads shall not contain unreferenced variables.

3.16.3.2.5 Data.

a. SSCFs shall exhibit strong data typing.

b. SSCFs shall not employ a logic "1" and "0" to denote the SAFE and ARM (potentially hazardous) states.

c. The ARM and SAFE states shall be represented by at least a unique 4-bit pattern.

d. The SAFE state shall be a pattern that cannot represent the ARM pattern as a result of a 1- or 2-bit error.

3.16.3.2.6 Interfaces. **NOTE:** These requirements include any SSCF interface between CPUs and hardware input/output devices.

a. Parity checks, checksums, cycle redundancy checks, or other data verification techniques shall be used for verification of correct data transfer.

b. Data transfer messages shall be of a predetermined format and content.

c. Limit and reasonableness checks shall be performed on all SSCF inputs and outputs.

d. Functions requiring two or more SSCF signals (such as ARM and FIRE) shall not receive all of the necessary signals from a single register or input/output port.

e. Functions requiring two or more SSCF signals (such as ARM and FIRE) shall not be generated by a single software module.

3.16.3.2.7 Logic.

a. SSCF conditional statements shall have all required conditions satisfied; there shall not be a potential for unresolved input to the conditional statement.

b. Decision statements in SSCF shall not rely on inputs of all 1s or 0s, particularly when this information is obtained from external sensors.

c. Flags and variable names shall be unique and shall have a single purpose.

d. Files shall be unique and shall have a single purpose.

e. Scratch files shall not be used for storing or transferring SSCF information, data, or control functions between processes.

f. The software shall contain only those features and capabilities required by the system. The SSCF programs shall not contain undocumented or unnecessary features.

g. Indirect addressing methods shall not be used unless absolutely necessary. When used the address shall be verified as being within acceptable limits prior to execution of SSCF operations. Data written to arrays in SSCF operations shall have the address boundary checked by the compiled code.

h. The results of an SSCF program shall not be dependent on the time taken to execute the program or time at which execution is initiated.

i. SSCF software shall be designed so that the full scale and zero representations of the software are fully compatible with the scales of any digital-

to-analog, analog-to-digital, digital-to-synchro, and/or synchro-to-digital converters used in the system.

j. One-to-one assignment statements shall not be used in SSCF code.

3.16.3.2.8 Memory.

a. Static Memory Allocation

1. All ground or prelaunch process memory not used for or by the operational program shall be initiated to a pattern that will cause the system to revert to a safe state if executed.

2. All flight processor memory not used for or by the operational program shall be initiated to a pattern that will cause the system to revert to a predefined state if executed. This predefined state shall not stop the CPU from operating. **NOTE.** Predefined state shall not change the FTS operating mode; for example, ARMED shall not be SAFED.

b. Dynamic Memory Allocation. Memory usage shall not exceed 85 percent. **NOTE.** Assumes average memory usage but is verified by testing against projected worst case to ensure protection from memory saturation as a result of memory leakage.

c. Random numbers, HALT, STOP, WAIT, or NO-OPERATION instructions shall not fill processing memory.

d. Data or code from previous overlays or loads shall not be allowed to remain.

e. Overlays of SSCF software shall all occupy the same amount of memory.

f. Safety kernels shall be resident in nonvolatile read only memory (ROM) or in protected memory that cannot be overridden by the computing system.

3.16.3.3 Configuration Control

a. Configuration control shall be established as soon as a practical software baseline is established.

b. A Software Configuration Control Board (SCCB) shall approve changes to configuration controlled software prior to their implementation.

c. A member from the system safety engineering team shall be a member of the SCCB and tasked with the responsibility for evaluation of all software changes for their potential safety impact.

d. A member of the hardware Configuration Control Board (CCB) shall be a member of the SCCB and vice versa to keep members apprised of hardware/software changes and to ensure that hardware/ software changes do not conflict with or

introduce potential safety hazards due to hardware/software incompatibilities.

e. All software changes shall be coded into the source code, compiled, and tested prior to being introduced into operational equipment.

f. Firmware changes shall be tested and deemed fully functional prior to use.

g. Electrically Erasable Programmable Read Only Memory (EEPROM):

1. EEPROM changes shall pass hardware/software functionality testing on similar hardware prior to installation onto the system.

2. EEPROM changes shall contain an embedded version identification number and be validated via checksum.

h. All SSCF software and associated interfaces shall be under configuration control.

3.16.3.4 Software Analyses

a. Internal Independent Validation & Verification (IIV&V) or similar formal process shall be used to ensure safety design requirements have been correctly and completely implemented for SSCF code.

b. Conditional statements shall be analyzed to ensure that the conditions are reasonable for the task and that all potential conditions are satisfied and not left to a default condition.

c. Comment statements shall be adequately describe the functionality of the code.

d. Test results shall be analyzed to identify potential safety anomalies that may occur. **NOTE:** It is recommended that hazards be investigated from a system level with hardware and software components.

3.16.3.5 Software Testing

SSCF software testing shall include the following:

a. GO/NO-GO path testing (functioning properly/not functioning properly)

b. Reaction of software to system (hardware, software, or combination of hardware and software) errors or failures

c. Boundary conditions (In, Out, Crossing)

d. Input values of zero, zero crossing, and approaching zero from either direction

e. Minimum and maximum input data rates in worst case configurations

f. Regression Testing for changes to SSCF software code

g. Operator interface/human errors during SSCF operations

h. Error Handling

- i. Special features such as safety kernels upon which the protection of SSCF features is based
- j. Formal Test coverage for software testing to include analysis and documentation

3.16.3.6 Software Reuse

- a. Reused software shall be evaluated to determine if it supports an SSCF in accordance with paragraphs 3.16.1 and 3.16.3.3 e.
- b. SSCF reused baseline software shall be analyzed for the following:
 - 1. Correctness of new or existing system design assumptions and requirements
 - 2. Changes in environmental or operational assumptions
 - 3. Impact to existing hazards
 - 4. Introduction of new hazards
 - 5. Correctness of interfaces with system hardware, software and operator
- c. Unused or unneeded functionality in SSCF reuse baseline software shall be eliminated.
- d. SSCF reused baseline software changes in system design, environment, or operation assumptions shall be requalified or revalidated.
- e. SSCF reuse baseline software compiled with a different compiler shall be analyzed and tested.

3.16.3.7 Commercial Off-the-Shelf Software

- a. Each Commercial-Off-The Shelf (COTS) software application shall identify every SSCF supported.
- b. Software Safety Hazard Analyses shall be performed on all SSCF COTS software to verify such software is sufficiently safe.

3.16.3.8 Language/Compilers

- a. Production qualified higher order language compilers shall be used for SSCF code.
- b. Beta test versions of higher order language compilers shall not be used for SSCF code.
- c. The heritage of the language(s) and compiler(s) being used for SSCF code shall be clearly identified for each portion of the system design.
- d. Translation routines/hardware between languages used in SSCFs shall be analyzed and tested.
- e. Non-standard languages (those languages without production qualified compilers) used in SSCFs shall be analyzed and tested.
- f. Programs or routines (compiled from different compiler versions) supporting SSCFs shall be analyzed and tested.
- g. Programmable Logic Controllers (PLCs).

1. PLC use should be minimized in SSCF systems.

2. Where PLCs must be used in SSCF systems, the contractor shall obtain Range Safety approval and document the following in the Software Development Plan (SDP):

- (a) The process to preclude hazardous or erroneous logic development
- (b) The process to preclude erroneous logic entry into the PLC
- (c) The validation process to ensure proper program operation. **NOTE:** If possible, this validation process should be accomplished in a non-hazardous state.

3.16.4 Computer System and Software Safety Data Requirements

The Range User shall provide the following SSCF related software information to Range Safety in the MSPSP or other documentation:

- a. System description including hardware, software, and layout of operator console and displays
- b. Flow charts or diagrams showing hardware data busses, hardware interfaces, software interfaces, data flow, and power systems
- c. Logic diagrams, Software Design Descriptions (SDDs)
- d. Operator user manuals and documentation
- e. List and description of all SSCFs including interfaces
- f. Software hazard analyses
- g. Software Test Plan (STP), test procedures, and test results
- h. SDP, including discussions on configuration control, COTS, and reuse

3.17 WR SEISMIC DESIGN

AFM 88-3, Chapter 13 places the WR in seismic zone 4. **NOTE:** Local geological structure determines zone determination 1 through 4 considering the potential severity, frequency, and damage of a seismic event. This designation means that the WR is located in the most severe seismic region. The probability of the WR being exposed to a great earthquake is large enough to require taking specific mitigating measures in design.

3.17.1 WR Seismic Design Standards

- a. Seismic design of all new or modified equipment shall be in accordance with AFM 88-3, Chapter 13, and Sections A and B. Where specific design guidance is not provided in these manuals, industry standards such as SEAOC "Blue Book", UBC, and

ATC 3-06 shall be used.

b. Equipment that must remain operational after a seismic event shall be designed in accordance with an importance factor “I” of 1.5 per AFM 88-3, Chapter 13.

c. Equipment needed for post-earthquake recovery shall be designed to remain operational after a seismic event.

d. Where cost-effective, high-cost computer or electronic equipment should be mounted on seismic isolation bearings (SIB) to mitigate damage during an earthquake. FEMA 74 shall be used as a guide to reduce the risk of earthquake non-structural damage.

3.17.2 WR Design Criteria for Equipment That Can Cause Seismic Hazards

a. The Range User shall identify equipment that has the potential, directly or by propagation, to cause the following seismic hazards:

1. Severe personnel injury
2. A catastrophic event
3. Significant impact on space vehicle or missile processing and launch capability. **NOTE:** This criteria does not apply to commercial programs
4. Damage to high value flight hardware. **NOTE:** This criteria does not apply to commercial programs

b. For equipment that can present a seismic hazard, the Range User shall identify the expected “G” forces, the level of “G” forces the equipment can withstand, and the magnitude of potential damage.

c. For equipment that can present a seismic hazard, the following design criteria shall apply:

1. Equipment shall be restrained to restrict movement and withstand a seismic event, but need not remain operational after a seismic event.

2. Restraints shall be designed to withstand loads as described in the following paragraphs:

(*a*) Restraints shall be designed to react to accelerations equivalent to a horizontal force of two times the equipment weight, applied through its center of gravity, in the direction in which movement is restricted. As an option, instead of using a force of two times the equipment weight, calculations of force may be made in accordance with AFM 88-3, Chapter 13. Vertical accelerations shall be considered whenever appropriate.

(*b*) Restraints shall prevent tip over, collapse, excessive deflection, or sliding.

3. Equipment interfacing flight hardware, where the failure of the flight hardware may cause a seismic hazard, shall be designed to mitigate the seismic forces being transmitted to the flight hardware to the point that the flight hardware will not cause a seismic hazard

4. Equipment shall be located so as not to exceed facility design limits.

5. Equipment that is mounted on casters or wheels shall have provisions for locking these casters or wheels and shall also comply with applicable parts of this section.

6. The use of friction to resist seismic loads is permitted only when accompanied by proper load and risk analysis.

d. Items of equipment that present seismic hazards for a cumulative total of 24 hours or less during any 365 consecutive day cycle are exempt from the above requirements.

3.17.3 WR Seismic Design Data Requirements

a. The Range User shall identify equipment that has the potential, directly or by propagation, to cause the following seismic hazards:

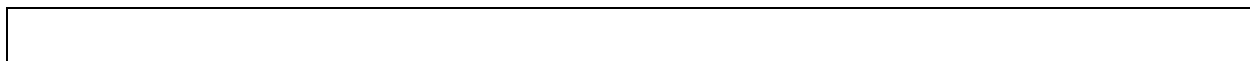
1. Severe personnel injury
2. A catastrophic event
3. Significant impact on space vehicle or missile processing and launch capability. **NOTE:** This criteria does not apply to commercial programs.

4. Damage to high value flight hardware.
NOTE: This criteria does not apply to commercial programs.

b. For equipment that can present a seismic hazard, the Range User shall identify the expected

“G” forces, the level of “G” forces the equipment can withstand, and the magnitude of potential damage and the method of restraint used.

4 CHAPTER 4



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GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

30 SW/SESX - 30th Space Wing, Flight Termination Systems Safety

45 and 30 SW - 45th and 30th Space Wings

45 and 30 SW/SE - 45th and 30th Space Wings, Offices of the Chief of Safety

45 and 30 SW/SES - 45th and 30th Space Wings, Systems Safety Sections

30 SW/SEY - 30th Space Wing, Flight Safety Analysis Sections

45 SW/SEOE - 45th Space Wing ELV Operations Support and Analysis

45 SW/SEOS - 45th Space Wing STS Operations Support and Analysis

AC - alternating current

ADS - Automatic Destruct System

AFR - Air Force Regulation

AFSC/AFLC - Air Force Systems Command/ Air Force Logistics Command; now called Air Material Command

AGC - automatic gain control

AM - amplitude modulation

AMC - Air Material Command

ANSI - American National Standards Institute

antenna - a device capable of radiating or receiving radio-frequency electromagnetic energy

ATP - acceptance test procedure

battery capacity - (1) rated capacity: the capacity assigned by the battery manufacturer based on a set of specific conditions such as discharge temperature, discharge current, end of discharge voltage, and state of charge at start of discharge; (2) measured capacity: the capacity determined by the specific qualification tests, including any time the battery is under load during qualification; the end of discharge voltage is the minimum voltage that Flight Termination System components have been qualified to.

C/A Code - Coarse Acquisition Code

cc - cubic centimeter

cDR - conceptual design review

CDR - critical design review; Command Destruct Receiver

CE - conducted emission

C/N₀ - Received carrier/noise density ratio

CRD - Command Receiver/Decoder

CS - conducted susceptibility

CW - continuous wave

crystal salts - the formation of salt oxidation by the cathode/electrolyte process in batteries; the resulting salt can inhibit the electrochemical process, be a corrosive to the metal plates, and affect the salt solubility that, in turn, affects the passivation film.

dB - decibel, a unit of relative power. The decibel ratio between two powers levels, P1 and P2 is defined by the relation $dB=10\log(P1/P2)$

dBA - decibels referenced to the "A" scale

dBm - decibels relative of one milliwatt

DC - direct current

DDP-70 - a double-base composite propellant

deviation - a term used when a design noncompliance is known to exist prior to hardware production or an operational noncompliance is known to exist prior to beginning operations at Cape Canaveral Air Station or Vandenberg Air Force Base

DGT - Digital Translator

DoD - Department of Defense

EBW - high voltage exploding bridgewire, an initiator in which the bridgewire is designed to be exploded (disintegrated) by a high energy electrical discharge that causes the explosive charge to be initiated

EBW-FU - high voltage exploding bridgewire firing unit

EED - low voltage electroexplosive device

EFP - explosively formed projectile

ELV - expendable launch vehicle

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

EMC - electromagnetic compatibility

EMI - electromagnetic interference

ER - Eastern Range

ERR - Eastern Range Regulation

ETL - Explosive Transfer Line

ETS - Explosive Transfer System

explosives - all ammunition, demolition material, solid rocket motors, liquid propellants, pyrotechnics, and ordnance as defined in AFM 91-201 and DoD 6055.9-STD.

FCDC - flexible confined detonation cord

Fire⁺ - command to initiate destruct energy to EBW used in a typical high voltage firing unit

Fire⁰ - command to remove inhibit used in a typical high voltage firing unit

FMECA - Failure Modes, Effects, and Criticality Analysis

fn - isolator resonant frequency

FOC - fiber optic cable

FOCA - fiber optic cable assembly

FSPO - Flight Safety Project Officer, Western Range

ft - foot, feet

FTS - Flight Termination System; includes the Radio Controlled Command Destruct System, the Automatic Destruct System, and associated subsystems

FU - firing unit

G - gravity

GDOP - Geometrical Dilution of Precision

GHz - gigahertz

GPS - Global Positioning System

GSE - ground support equipment

h - hour, hours

Hg - Mercury

HMX - cyclotetramethylenetetranitramine

HNS - 2,2,4,4,6,6 hexanitrostilbene

Hz - Hertz

IEEE - Institute of Electrical and Electronics Engineers

IIP - Instantaneous Impact Point

IF - intermediate frequency

IV&V - independent verification and validation

kHz - kilohertz

kV - kilovolt

launch vehicle - a vehicle that carries and/or delivers a payload to a desired location; this is a generic term that applies to all vehicles that may be launched from the Eastern and Western Ranges, includes but not limited to airplanes; all types of space launch vehicles, manned launch vehicles, missiles and rockets and their stages; probes; aerostats and balloons; drones; remotely piloted vehicles; projectiles, torpedoes and air-dropped bodies

LFU - laser firing unit

LID - laser initiated device

LIOS - laser initiated ordnance system

liquid electrolyte - an electrolyte that stays in liquid form throughout an electrical reaction

LPF - low pass filter

LSC - linear shaped charges

MDC - mild detonating cord

MDF - mild detonating fuse

Meets Intent Certification - A certification used to indicate an equivalent level of safety is maintained despite not meeting the exact requirements stated in this document

MFCO - Mission Flight Control Officer

MHz - megahertz

MIC - meets intent certification

MIL-STD - military standard

min - minute, minutes

mismating - the improper installation and/or connection of connectors

MPE - maximum predicted environment

NASA - National Aeronautics and Space Administration

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

NFPA - National Fire Protection Association

NIST - National Institute of Standards and Testing

NSA - National Security Agency

NSI - NASA Standard Initiator

NTISS - National Telecommunications and Information Systems Security

OCV - open circuit voltage

operating life - the period of time in which prime power is applied to electrical and/or electronic components without maintenance or rework

optical coverage ratio - the percentage of the surface area of the cable core insulation covered by a shield

OSC - Operations Safety Console

OSHA - Occupational Safety and Health Act

P-Code - Precision Code

PAD - percussion activated device

payload - the object(s) within a payload fairing carried or delivered by a launch vehicle to a desired location; this is a generic term that applies to all payloads that may be delivered from the ER and WR; includes but is not limited to satellites, other spacecraft, experimental packages, bomb loads, warheads, reentry vehicles, dummy loads, cargo, and any motors attached to them in the payload fairing

PDOP - Position Dilution of Precision

PDR - Preliminary Design Review

PETN - pentaerythritoltetranitrate

power source - (1) a battery; (2) the point of direct current (DC) to alternating current (AC) conversion for capacitor charged systems

pps - pulses per second

PRF - pulse repetition frequency

Primacord - explosive detonating cord

primary battery - a battery that is not intended to be recharged and that is disposed of in controlled conditions when the battery has delivered all of its electrical energy

PSD - Power Spectrum Density

Q - resonant amplification factor

QPSK - Quadrature Phase Shift Key; also PSK

RCC - Range Commanders Council

RCO - Range Control Officer

RDx - cyclotrimethylenetrinitramine

RF - radio frequency

RFML - Radio Frequency Measurement Laboratory

RMS - root mean square

RSS - Range Safety System

RSSR - Airborne Range Safety System Report

RTS - Range Tracking System; includes the tracking aid and/or GPS and associated subsystems

S&A - Safe and Arm Device

sc - standard cubic centimeter

sec - second, seconds

secondary battery - a battery that may be restored after discharge by the passage of electrical current in the opposite direction to that of discharge

self-test capability - the capability of a microprocessor to employ a self-test to detect errors and to output the results via telemetry

separate power source - a dedicated and independent source of power

service life - the period of time between the initial lot acceptance testing and the subsequent age surveillance testing for ordnance

SFP - single failure point

shelf life, battery - the specified period of time a battery may be stored in a logistical environment and still perform to all specifications when placed in service

shelf life, explosive - the period of time between explosive loading and end use

single point ground - the one interconnection for a grounded circuit with other circuits

SNR - signal-to noise ratio

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

solid electrolyte - an electrolyte that is absorbed in a gelatinous or semi-solid composition

SSTO - signal strength telemetry output; also known as AGC

std - standard

storage life - the period of time during which an item can remain in storage without having its operability affected; the operating and storage life clocks start at burn-in or acceptance test

STS - space transportation system

TDTS - Telemetry Data Transmitting System

threshold sensitivity - the minimum RF input signal level at which a CRD meets all performance specifications

TIM - Technical Interchange Meeting

Torr - 1 millimeter of Mercury pressure

transponder - the portion of the airborne Range tracking system that receives and decodes interrogations and generates replies to the interrogations. The transponder permits the ground instrumentation radar to furnish significantly greater precision and accuracy data at much greater distances and prevents mistracking of powered vehicles due to interference of exhaust plumes or spent stages.

UN - United Nations

VAFB - Vandenberg Air Force Base

Vac - Voltage, alternating current

Vdc - Voltage, direct current

VDL - voice direct line

vehicle - launch vehicle and/or payload

VSWR - Voltage Standing Wave Ratio

Vrms - voltage root mean square

waiver - a designation used when, through an error in the manufacturing process or for other reasons, a hardware noncompliance is discovered after hardware production or an operational noncompliance is discovered after operations have begun at Eastern or Western Range

wet stand time - (1) the time from activation and initial load pulse to the beginning of qualification operational environmental testing of a liquid electrolyte battery; (2) for the actual use of batteries, the wet stand time is from the time of activation and initial load test to end of use

WR - Western Range

WRR - Western Range Regulation

WSMC - Western Space and Missile Center

REFERENCED DOCUMENTS

- 45 SWR 160-1, *Radiation Protection Program*
- AFTO 11A-1-47, *Explosive Hazard Classification Procedure*
- AFSC/AFLC Pamphlet 800-5, *Software Independent Verification and Validation*
- ASTM-E-748, *Standard Practices for Thermal Neutron Radiography of Material*
- DoDI 5000.2 AF Sup 1, *Mandatory Procedures for Major Defense Acquisition Programs and Major Automated Information System Acquisition Programs*
- DoD 6055.9-STD, *DoD Ammunition and Explosives Safety Standards*
- ELV-JC-002D, *Parts, Materials, and Processes Control Program for Expendable Launch Vehicles*
- MIL-C-38999J, *General Specification for Connector, Electrical Circular, Miniature, High Density Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts*
- MIL-STD-202, *Test Methods for Electronic and Electrical Component Parts*
- MIL-STD-453, *Inspection, Radiographic*
- MIL-STD-461, *Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility*
- MIL-STD-462, *Measurement of Electromagnetic Interference Characteristics*
- MIL-STD-785, *Reliability Program for System and Equipment Development and Production*
- MIL-STD-810, *Environmental Test Methods and Engineering Guidelines*
- MIL-STD-1543, *Reliability Program Requirements for Space and Missile Systems*
- National Policy Directive, 1988, *National Policy on Application of Communication Security to Command Destruct Systems*
- NAVSEAINST 8020.3/TB 700-2/DLAR 8200.1, *Explosive Hazard Classification Procedure*
- RCC 106, *Telemetry Standards*
- RCC 253, *Missile Antenna Pattern Coordinate System and Data Formats*
- RCC 313, *Flight Termination Receiver/Decoder Design, Test, and Certification Requirements*
- RCC 319, *Flight Termination Systems Commonality Standard*
- VAFBR 161-1, *Control of Ionizing Radiation*

CHAPTER 4

AIRBORNE RANGE SAFETY SYSTEM DOCUMENTATION, DESIGN, AND TEST REQUIREMENTS

4.1 INTRODUCTION

4.1.1 Purpose of the Chapter

The purpose of this Chapter is to establish the documentation, design, and test requirements for a Range Safety System (RSS) on vehicles launched from the Eastern Range (ER) and/or Western Range (WR). The following major topics are addressed:

- 4.2 Responsibilities and Authorities
- 4.3 Airborne Range Safety System Policy
- 4.4 Documentation Requirements
- 4.5 Flight Termination System General Requirements
- 4.6 Flight Termination Action Requirements
- 4.7 Flight Termination System Design Requirements
- 4.8 FTS Component Design Requirements
- 4.9 Range Tracking System General Requirements
- 4.10 RTS Design Requirements
- 4.11 RTS Component Design Requirements
- 4.12 Telemetry Data Transmitting System Design Requirements
- 4.13 RSS Ground Support and Monitoring Equipment Design Requirements
- 4.14 RSS Analyses Requirements
- 4.15 RSS Test Requirements

Design requirements for other vehicle and payload systems and their ground support equipment (GSE) are in Chapter 3. When conflicts arise be-

tween this Chapter and other referenced documents, this Chapter takes precedence. Conflicts between referenced documents shall be resolved by Range Safety.

4.1.2 Applicability

Unless otherwise noted, the requirements in this Chapter are applicable to the following components that make up the Airborne RSS:

NOTE: Unless otherwise noted, RSS in this Chapter is limited to only the Airborne Range Safety System.

- a. Flight Termination System (FTS), including the radio controlled Command Destruct System, the Automatic Destruct System, and associated subsystems
- b. Range Tracking System (RTS), including the tracking aid system and associated subsystems
- c. Telemetry Data Transmitting System (TDTS)

4.2 RESPONSIBILITIES AND AUTHORITIES

4.2.1 Commanders, 45th Space Wing and 30th Space Wing

The Commanders, 45th Space Wing (45 SW) and 30th Space Wing (30 SW) are responsible for determining the applicability of this document or the Range Commanders Council (RCC) 319 when Range Users intend to launch a vehicle from multiple ranges, including the Eastern Range (ER) and the Western Range (WR).

4.2.2 Offices of the Chiefs of Safety, 45th Space Wing and 30th Space Wing

The 45th Space Wing, Office of the Chief of Safety (45 SW/SE) and the 30th Space Wing, Office of the Chief of Safety (30 SW/SE) are responsible for approving all noncompliances to the requirements of this Chapter.

4.2.3 Flight Analysis, 45th Space Wing and 30th Space Wing

The 45th Space Wing, Flight Operations Support and Analysis Elements (45 SW/SEOE & SEOS) and the 30th Space Wing, Flight Safety Analysis Section (30 SW/SEY) are responsible for determining the need for an RSS, including a command and automatic flight termination system on launch vehicles and payloads in accordance with the requirements in Chapter 2 of this document.

4.2.4 Systems Safety, 45th Space Wing and Flight Termination System Safety, 30th Space Wing

The 45th Space Wing, Systems Safety Section (45 SW/SES) and the 30th Space Wing, Flight Termination Systems Safety Section, (30 SW/SES) are responsible for the following: **NOTE:** Unless otherwise noted, all references to Range Safety in this chapter refer to the System Safety Section or the Flight Termination Safety Section.

a. Reviewing and approving the conceptual design, detail design, and test requirements for the RSS

b. Resolving problems associated with the design, installation, checkout, and use of the RSS

c. Reviewing and recommending action on all noncompliances

d. Attending meetings, design reviews, procedures reviews, and monitoring tests conducted on any Range Safety System component or system including installation of such components on launch vehicles. **NOTE:** This participation is essential for safety to fully understand the design and operating characteristics of RSS components and is cost effective for the range user when requesting safety approvals. It simplifies the process and time involved to obtain RSS approvals.

4.2.5 Range Users

Range Users are responsible for the following:

a. Meeting the requirements of Chapters 2 and 4 of this document when launching vehicles from the Eastern Range (ER) or Western Range (WR)

b. When launching vehicles from multiple ranges, meeting the requirements of this document or the RCC Standard 319-92 as determined by the Range Commanders. **NOTE:** All RCC documents can be obtained from the Range Commands Council Secretariat, ATTN: STEWS-SA-R, White Sands Missile Range, New Mexico 88002-5110, Phone: (505) 678-1107 or DSN 258-1107, FAX: (505) 678-7519 or DSN 258-7519.

c. Submitting RSS design and test documentation in a timely manner

d. Notifying Range Safety of meetings, design reviews tests including installation of the RSS on the vehicle at least two weeks to allow sufficient time to review documentation, design material and test plans in preparation to provide adequate and meaningful comments and recommendations. It is important to note that RSS approval cannot be granted unless Range Safety is fully cognizant of all aspects of the RSS. **NOTE:** No meetings or tests shall be conducted without Range Safety or a designated representative being in attendance unless otherwise approved by Range Safety.

e. Ensuring RSS compatibility with the Range ground support and monitoring equipment. **NOTE:** Ground support and monitoring equipment system characteristics may be obtained from the appropriate Range organization through Range Safety office.

4.3 AIRBORNE RANGE SAFETY SYSTEM POLICY

4.3.1 Airborne Range Safety System Design

a. It is the policy of the ER and the WR that the design of the RSS be simple, uncomplicated, and safe, and meet the reliability and design requirements as specified in this Chapter.

b. Final acceptance of the RSS for each launch depends on the satisfactory completion of all required prelaunch tests and system installation functions. All design, test, data, or procedural discrepancies shall be resolved prior to RSS launch approval.

4.3.2 Technical Interchange Meetings

a. Separate and independent RSS concept design reviews, preliminary design reviews, and critical design reviews from the vehicle design review shall be held with Range Safety participation.

b. Meeting dates shall be coordinated with Range Safety.

c. Technical interchange meeting supporting data shall be submitted 14 calendar days prior to scheduled meeting.

d. Full details for all interchange meeting can be found in Chapter 1.

4.3.3 Noncompliance Requests

a. Potential noncompliances to the requirements of this Chapter shall be identified and presented at the earliest possible time, preferably during the conceptual design review.

b. Deviation, waiver, and Meets Intent Certification (MIC) requests shall be submitted for review and approval separately, and all approved deviations, waivers, and MICs shall be included in the Range Safety System Report as an appendix.

c. Full details for submitting noncompliance requests can be found in Chapter 1 and Appendix 1A.

4.3.4 Tailoring

a. The requirements outlined in this Chapter can be tailored for each specific program, considering applicability, design pedigree, design complexity, state of the art technology, cost, and risk.

b. Full details for the tailoring process can be found in Chapter 1 and Appendix 1A.

4.4 DOCUMENTATION REQUIREMENTS

4.4.1 Range Safety System

Range Safety System Reports (RSSRs) shall be developed by the Range User in accordance with the requirements in Appendix 4A and submitted to Range Safety for review and approval.

a. The RSSR is the medium through which RSS approval is obtained.

b. The RSSR is a detailed description of the Flight Termination System (FTS) system analysis results, design data, reliability data, component design data, ground support systems data, and test data; the Range Tracking System (RTS); and the Telemetry Data Tracking System (TDTS). **NOTE:** All schematics, functional diagrams, and operational manuals shall have well defined, standard Institute of Electrical and Electronics Engineers (IEEE) or MIL-SPEC terminology and symbols.

c. Three copies of initial and updated RSSRs shall be submitted to Range Safety for review 45 calendar days prior to each design review (conceptual, preliminary, and critical). **NOTE:**

Data submittal items such as procedures, component operation, specifications, and manuals that cannot be included in the RSSR because of size or configuration shall be referenced in the applicable sections and submitted as attachments. The RTS and TDTS descriptions shall be included as appendixes.

d. The final RSSR shall be submitted to Range Safety for review and approval no later than four months prior to the first scheduled launch.

e. The formal acceptance of the RSS will only be granted after approval of the final RSSR and its appendixes.

4.4.2 RSS Development, Qualification, Acceptance, Age Surveillance, Reuse, and Other Test Plans, Test Procedures, and Test Reports

a. Detailed development, qualification, acceptance, age surveillance, reuse, and other RSS test plans and test procedures shall be developed by the Range User and submitted to Range Safety for review and approval 45 calendar days prior to the need date. **NOTE:** A test procedure may not be required if Range Safety determines that the test plan alone adequately addresses the test parameters during each test sequence.

b. Test plans and test procedures shall be approved by Range Safety prior to testing.

c. Once approved, test plans and procedures shall not be revised. **NOTE:** Revisions to any part of an approved test plan or procedure require that the test plan or procedure be resubmitted to Range Safety for review and approval.

d. Each test report shall be provided to Range Safety for review and approval.

e. A list of all test plans, test procedures, and test reports shall be incorporated as appendixes to the RSSR.

4.4.3 RSS Installation and Checkout Procedures

a. Detailed procedures for checkout, calibration, and installation of all components of the RSS and its associated ground checkout equipment, including the launch day countdown procedures, shall be developed by the Range User and submitted to Range Safety for review and approval no later than 45 calendar days prior to the need date. **NOTE:** Previously used procedures may be submitted 30 calendar days prior to the need date.

b. Once approved, these procedures shall not be revised. **NOTE:** Revisions to any part of an approved procedure require that the procedure be resubmitted to Range Safety for review and approval.

c. A list of all procedures shall be incorporated as an appendix to the RSSR.

Test section of this Chapter

4.4.4 RSS Prelaunch Test Results

The following test results for each launch shall be submitted to Range Safety in a timely manner to facilitate a launch ready status:

4.4.4.1 FTS Prelaunch Test Results

a. One copy of the following Range prelaunch test results shall be submitted to Range Safety for each receiver/decoder specified by serial number no later than 30 calendar days prior to launch of that receiver/decoder:

1. Results of the vendor acceptance test

2. Results of the bench test required by the **FTS CRD Range Prelaunch Bench Test** section of this Chapter (ER only)

3. Results of the bench test required by the **FTS CRD Range Prelaunch Bench Test** section of this Chapter (WR only)

4. Results of the in-vehicle test required by the **ER CRD Prelaunch Systems Test** section of this Chapter (ER only)

b. Results of the antenna system test required by the **FTS Antenna Systems Prelaunch Tests** section of this Chapter

c. Results of the battery test required by the **FTS Battery Prelaunch Tests** section of this Chapter shall be submitted as soon as possible but no later than 24 h after completion of the test.

d. Any additional data that Range Safety deems necessary shall be submitted on a case-by-case basis.

4.4.4.2 RTS Prelaunch Test Results

a. Results of the antenna system test, as required by the **RTS Antenna Systems Prelaunch Tests** section of this Chapter

b. Results of the tracking aid vendor acceptance test

c. Results of the **RTS Transponder Prelaunch Bench Test** section of this Chapter

d. Results of the **RTS GPS Prelaunch Bench Test** sections of this Chapter

e. Results of the **RTS GPS Systems Prelaunch**

f. Results of the transponder RF closed loop mode performance test as required by the **RTS Transponder System Level Performance Test** section of this Chapter. **NOTE 1:** Results of this test shall be annotated on WSMC Form 5625. **NOTE 2:** Transponder performance characteristic data from this test is distributed to personnel at the WR tracking radar sites. To permit a timely dissemination of this data, WSMC Form 5625 shall be provided to Range Safety no later than 20 working days prior to the forecast launch date.

g. Results of the battery load and activation test required by the **RTS Battery Prelaunch Tests** section of this Chapter shall be submitted as soon as possible but no later than 24 h after the completion of the test.

4.4.5 RSS Component Test History

a. A test history shall be maintained for each RSS component with the exception of DC cabling.

b. The test history shall be made available to Range Safety upon request.

c. The test history shall include the following information:

1. Component serial number
2. Date of initial manufacture
3. Date of initial acceptance test procedure
4. Date of modification with brief description of the modification
5. Date of any subsequent tests or acceptance test procedures
6. Date of test and/or retest
7. Reason for the retest (failure, exceeded the certification period)
8. For each test, the test procedure shall be referenced and the parts of the test attempted shall be identified.
9. Any tests performed by the Range shall be annotated by the Range on the test history.

4.4.6 RSS Ground Support and Monitoring Equipment Calibration Program

a. A calibration program for ground support test equipment and for equipment in the ER Operations Safety Console and the WR Safety Console shall be developed and submitted to Range Safety for review and approval and included in the RSSR.

b. Data relative to calibration of the FTS ground support systems shall be provided to Range Safety upon request.

4.4.7 RSS Component and System Test

Failure Reports

Systems or components that fail to meet manufacturer specifications or the limits imposed by this Chapter shall not be approved for flight until corrective action, acceptable to Range Safety, has been made. **NOTE:** The requirement for reporting failure of a component or system to meet the requirements of a specific test applies to the tracking aid. It can be fulfilled by a properly executed WSMC Form 5632.

4.4.7.1 Reporting Component Failure to Meet Specifications

a. The failure of an RSS component or an identical non-RSS component to meet specifications shall be reported verbally to Range Safety within 72 h and in writing within 14 calendar days of the date the failure is noted.

b. This requirement includes failure of tests conducted at the supplier plant, contractor's plant, or at the Range.

c. A formal report containing a description of the failure, an analysis of the failure, and planned corrective actions shall be submitted to Range Safety within 30 calendar days of the failure analysis completion regardless of when or where the failure occurred. **NOTE:** Components whose test data reflect the unit is out-of-family when compared to other units shall be considered as out of specifications.

4.4.7.2 Reporting Component Failure to Meet System Test Requirements

a. The failure of an RSS component to meet system test requirements contained in this Chapter shall be reported verbally to Range Safety within 72 h of the failure.

b. A written report containing a description and analysis of the failure and planned corrective actions planned shall be submitted to Range Safety before the component is approved for flight.

4.4.7.3 Reporting In-Flight Anomalies

a. Any in-flight anomaly occurring in an RSS component or identical non-RSS component shall be reported to Range Safety immediately. **NOTE:** Anomalies include exposing an RSS component to an environment exceeding the maximum predicted environment (MPE).

b. A detailed written report containing a description and analysis of the anomaly and planned cor-

rective actions shall be submitted to Range Safety before the component will be approved for any subsequent flights.

4.4.8 Modifications to RSS Components and Systems

a. Modification or change to an approved RSS, RSS associated equipment, components, component identification, test procedures, performance test limits, basic characteristics, and ratings, including any firmware or software used on flight and ground equipment or any changes that may affect the safety and reliability of the RSS shall not be made without prior Range Safety approval.

b. If modifications are made without the approval of Range Safety, the approval of the entire system and approval to launch shall be revoked automatically until the change is approved.

c. Modification proposals, including the same type of data that would be required for the approval of a new system, shall be submitted to Range Safety for review and approval 60 calendar days prior to implementation and shall be submitted as an amendment to the RSSR.

4.4.9 Antenna Patterns

a. One copy of RSS antenna patterns on floppy discs and in graphical representation, developed in accordance with RCC document 253, shall be submitted to the Range.

b. The submittal schedule is found in RCC 253.

4.4.10 Telemetry Measurement List

Range Users shall submit the telemetry measurement list as required in the **TDTS In-Flight RSS Telemetry Data** section of this Chapter.

4.5 FLIGHT TERMINATION SYSTEM GENERAL REQUIREMENTS

4.5.1 Flight Termination System Description

a. A typical flight termination system (FTS) consists of a command destruct system, and an automatic destruct system.

b. Ideally, each powered stage of a vehicle should contain both a command and automatic destruct system.

c. Each new vehicle shall be evaluated and a determination made by Range Safety concerning FTS configuration. **NOTE:** Considerations such as

added weight, cost, vehicle design, breakup analysis, destruct response time, and mission objectives often result in acceptable alternative configurations. Range Safety may require Range Users to supply documentation such as breakup analysis (with or without destruct action) and tip-off analysis to support the evaluation.

d. The requirement for these and/or other analyses shall be identified by Range Safety as early in the conceptual design phase as possible.

4.5.1.1 Command Destruct System

A typical command destruct system consists of an antenna, battery, Command Receiver and Decoder (CRD), controls, relays, liquid engine shutdown devices, arming devices, destruct charges, and associated circuitry.

4.5.1.2 Automatic Destruct System

A typical automatic (ADS) consists of a power source, control logic, activation device, arming device, destruct charge, and associated circuitry.

4.5.1.2.1 Automatic Destruct System General Requirements.

a. An ADS shall be installed on each powered stage or strap-on motor not containing a command FTS if determined to be required by the Flight Safety Analysis Section.

b. The individual powered stage or strap-on motor ADS shall be designed to be activated upon launch vehicle breakup or premature separation of the individual powered stage or strap-on motor.

c. Each stage requiring an electrically initiated ADS shall contain dedicated power sources to supply the energy required to initiate destruct ordnance.

4.5.1.2.2 ADS Action Requirements.

a. Activation of the ADS on a stage or other propulsion system shall result in the appropriate flight termination action required by the **Flight Termination Action Requirements** section of this Chapter.

b. This action shall preclude the possibility of any stage being capable of powered flight without a method of flight termination.

4.5.1.2.3 ADS Activation and Timing.

a. The ADS may be activated by any method such as lanyard, microswitch, break wires, or similar activation or sensing device that activates the system upon launch vehicle breakup or premature separation.

b. A breakup analysis shall determine the best method of ADS activation and locations of ADS components to maximize ADS survivability during a breakup scenario.

c. The ADS shall be designed to survive vehicle breakup or inadvertent stage separation loads and initiate destruct action.

d. A timing analysis shall be performed on the ADS to calculate the worst case time between ADS triggering and final destruct action.

4.5.2 FTS Standard Configuration

a. The command FTS shall be installed on or above the last (uppermost) propulsive stage of the vehicle that is capable of violating Range Safety criteria.

b. All other stages capable of violating Range Safety criteria shall contain flight termination actuation devices capable of accomplishing the action required in the **Flight Termination Action Requirements** section of this Chapter.

4.5.3 FTS Configuration for Orbital Inserted Stages and Payloads

a. When an FTS is required, orbital inserted stages and payloads shall contain actuating devices capable of flight termination.

b. The FTS requirement for payloads may be met by locating the FTS for the payload at the launch vehicle/payload interface.

4.5.4 FTS Requirements for Propulsion Systems Other Than a Stage of the Vehicle

Propulsion systems such as ullage systems rockets, retro-rockets, or escape rockets that are not considered a stage of the vehicle, and that present radiological, toxicological, explosive, or other hazards in the event of premature ignition or separation, may require an FTS.

4.5.5 FTS Requirements for Manned Vehicles

a. Manned vehicle FTSs shall comply with all requirements of this document with the exception that the manned portion of the vehicle shall not require destruct capability.

b. If manned vehicles are flown unmanned, all requirements of this document shall be met.

c. Additional FTS requirements for manned vehicles are listed below:

1. The effect of abort action on engine shut-

down shall be approved by Range Safety.

2. Time delays between engine shutdown and destruct action required for crew escape shall be provided by the Range in the ground equipment. The extent of these delays shall be determined by vehicle parameters, the type of escape system, and the degree of hazard presented to public safety.

3. Payloads and their booster stages transported on or within a manned portion of a launch vehicle will be evaluated by Range Safety to determine the need for an FTS.

4.6 FLIGHT TERMINATION ACTION REQUIREMENTS

4.6.1 Liquid Propellant Vehicles

a. For vehicles consisting of all liquid propellant stages, both engine shutdown and destruct capability are required for each stage of the vehicle.

b. The Range transmitted ARM command shall be used as a preterminate logic function in the FTS receiver and shall cause nondestructive engine shutdown of all thrusting stages and inhibit ignition of all other liquid stages.

c. The subsequent Range transmitted DESTROY command or activation of the Automatic Destruct System (ADS) shall cause the following actions to occur:

1. For liquid propellant stages using toxic propellants, the destruct charges shall cause penetration of the propellant tanks and initiate rapid burning of the propellants so that as much propellant as possible is consumed or dispersed.

2. For liquid propellant stages using non-toxic propellants, the destruct charges shall cause penetration of the fuel and oxidizer propellant tanks to the extent necessary for rapid dispersion of the propellants.

d. The destruct charge shall not detonate the liquid propellants.

4.6.2 Solid Propellant Vehicles

a. For vehicles consisting of all solid propellant stages, the Range transmitted ARM command shall be used only as a preterminate logic function within the FTS receiver.

b. The subsequent Range transmitted DESTROY command or activation of the automatic FTS shall cause the destruct charge to destroy the pressure integrity of the motor and should ignite any non-burning propellant.

c. Destruct action shall cause a condition of zero

thrust or any residual thrust shall cause tumbling such that no significant lateral or longitudinal deviation of the impact point could result.

d. For propellant formulations (double-base composites like DDP-70 and cross-linked Poly Ethylene Glycol [PEG] high energy formulations) that are sensitive to shock to the extent that impact at a velocity greater than 250 ft/sec may result in detonation or explosion, destruct charges shall be designed to split the motor case and break up the propellant grain into fragments. **NOTE:** The goal is to have fragments not greater than 10,000 lb.

e. The destruct charge shall not detonate the solid propellant.

4.6.3 Combination Liquid and Solid Propellant Vehicles

For vehicles using a combination of liquid and solid stages, the requirements of the **Liquid Propellant Vehicles** and **Solid Propellant Vehicles** sections of this Chapter are applicable to individual stages.

4.6.4 Solid Propellant Thrust Augmenting Rockets

When solid propellant thrust augmenting rockets are used with a liquid propellant stage, they shall be treated as solid propellant stages and the **Solid Propellant Vehicles** section of this Chapter shall apply.

4.6.5 Auxiliary Propulsion Systems

If required, the FTS for auxiliary propulsion systems shall cause the same actions as required in the following sections of this Chapter: **Liquid Propellant Vehicles**, **Solid Propellant Vehicles**, and **Combination Liquid and Solid Propellant Vehicles**.

4.7 FLIGHT TERMINATION SYSTEM DESIGN REQUIREMENTS

4.7.1 FTS General Design Requirements

4.7.1.1 FTS Component Redundancy

NOTE: The only exceptions to this redundancy requirement, if approved by Range Safety, are FTS antenna/RF transmission systems.

a. All launch vehicles and payloads and their stages determined by Range Safety to need an FTS shall contain redundant FTS command and automatic destruct components.

b. This redundancy shall be structural, mechanical, and electrical with maximum practical physical

separation between redundant components.

c. Physically redundant components shall be mounted in different orientations on different axes where technically possible.

d. There shall be one dedicated battery for each redundant leg of the FTS.

e. The batteries used in the FTS shall be independent of all other vehicle systems.

f. Redundant destruct charges shall be provided unless Range Safety approved analyses (breakup, space considerations, feasibility, reliability, and other analyses) clearly indicate that redundant destruct charges are not required.

4.7.1.2 FTS Design Simplicity

a. The number of FTS components and piece/parts shall be kept to an absolute minimum.

b. The destruct command output signal from the command receiver and decoder (CRD) shall be designed to go directly to FTS arming devices such as safe and arm (S&A), exploding bridgewire firing unit (EBW-FU), and laser firing unit (LFU). **NOTE:** Any component that interrupts this direct path shall be technically justified.

4.7.1.3 FTS Component Isolation

FTS components shall be independent of other vehicle components and systems.

4.7.1.4 FTS Fratricide

a. FTS design shall be such that the flight termination action of a stage will not sever interconnecting FTS circuitry or ordnance to other stages until the other stages have been initiated.

b. Analysis verifying compliance with this requirement may be required by Range Safety.

4.7.1.5 FTS Software and Firmware

a. All software and firmware used in FTS shall be subjected to independent verification and validation (IV & V) in accordance with DoDI 5000.2, AF Sup 1 paragraph 3-9 and AFSC/AFLC Pamphlet 800-5 or equivalent.

b. Approval shall be obtained from Range Safety prior to production of the component or system.

c. Once approved, any modification shall be validated in the same manner and approved by Range Safety prior to further production.

4.7.1.6 FTS Failure Mode, Effects, and Criticality Analysis

A Failure Modes, Effects, and Criticality Analysis

(FMECA) shall be performed in accordance with MIL-STD-1543 (Task 204) or equivalent.

4.7.1.7 FTS Laser Systems

Laser systems shall meet the requirements of Vandenberg Air Force Base (VAFB) Regulation 161-6 and the 45th Space Wing Radiation Protection Program (45 SPWR 160-1).

4.7.1.8 FTS Component Maximum Predicted Environment

4.7.1.8.1 Determining FTS Component Maximum Predicted Environment Levels.

a. An analytical approach for determining FTS component maximum predicted environment (MPE) levels such as shock, thermal, and vibration shall be developed by the Range User and submitted to Range Safety for review and approval.

b. The analytical approach shall use existing flight data from other similar vehicles (if available), analysis, computer modeling, and subsystem testing such as bracket and truss vibration testing.

c. If there are fewer than three existing flight data samples, a minimum 3 decibel (dB) margin for vibration, 4.5 dB for shock, and 11°C for thermal shall be added to the analytical environment to obtain the predicted MPE.

4.7.1.8.2 Validating the FTS Predicted MPE. The predicted MPE shall be validated by actual environmental load measurements taken during launch and flight of at least three vehicles. If all data does not correlate, then additional load measurements on additional vehicles shall be taken.

4.7.2 FTS Environmental Design Margin

4.7.2.1 FTS Environmental Design Margin General Requirements

a. The FTS shall be designed to function normally under environmental forces greater than those that would result in breakup of the vehicle.

b. FTS components, including methods of attachment, mounting hardware, and cables and wires, shall be designed to function within performance specifications when exposed to environmental levels that exceed the ground transportation, pre-launch processing, checkout, and launch through end of Range Safety responsibility.

c. FTS design shall take into consideration the test requirements in Appendixes 4B1 through 4B11.

4.7.2.2 FTS Component Thermal Environment

4.7.2.2.1 Nonordnance Devices.

a. Unless otherwise specified by Range Safety, FTS nonordnance devices shall be designed to function normally in thermal environments 10°C higher and 10°C lower than the predicted thermal range.

b. The minimum design thermal range shall be -34°C to +71°C. *EXCEPTION: Batteries shall meet the requirements in paragraph a above.*

c. The nonordnance devices shall be designed to survive the thermal environment for a minimum of 24 qualification cycles and 8 acceptance cycles. *EXCEPTION: Batteries shall meet the requirements in Appendix 4B4.*

4.7.2.2.2 Ordnance Devices.

a. Unless otherwise specified by Range Safety, FTS ordnance devices shall be designed to function normally in thermal environments 10°C higher and 10°C lower than the predicted thermal range.

b. The minimum design thermal range shall be -54°C to +71°C.

c. Ordnance devices shall be designed to survive this thermal environment for a minimum of 8 cycles.

4.7.2.3 FTS Component Random Vibration Environment

a. Unless otherwise specified by Range Safety, FTS components shall be designed to survive random vibration environments that are 6 dB above the MPE level or a minimum of 12.2 Grms, whichever is greater.

b. The minimum design duration shall meet the following criteria:

1. Three times the expected flight exposure time or 3 min per axis, whichever is greater, for qualification

2. The flight exposure time or 1 min per axis, whichever is greater, for acceptance

c. The minimum frequency range shall be from 20 to 2000 Hz.

4.7.2.4 FTS Component Acoustic Noise Environment

a. Unless otherwise specified by Range Safety, FTS components shall be designed to survive acoustic noise that are 6 dB above the MPE level or a minimum 144 dB overall sound pressure for acoustic, whichever is greater.

b. The minimum design duration shall meet the

following criteria:

1. Three times the expected flight exposure time or 3 min, whichever is greater, for qualification
2. The flight exposure time or 1 min, whichever is greater, for acceptance

4.7.2.5 FTS Component Shock Environment

- a. Unless otherwise specified by Range Safety, FTS components shall be designed to a margin of 6 dB above the MPE level or a minimum of 1300 G, whichever is greater.
- b. The duration shall simulate the actual shock environment.
- c. The minimum frequency range shall be from 100 to 10,000 Hz.
- d. The minimum number of shocks shall be 3 shocks per axis for each direction, positive and negative, for a total of 18 shocks.

4.7.2.6 FTS Component Acceleration Environment

- a. Unless otherwise specified by Range Safety, FTS components shall be designed to 2 times the MPE level or a minimum of 20 G, in each direction, whichever is greater.
- b. The minimum duration for acceleration shall be 5 min per axis.

4.7.2.7 Other FTS Component Environments

- a. Other environments applicable to FTS components are humidity, salt fog, dust, fungus, explosive atmosphere, thermal vacuum, electromagnetic compatibility (EMC), electromagnetic interference (EMI), sinusoidal vibration, and other non-operational environments.
- b. Tests and test levels for these environments are described in Appendixes 4B1 through 4B10.

4.7.3 FTS Reliability

4.7.3.1 FTS Reliability Goal

- a. The overall FTS system reliability goal shall be a minimum of 0.999 at the 95 percent confidence level.
- b. This reliability goal shall be satisfied by

combining the design approach and testing requirements described in this Chapter.

- c. A reliability analysis shall be performed in accordance with guidelines in MIL-STD-785 to demonstrate the reliability goal was used in the concept and detailed design of the components and/or system.

4.7.3.2 FTS Single Point Failure

- a. The FTS, including monitoring and checkout circuits, shall be designed to eliminate the possibility of a single failure point (SFP) inhibiting the function of the system or causing an undesired output of the system.
- b. An SFP analysis shall be performed to verify compliance with this requirement.

4.7.4 FTS Design Life

4.7.4.1 FTS Electrical Component Design Life

- a. Electrical components shall have their operating and storage life specified.
- b. The operating and storage life for electrical components starts at completion of the initial acceptance test.
- c. Range Safety shall be notified if the operating and storage life of an FTS component expires prior to launch.
- d. If required, expired component retest shall be determined by mutual agreement between Range Safety and the Range User.

4.7.4.2 FTS Ordnance Component Design Life

- a. Ordnance components shall have their service life and shelf life specified.
- b. Range Safety shall be notified if the service life of a component expires prior to launch.
- c. If required, expired component retest shall be determined by mutual agreement between Range Safety and the Range User.

4.7.5 FTS Arming Device Design

4.7.5.1 FTS Arming Device Design for Surface Launched Vehicles

- a. The FTS arming device for surface launched vehicles shall be designed so that all command and automatic FTS arming devices are armed prior to arming launch vehicle and payload ignition circuits.
- b. Remote hardline and RF telemetry shall be provided to verify the armed status of each FTS arming device.

4.7.5.2 FTS Arming Device Design for Air or Sea Launched Vehicles

For those air or sea launched vehicles in which propulsive ignition occurs after first motion, an ignition interlock shall be provided for mechanically or electrically armed systems so that ignition cannot occur unless the FTS arming devices are armed.

4.7.6 FTS Prelaunch and In-Flight Safing Design

4.7.6.1 Prelaunch FTS Safing Design

Redundant ground safing systems shall be provided to remotely safe the FTS arming device.

4.7.6.2 In-Flight FTS Safing Design

4.7.6.2.1 ADS Safing.

a. The airborne safing system hardware and software used to safe the ADS shall be single fault tolerant against inadvertent safing.

b. Safing shall depend on a minimum of two independent vehicle parameters such as altitude and time.

c. Unless otherwise specified by Range Safety, the single fault tolerant safing requirement shall be met by providing an airborne safing system which requires two independent and physically separate control devices such as a guidance computer and an external timer to safe the ADS.

4.7.6.2.2 Command FTS Safing.

a. In some cases, it may be necessary to safe the command FTS in flight when the vehicle has proceeded beyond the limits of Range Safety responsibility.

b. The need to safe the FTS shall be justified and approved by Range Safety.

c. In these cases, the safing action shall be accomplished by automatic functions within the vehicle

1. The airborne safing system hardware and software used to safe the command destruct system shall be single fault tolerant against inadvertent safing.

2. Safing shall depend on a minimum of two independent vehicle parameters such as altitude and time.

3. Unless otherwise specified by Range Safety, the single fault tolerant safing requirement shall be met by providing an airborne safing system that requires two independent and physically separate control devices such as a guidance computer and an external timer to safe the ADS.

rate control devices such as a guidance computer and an external timer to safe the command FTS.

d. In the event safing cannot be accomplished automatically and can be justified to and approved by Range Safety, safing can be accomplished by radio command using command transmitters.

4.7.7 FTS Electrical and Electronic Systems Design

4.7.7.1 FTS Piece/Part Selection Criteria

a. Piece/parts used in FTS electronic components shall meet the requirements of ELV-JC-002D (including Amendment 2) for Category 1 components.

b. Addition, subtraction, or replacement of piece/parts in a Range Safety approved FTS component shall require specific approval.

4.7.7.2 FTS Voltage and Current Parameters

a. The input voltage range of each component shall be specified, and the current in the stand-by and operating modes shall be noted in the specification.

b. The components shall meet the requirements of this Chapter at any voltage level between the minimum and maximum specified.

c. The components shall not produce an output or be damaged because of low or fluctuating input voltage.

4.7.7.3 FTS Transient Voltage Generation

All FTS and vehicle system interface components containing reactive elements such as relays, electrical motors or similar devices, that are capable of producing transient voltages shall be provided with suppression circuitry to prevent interference or damage to other FTS components.

4.7.7.4 FTS Voltage Protection

a. FTS components shall not be damaged by the application of up to 45 volts, direct current (Vdc) or the open circuit voltage (OCV) of the power source, whichever is greater.

b. This voltage shall be applied in both normal and reverse polarity modes to the component power input ports for a period not less than 5 min.

4.7.7.5 FTS Series Redundant Circuits

FTS components that use series redundant branches in the firing circuit to satisfy the no single failure point (SFP) requirement shall provide monitoring circuits or test points to verify integrity

of each redundant branch after assembly.

4.7.7.6 FTS Switch and Relay Selection Criteria

- a. Any power transfer switch and/or assembly shall not change state as a result of input power drop-out for a period of 50 milliseconds minimum.
- b. Relays shall be designed and/or selected to prevent chatter.
- c. Relays that are series inhibits shall be mounted on axes to minimize the potential of vibration or shock activating more than one of the relays simultaneously.
- d. Electromechanical and solid-state switches and relays used in the firing circuit shall be capable of delivering the maximum firing current for a time interval at least 10 times the duration of the intended firing pulse.

4.7.7.7 FTS Continuity and Isolation

- a. The isolation resistance of the output pin to input pins and case ground shall not be less than 2 megohms.
- b. The resistance from each pin to common return and/or case ground shall also be specified.
- c. Measurements that are polarity-sensitive, such as those containing diodes, shall be identified.
- d. Significant pin-to-pin measurements shall be included where their inclusion will provide meaningful data relative to the health of the component.

4.7.7.8 FTS Circuit Isolation

- a. FTS circuitry shall be shielded, filtered, grounded, or otherwise isolated to preclude energy sources such as electromagnetic energy from the Range and/or launch vehicle causing interference that would inhibit the functioning of the system or cause an undesired output of the system.
- b. Electrical firing circuits shall be isolated from the initiating ordnance case, electronic case, and other conducting parts of the vehicle.
- c. If a circuit must be grounded, there shall be only one interconnection (single point ground) with other circuits.
- d. The interconnection (single point ground) shall be at the power source only. **NOTE:** Static bleed resistors between 10 kilohms and 100 kilohms are not considered to violate the single point ground. Other ground connections with equivalent isolation will be handled on a case-by-case basis.
- e. Ungrounded circuits, capable of building up

static charge, shall be connected to the structure by static bleed resistors of between 10 kilohms and 100 kilohms.

4.7.7.9 FTS Circuit Shielding

- a. Shields shall not be used as intentional current carrying conductors.
- b. Electrical firing circuits shall be completely shielded or shielded from the initiating ordnance, EBW firing unit, or laser firing unit (LFU) back to a point in the firing circuit at which filters or absorptive devices eliminate RF entry into the shielded portion of the system.
- c. RF shielding shall provide a minimum of 85 percent of optical coverage ratio. **NOTE:** A solid shield rather than a mesh would have 100 percent coverage.
- d. There shall be no gaps or discontinuities in the termination at the back faces of the connectors nor apertures in any container that houses elements of the firing circuit.
- e. Electrical shields terminated at a connection shall be joined around the full 360° circumference of the shield.
- f. The DC bonding resistance between connection points of the shielded system, metallic enclosures, and structural ground shall be 2.5 milliohms or less.
- g. Firing, control, and monitor circuits shall be shielded from each other.

4.7.7.10 FTS Circuit Protection

- a. The FTS firing circuitry shall not contain fuses or similar type protection devices. For exceptions to this requirement, see the **FTS Battery Design** section of this Chapter. **NOTE:** Current limiting resistors are permitted in firing circuits.
- b. When the output of FTS component is interfaced with vehicle functions such as CRD ARM command, the output circuit shall be protected against overcurrent including a direct short by such means as fuses, circuit breakers, and limiting resistors.

4.7.7.11 FTS Repetitive Function

All circuitry, elements, components, and subsystems of the FTS shall be capable of withstanding, without degradation, repetitive functioning for 100 times or 5 times the expected number of cycles required for checkout and operation, whichever is greater.

4.7.7.12 FTS Sneak Circuits

Firing circuit design shall preclude sneak circuits and unintentional electrical paths such as ground loops and failure of solid state switches.

4.7.7.13 FTS Watchdog Circuits

Watchdog circuits that automatically shutdown or disable FTS circuitry when certain parameters are violated, such as snap-on and snap-off circuits in power supplies, shall be specifically approved by Range Safety. The parameters shall be specified in the component specification and included in testing.

4.7.7.14 FTS Testability

FTS and associated ground support and monitoring equipment design shall provide the capability to perform the prelaunch tests described in the **RSS Test Requirements** section of this Chapter.

4.7.7.15 FTS Self-Test Capability

a. If the component uses a microprocessor, it shall have the capability to perform a self-test (error detection) and output the results via telemetry.

b. The self-test shall be capable of initiation by POWER ON and upon receiving a special test command.

c. Failure of a self-test shall not intentionally disable the component.

d. The execution of a self-test shall not inhibit the processing intended function of the unit or cause any output to change state.

4.7.7.16 FTS Interference Protection

The FTS component shall be designed to meet the requirements of MIL-STD-461, Class A2, Methods: CE 102, CE 106, CS 101, CS 103, CS 104, CS 105, CS 114, CS 115, CS 116, RE 102, RE 103, and RS 103. For RS 103 test C-band and S-band frequencies shall use 0 dBm instead of MIL-STD-461 level.

4.7.8 FTS Low Voltage EED System Circuitry Design

In addition to the requirements noted in the **FTS Electrical and Electronic Systems Design** section of this Chapter, the following requirements shall be met for low voltage EED systems:

a. An electromechanical safe and arm (S&A) device is required for interruption of the firing circuit and ordnance train.

b. The EED system circuitry shall be designed to limit the power produced at each EED by the electromagnetic environments acting on the system to a level at least 20 dB below the pin-to-pin DC no-fire power of the EED.

c. The FTS shall be designed to provide for final electrical connections to the initiator to be made as late in the countdown as possible.

d. The operating current delivered to an EED shall be a minimum of (1) 1.5 times the all-fire (qualification test level) or (2) 2 times the Bruceton or (3) the manufacturer recommended sure-fire current, whichever is greater.

e. The operating current specified above shall be at the lowest system battery voltage and using the worst case system tolerances.

4.7.9 FTS High Voltage EBW System Circuitry Design

In addition to the requirements noted in the **FTS Electrical and Electronic Systems Design** section of this Chapter, the following requirements shall be met for high voltage EBW systems:

a. EBW systems shall use arming and safing plugs, in addition to EBW Firing Units (EBW-FUs).

b. Trigger circuits shall be designed to activate upon the input of a single destruct signal during flight.

c. Any component and/or circuit such as inhibits or Fire Zero (Fire^o) that interrupts these direct paths shall be technically justified.

d. The FTS shall be designed to provide for final electrical connections to the initiator to be made as late in the countdown as possible.

e. Operating voltage delivered to an EBW shall be a minimum of (1) 1.5 times the all-fire (qualification test level) or (2) 2 times the Bruceton or (3) the manufacturer recommended sure-fire voltage, whichever is greater.

f. The EBW initiator shall be designed to initiate reliably (0.999 at 95 percent confidence level) by application of an electrical pulse from an EBW-FU that conforms to the program specifications as approved by Range Safety.

g. Bruceton-type testing or other statistical methods acceptable to Range Safety shall be performed to establish reliability.

4.7.10 FTS Laser Initiated Ordnance System Circuitry Design

4.7.10.1 Optic Systems

a. The laser initiated ordnance system (LIOS) optic system design shall preclude stray energy sources such as photostrobe, magnified sunlight, arc welding, xenon strobe, lightning, static electricity, and RF from causing interference that would inhibit system function or cause an undesired output.

b. This requirement shall be demonstrated during development and qualification testing.

c. The FTS shall be designed to provide for final optical connections to the initiator to be made as late in the countdown as possible.

4.7.10.2 LIOS Power Sources

a. LIOS power sources shall have a minimum of two independent and verifiable inhibits.

b. One of these inhibits for the main laser shall be a power interrupt plug that removes all airborne and ground power to the laser firing unit (LFU).

4.7.10.3 LIOS Safety Devices

4.7.10.3.1 High Voltage LIOS Safety Devices. High voltage LIOSs shall use one of the following safety devices:

a. Laser Firing Units

1. An LFU shall be used in conjunction with two optical barriers capable of being armed and safed and locked and unlocked remotely.

2. A manual safe plug capable of interrupting power to the barrier control circuits shall be provided.

b. An optical S&A

c. An ordnance S&A

4.7.10.3.2 Low Voltage LIOS Safety Devices. Low voltage LIOSs such as Diode Lasers shall use one of the following safety devices:

a. An optical S&A

b. An ordnance S&A

4.7.10.4 LIOS Firing Circuits

In addition to the requirements noted in the **FTS Electrical and Electronic Systems Design** section of this Chapter, the following requirements shall be met for LIOS Firing Circuits:

a. Energy delivered to an LID shall be a minimum of (1) 2 times the all-fire (qualification test level) or (2) the manufacturer recommended sure-fire energy level, whichever is greater.

b. LIOS firing circuits shall be designed to activate upon the input of a single destruct signal during flight.

c. Any component and/or circuit such as inhibits or Fire Zero (Fire^o) that interrupts these direct paths shall be technically justified.

d. Low Energy Level End-to-End Test Requirements. If a low energy level end-to-end test is to be performed by the Range User when the LIOS is connected to the receptor ordnance, the following criteria shall be met:

1. The energy level shall be less than 1/10,000 of the no-fire level of the LID.

2. The single failure mode maximum energy level of the test system shall be less than 1/100 of no-fire level of the LID.

3. The test source shall emit a different wave length than the main firing unit laser.

4. One of the following inhibit options shall be implemented during a low energy level test:

(a) An ordnance S&A device and a safe plug that interrupts power to the main laser shall be required.

(b) Three independent verifiable inhibits shall be in place to preclude inadvertent initiation of the LID by the main firing unit laser during the low level energy test. One of the inhibits shall be a safe plug that interrupts power to the main laser.

e. LIOS Main Laser Subsystem Firing Test Requirements. If a main laser subsystem firing test is performed by the Range User when the LIOS is connected to the receptor ordnance, a minimum of three independent, verifiable inhibits shall be in place.

1. Two of the inhibits shall be optical barriers capable of being independently locked in place.

2. The third inhibit shall be a safe plug that interrupts the power control circuit or circuits to the optical barriers.

4.7.10.5 LIOS Laser Emission Path Enclosures

Lasers shall be completely enclosed during check-out or provided with ground support equipment that can enclose the laser emission path at all times the system is powered.

4.7.10.6 LID Design Reliability

a. LIDs shall be designed to initiate reliably

(0.999 at the 95 percent confidence level) by application of an energy pulse from an LFU that conforms to the program specifications as approved by Range Safety.

b. Bruceton-type testing or other statistical methods acceptable to Range Safety shall be performed to establish reliability.

4.7.11 FTS Ordnance Train Design

4.7.11.1 FTS Ordnance Train General Design

a. Destruct ordnance trains may include any or all of the following items:

1. Initiators and/or detonators
2. Energy transfer lines
3. Boosters
4. Explosive manifolds
5. Destruct charges

b. The destruct ordnance train shall be designed to reliably initiate with the energy provided by the command or automatic FTS.

c. Upon initiation, the destruct action shall reliably propagate through the ordnance train, initiate the destruct charges, and result in the appropriate destruct action.

d. Destruct ordnance shall be designed, but not limited to, a service life of at least 10 years.

e. The service life of each production lot of ordnance train components containing explosives must be verified by tests contained in Appendixes 4B1 and 4B6 through 4B10.

f. The decomposition, cook-off, and melting temperatures of all explosives shall be at least 30°C higher than the maximum predicted environmental temperature to which the material will be exposed during storage, handling, installation, and transportation.

g. Specific approval from Range Safety is required for all explosive compositions.

h. Explosive ordnance shall be manufactured in accordance with documented procedures and process control.

i. Manufacturer process controls shall provide a supplier controlled baseline that assures subsequent production items can be manufactured that are equivalent in performance, quality, and reliability to initial production items used for qualification and flight.

j. Redundant destruct charges shall be used unless otherwise approved by Range Safety.

k. If a single destruct charge is approved, the destruct charge shall be initiated by a minimum of two structurally and functionally independent initiators. Linear-shaped charges shall be initiated at each end by an independent initiator.

l. An electrically conductive path shall exist between metallic part(s) of the ordnance train (excluding the electrically initiated detonator), fittings, bracket holder, and the vehicle ground plane. The bonding resistance shall not exceed 5 ohms.

m. The bonding resistance between the electrically initiated detonator, the detonator holder such as an S&A device, metallic fitting, and the vehicle ground plane shall not be greater than 2.5 milliohms per each connection.

4.7.11.2 FTS Ordnance System Initiating Device Installation

a. Ordnance systems shall be designed so that the initiating devices can be installed in the system just prior to final electrical and/or optical hookup on the launch pad.

b. The initiating device locations shall be accessible to facilitate installation and/or removal and electrical and/or optical connections as late as possible in the launch countdown.

c. Launch complexes shall be designed to accommodate this accessibility requirement.

4.7.11.3 FTS Ordnance Interface

a. All ordnance components and interfaces, including S&A rotor leads and/or booster charges, shall be designed with the following performance margins:

1. The ability of the detonating donor to propagate the detonation to the receptor without failure shall be demonstrated by one of the following methods:

(a) A minimum of 10 firings using a donor charge that is 75 percent or less of the minimum specified charge and at the nominal operating temperature shall be conducted. Half of the test firings shall be conducted using the minimum specified air gap and half conducted using the maximum specified air gap.

(b) A minimum of 10 firings using the specified nominal donor charge and at the nominal operating temperature shall be conducted. Half of these test firings shall be conducted using an air gap

that is at least four times the maximum design air gap width or a 0.15 in. gap (whichever is greater) and half conducted using an air gap that is 50 percent of the minimum design air gap.

2. Axial and/or angular alignment tolerance shall be specified for each ordnance fitting interface. A minimum of 10 firings shall be conducted at the nominal temperature to demonstrate that the ordnance items will function when offset 4 times the nominal alignment tolerance at maximum air gap.

3. Unless otherwise agreed to by Range Safety, margin testing shall be conducted in an enclosure that simulates the actual internal volume of flight configuration.

b. Detonation interconnects or crossovers shall not be used between redundant explosive trains unless approved by Range Safety.

c. Detonation transfer in an ordnance train shall be accomplished using the end-to-end transfer mode.

1. Designs that preclude use of the end-to-end transfer mode may use end-to-side or side-to-end, in that order of preference.

2. Side-to-side detonation transfer mode shall not be used unless approved by Range Safety.

d. The distance from the point of ordnance train initiation by electrical and/or optical energy to the destruct charge shall be as short as possible.

4.7.11.4 FTS Ordnance Hazard Classification and Compatibility

a. Ordnance items shall be assigned to the appropriate Department of Defense (DoD) or United Nations (UN) hazard classification and the storage compatibility group in accordance with DoD 6055.9-STD.

b. Items that have not previously been classified and cannot be classified based on similarity with previously classified items shall be tested in accordance with AFTO 11A-1-47 (NAVSEAINST 8020.3/TB 700-2/DLAR 8220.1) and classified accordingly. **NOTE:** The Range User is responsible for having the tests run and submitting the results to Range Safety.

c. Ordnance items shall also have a Department of Transportation (DOT) classification.

d. The Range User shall provide documentation demonstrating proper classification to Range Safety prior to delivery of the ordnance to the Ranges.

4.7.12 FTS Monitor, Checkout, and Control Circuit Design

4.7.12.1 FTS Monitor, Checkout, and Control Circuit General Design

a. Monitor, checkout, and control circuits shall be designed so that the actual status of critical parameters can be monitored directly during prelaunch and flight. Critical parameters to be monitored are specified in the **TDTs In-Flight RSS Telemetry Data, ER Operations Safety Console, and WR Safety Console and RSS Repeater System** sections of this Chapter.

b. Monitor, control, and checkout circuits shall be completely independent of the firing circuits and shall use a separate and non-interchangeable electrical connector.

c. Monitor, control, and checkout circuits shall not be routed through ARM or SAFE plugs unless approved by Range Safety.

d. The electrical continuity of one status circuit (SAFE or ARM) shall completely break prior to the time that the electrical continuity is established for the other status circuit (ARM or SAFE).

4.7.12.2 FTS Monitor and Checkout Circuits

a. The function of the FTS shall not be affected by the external shorting of a monitor circuit or by the application of any positive or negative voltage between 0 and 45 Vdc for up to 5 min to an FTS monitor circuit.

b. Monitor and checkout current in an EED system firing line shall not exceed 1/10 the no-fire current of the EED or 50 milliamperes, whichever is less.

c. The monitor circuit that applies current to the EED shall be designed to limit the open circuit output voltage not greater than 1 volt.

d. Monitor circuits shall be designed so that application of operational voltage shall not cause inadvertent function or loss of function of the FTS nor cause the FTS to be armed.

e. Resolution, accuracies, and data rate for monitor circuit outputs shall be specified for both RF and hardline and shall be submitted to Range Safety for review and approval.

f. Maximum and minimum values for monitor circuit outputs shall be specified and submitted to Range Safety for review and approval.

4.7.12.3 FTS Control Circuits

Control circuits shall be electrically isolated from the firing circuit so that a stimulus in these circuits

does not induce a stimulus greater than 20 dB of activation level in the firing circuit.

4.8 FTS COMPONENT DESIGN REQUIREMENTS

4.8.1 FTS Antenna System Design

4.8.1.1 FTS Antenna System Radio Command Coverage

a. The FTS antenna system shall provide adequate gain coverage over 95 percent of the radiation sphere.

b. The FTS shall be capable of reliable operation with signals having electromagnetic field intensity 12 dB below the intensity provided by the Range at any point along the vehicle trajectory where the Range retains safety responsibility for the flight vehicle.

c. Deep nulls in the pattern shall be minimized both as to the number of nulls and angular width.

d. The entire ground and airborne command FTS shall be subjected to an RF link analysis that shall show a minimum of 12 dB margin.

e. The RF link analysis shall include path losses due to plume or flame attenuation, aspect angle, vehicle trajectory, ground system RF characteristics, and any other possible attenuation factors.

f. Antenna patterns shall be provided to Range Safety in accordance with RCC 253 and shall be used in the RF link analysis.

4.8.1.2 FTS Antenna System Components

a. Power splitters, combiners, hybrids, coaxial cables or other passive devices used to connect the antenna to the CRD shall be considered as part of the FTS antenna system.

b. An RF coupler shall be used on FTSs that employ multiple antenna.

1. Hybrid couplers that inherently offset the phase (90° or 180°) between the outputs are preferred.

2. Use of other style couplers shall be technically justified and approved by Range Safety.

3. If a dedicated, independent FTS antenna system is used for each CRD, each antenna system shall meet the requirements specified in this section.

d. The bandwidth of the FTS antenna system shall be ± 180 kilohertz (kHz) minimum.

e. FTS antenna system components shall be designed for a nominal 50 ohms impedance.

f. The antenna system shall have a voltage standing wave ratio (VSWR) of 2:1 or less across

g. If FTS antenna heat shields are used, they

shall be considered part of the antenna system and shall be subjected to all the antenna system requirements for design, test, pattern measurements and approval. **NOTE:** All antenna heat shields shall be subjected to a fly-off analysis that includes test data reflecting antenna performance with and without the heat shields.

4.8.1.3 FTS Antenna System Compatibility

The FTS antenna system shall be fully compatible with the ground command transmitters and their left-hand circular polarized antennae.

4.8.2 FTS Standard Command Receiver and Decoder Design

In addition to the requirements specified below, information on the FTS Command Receiver and Decoder (CRD) design and test requirements may be found in the RCC 313. In the case of conflicts between the requirements of this Chapter and RCC 313, the requirements of this Chapter shall take precedence.

4.8.2.1 FTS Standard CRD General Design Requirements

a. ARM, DESTRICT, and optional output commands shall be routed through a separate connector(s) from input power, monitor circuits, and RF inputs.

b. RF inputs shall be routed through a dedicated connector.

c. After initial adjustment, the CRD shall perform in accordance with the requirements of this section without subsequent adjustment.

d. The CRD sealing shall be designed to survive exposure to environments such as humidity, salt, and fog as described in Appendix 4B1.

e. The CRD shall be capable of delivering the specified power to the specified load on each output at any CRD input power supply voltage level between the minimum and maximum.

f. The output load impedance characteristics shall be defined in the procurement specification and all output load testing must be conducted under the specified load characteristics.

g. The maximum leakage current through the command destruct output port shall be specified in the procurement specification and shall not be more than 50 microamperes.

4.8.2.1.1 CRD Interference Protection. The CRD shall be designed to meet the requirements of MIL-STD-461, methods CE102, CE106, CS101, CS103, CS104, CS105, CS114, CS115, CS116, RE102, RE103, and RS103. *EXCEPTIONS: CS104 limits are changed to 60 dB above threshold sensitivity at center frequency; and RS103 shall be at least 0 dBm throughout the following frequency ranges: 2200-2400 MHz, 5400- 5900 MHz, and 9200-9600 MHz.*

4.8.2.1.2 CRD Radiation Analysis. Launch vehicle and payload systems shall be analyzed to ensure that radiations profiled are not greater than the environment the CRD is tested to.

4.8.2.1.3 CRD Transient Response. The tolerance-to-transient voltages shall be specified for each input/output connector.

a. Amplitude, polarity, rise time, and duration shall be identified.

b. The CRD shall not produce any output and shall meet the performance requirements after the application of the specified transient.

4.8.2.2 Standard Receiver

4.8.2.2.1 Standard Receiver Operating Frequency Band.

a. The receiver shall be operable over the frequency range of 400-450 MHz.

b. Unless otherwise directed by Range Safety, all ER/WR receivers shall be factory tuned to 416.5 MHz by use of fixed tuning elements.

c. Operating frequency changes shall require rework at the original manufacturer.

4.8.2.2.2 Standard Receiver Input VSWR and Impedance. The receiver RF input VSWR shall be 2:1 or less with respect to 50 ohms across the specified bandwidth of the assigned operating frequency.

4.8.2.2.3 Standard Receiver RF Sensitivity. The receiver measured threshold sensitivity shall be between -107 dBm and -116 dBm across a 50 ohms impedance. **NOTE:** Subsequent sensitivity bench test results shall be within ± 3 dB of original acceptance test measurements.

4.8.2.2.4 Standard Receiver Maximum Usable RF Input. The receiver shall be capable of operating within its performance specification

limits during and after the application of RF signal levels between the threshold and +13 dBm.

4.8.2.2.5 Standard Receiver Operational Bandwidth. The receiver shall initiate and sustain all command functions over a continuous range of ± 45 kHz from the assigned RF center frequency when subjected to command tones having deviations of plus and minus 30 ± 3 kHz peak per tone and at the specified threshold sensitivity level.

4.8.2.2.6 Standard Receiver Peak to Valley Ratio. The intermediate frequency (IF) filter peak-to-valley ratio shall not exceed 3 dB within ± 45 kHz of the assigned operating frequency.

4.8.2.2.7 Standard Receiver Continuous Wave Bandwidth. The receiver shall provide an IF bandwidth of 180 kHz minimum at 3 dB points and 360 kHz maximum at the 60 dB points.

4.8.2.2.8 Standard Receiver Noise Immunity. The CRD shall not produce command outputs when subjected to an RF signal of -95 dBm that is FM modulated with white noise at an amplitude of 12 dB higher than the highest measured deviation threshold of any individual audio tone. The white noise spectrum shall be at least 0 to 600 kHz.

4.8.2.2.9 Standard Receiver Capture Ratio. The application of an unmodulated RF signal at the assigned frequency at a level up to 80 percent (-2 dB) below the desired, modulated RF carrier signal shall not capture the receiver or interfere with the desired signal.

4.8.2.2.10 Standard Receiver Signal Strength Telemetry Output Monitor. While operating into a 10 kilohms load, the Signal Strength Telemetry Output (SSTO) voltage of the receiver shall meet the following requirements:

a. The SSTO output level quiescent (no RF signal) condition shall be 0.5 ± 0.25 Vdc.

b. The SSTO measured command threshold sensitivity input condition shall be 0.1 Vdc minimum above the quiescent value.

c. The SSTO output level shall reach a maximum (4.75 ± 0.25 Vdc) with no less than 500 microvolts (-53 dBm) of RF input.

d. The shape of the transfer function shall not exceed approximately 1.0 Vdc change in voltage for each 13 dB change in RF input signal over the range between threshold and saturation.

e. The maximum SSTO voltage shall not exceed 5 Vdc under all conditions.

f. The slope of the SSTO voltage shall not change polarity from measured threshold to +13 dBm. **NOTE:** The slope of the SSTO voltage is monotonic with no more than 50 mV droop after saturation has been reached.

g. The SSTO voltage shall not be used as a command output monitor.

4.8.2.2.11 Standard Receiver Amplitude Modulation (AM) Rejection. The CRD shall not produce an output from any decoder channel under the following conditions:

a. An RF input signal at the assigned center frequency of -90.1 dBm (7 microvolts) with 50 percent AM modulation by the assigned RCC tone frequencies

b. An RF input signal at the assigned frequency of -85.4 dBm (12 microvolts) signal with 50 percent AM modulation by the assigned RCC tone frequencies

c. An RF input signal at the assigned RF center frequency of -67 dBm (100 microvolts) with 100 percent peak AM modulation at Low Pass Filter (LPF) 3 dB frequencies of 3.5 kHz or 7.0 kHz.

4.8.2.2.12 Standard Receiver Dynamic Stability. The receiver shall not produce false commands or spurious outputs as a result of changing input VSWR, including open and short RF transmission circuits.

4.8.2.2.13 Standard Receiver Warm-Up Time. The receiver shall meet all performance requirements within a time period specified in the procurement document or 3 min, whichever is less, after application of DC power.

4.8.2.2.14 Standard Receiver Out-Of-Band Rejection.

a. The receiver shall be immune to all out-of-band frequencies.

b. Special emphasis shall be given to those signals originating from 2.2 to 2.4 GHz continuous wave (CW), from 5.4 to 5.9 GHz pulsed, and from 9.2 to 9.6 GHz pulsed.

c. Out-of-band rejection shall be a minimum of 60 dB above measured threshold sensitivity.

d. The receiver shall provide at least 60 dB of rejection from 10 to 1,000 MHz, excluding the frequency band within the 60 dB bandwidth at the assigned center frequency referenced to the response at the center frequency.

4.8.2.3 Standard Decoders

4.8.2.3.1 Standard Decoder General Design Requirements.

a. The decoder shall simultaneously output three channels: ARM, DESTROY, and CHECK CHANNEL. **NOTE:** Any additional decoder output channels shall be approved by Range Safety.

b. The decoder shall process a minimum of 4 RCC audio tone inputs simultaneously.

c. The RCC audio tone frequencies and their tolerances are shown in Table 4-1.

Table 4-1
RCC Standard Decoder Tones

RCC Tone	Frequency (in kHz)
1	7.50
2	8.46
3	9.54
4	10.76 (CHECK CHANNEL)
5	12.14
6	13.70
7	15.45
8	17.43
9	19.66
10	22.17
11	25.01
12	28.21
13	31.83
14	35.90
15	40.49
16	45.68
17	51.52
18	58.12
19	65.56
20	73.95
Tolerances:	
Frequency	±0.1 percent
Amplitude	±1 dB
Distortion	<2 percent total harmonic distortion

4.8.2.3.2 Standard Decoder Standard Logic Sequence. Unless otherwise specified by Range Safety, the decoder shall not produce a command output under any condition or set of conditions except those described below and shown in Table 4-2.

a. ARM command

1. RCC Tones 1 and 5 are applied in any order.

2. Removal of Tone 5 while switching from ARM to DESTROY shall not cause the loss of ARM output.

b. DESTROY command

1. With RCC Tones 1 and 5 applied (ARM), Tone 5 is removed and Tone 2 is applied.

2. If Tone 2 is applied before Tone 5 is removed, neither the ARM nor the DESTROY

shall be lost or inhibited.

c. CHECK CHANNEL command

1. With RCC Tone 4 applied, the decoder shall be capable of driving the external load.

2. The presence or absence of Tone 4 shall not affect the performance or function of the other decoder channels.

d. Other sequential coding techniques for ARM and DESTRUCT commands may be used if they fall within the capability of the range transmitting system and if approved by Range Safety.

Table 4-2
Standard Logic Sequence

Logic Sequence	Decoder Output
Tones 1 and 5	ARM
Tones 1 and 5 followed by: remove Tone 5 and apply Tone 2	DESTRUCT
Tone 4	CHECK CHANNEL

4.8.2.3.3 Standard Decoder Channel Deviation Threshold and Range.

a. The RF deviation threshold for each channel shall be between plus and minus 9 and between plus and minus 18 kHz per tone.

b. The decoder shall not provide any output at deviation levels of less than plus and minus 9 kHz per tone.

c. Each decoder channel shall provide proper, intermittent free output when the tones are deviated over the range of plus and minus 27 kHz to plus and minus 33 kHz per tone and at a two tone deviation of plus and minus 54 to 66 kHz.

4.8.2.3.4 Standard Decoder Channel Bandwidth. The decoder channel bandwidth required for the generation of a tone detected output shall meet the following criteria:

a. The 2 dB channel bandwidth shall be ± 1 percent of the assigned tone frequency minimum, when measured at the board or box level.

b. The 14 dB channel bandwidth shall be ± 4 percent of the assigned tone frequency maximum, when measured at the box level.

c. The 20 dB channel bandwidth shall be ± 4 percent of the assigned tone frequency maximum, when measured at the decoder board level.

4.8.2.3.5 Standard Decoder Adjacent Channel Rejection. The decoder shall not produce an output on unkeyed channels or cause a keyed channel to drop out in the presence of adjacent channel interference resulting from any combination of simultaneous tones with carrier FM deviation set at

plus and minus 50 kHz.

4.8.2.3.6 Standard Decoder Response Time.

The response time of each function shall be between 4 milliseconds and 25 milliseconds from the time the command is received by the CRD.

4.8.3 FTS Secure Command Receiver and Decoder Design

4.8.3.1 Secure CRD Policy

a. To comply with national policy directive *National Policy on Application of Communication Security to Command Destruct System* issued in 1988, Range Users are required to provide secure CRDs on FTSs.

b. Secure CRDs are designed to prevent inadvertent flight termination command outputs caused by unauthorized and/or accidental radio transmissions.

c. The timetable for implementation of this requirement is contained in the directive.

d. Only the Range Commanders are empowered to waive all or part of this policy.

e. The use of secure CRDs are not a Range Safety requirement.

4.8.3.2 Secure Receiver

The secure receiver shall meet the requirements in **FTS Standard Command Receiver and Decoder General Design Requirements** and **Standard Receiver** sections of this Chapter.

4.8.3.3 Secure Decoder

4.8.3.3.1 Secure Decoder General Design Requirements.

a. The secure decoder design shall be approved by Range Safety.

b. The Ranges will consider any design that satisfies the manager of the National Telecommunications and Information Systems Security (NTISS) requirements while maintaining Range Safety reliability requirements.

c. Secure decoder designs shall be compatible with existing secure flight termination transmitting equipment. **NOTE:** Designs that result in the re-design of existing secure flight termination transmitting equipment require long range planning and extensive coordination and approval efforts.

4.8.3.3.2 Secure Decoder Minimum Output Channel.

- a. The secure decoder is required to output 3 channels: ARM, DESTRUCT, and PILOT TONE.
- b. Any additional decoder output channels shall be approved by Range Safety.

4.8.3.3.3 Secure Decoder Tone Frequency.

The tones and tolerances used in the secure mode are shown in Table 4-3. **NOTE:** These are not standard RCC audio tones.

Table 4-3
Secure Decoder Tones

Secure Tone	Frequency (kHz)
1	7.35
2	8.40
3	9.45
4	10.50
5	11.55
6	12.60
7	13.65
Pilot	15.45

Tolerances: Frequency ± 0.1 percent
 Amplitude ± 1 dB
 Distortion < 2 percent total harmonic distortion

4.8.3.3.4 Secure Decoder Logic Sequence.

- a. The decoder input command message shall consist of an 11 character, frequency modulated, tone pattern.
- b. Each character shall consist of the sum of two tones of frequencies specified in the above paragraph and form a high-alphabet code.
- c. The secure high-alphabet command codes are provided to the Range User by the National Security Agency (NSA).
- d. For a typical secure command message format, refer to Figure 4-1.

4.8.3.3.5 Secure Decoder ARM (Engine Shutdown) Command. The arm output shall be active only after successfully decoding a high-alphabet encoded ARM command and shall stay on continuously.

4.8.3.3.6 Secure Decoder DESTRUCT Command. The destruct output shall be active only after successfully decoding a high-alphabet encoded DESTRUCT command and a currently active ARM and shall stay on continuously.

4.8.3.3.7 Secure Decoder Response Time.

The time interval between the complete reception of the 11th character (tone pair) of the command message at the front end of the receiver and the occurrence of the respective decoder output shall not exceed 25 milliseconds.

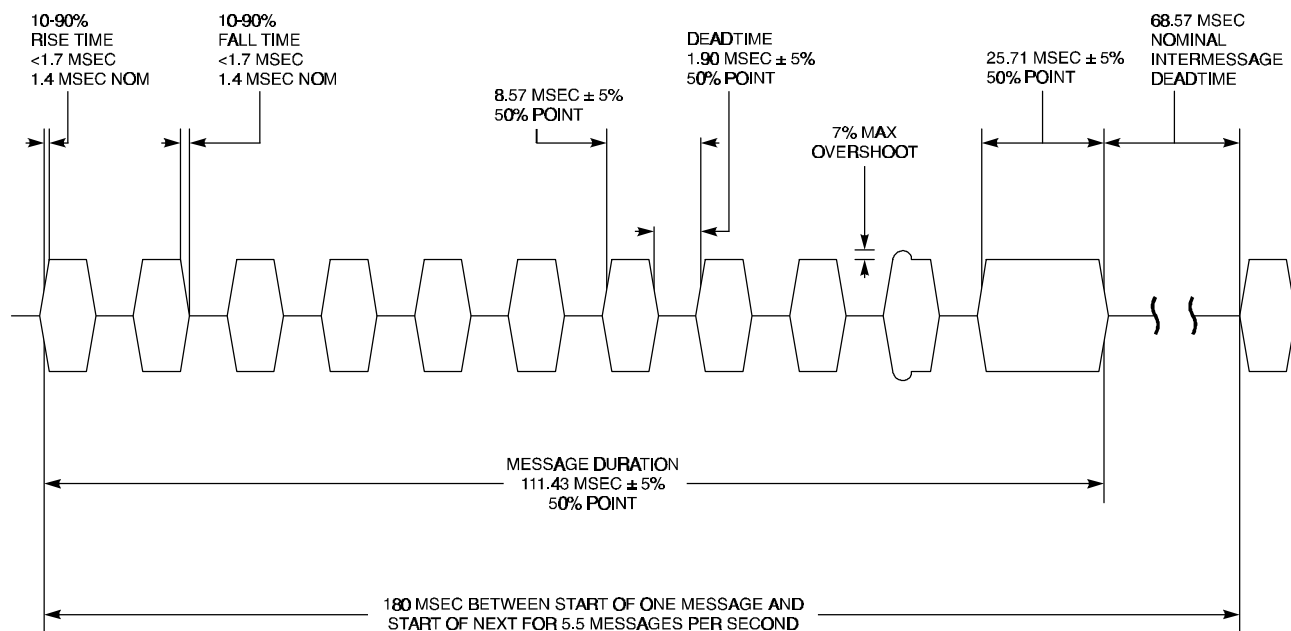


Figure 4-1
Typical Secure Command Message Format

4.8.3.3.8 Secure Decoder Tolerance. Decoder tolerance to tone drop, tone imbalance, abnormal logic, and message timing shall be specified.

4.8.3.3.9 Secure Decoder Channel Bandwidth. The decoder channel bandwidth shall be ± 40 Hz minimum at 2 dB and ± 600 Hz maximum at 20 dB.

4.8.3.3.10 Secure Decoder Automatic RESET Command.

a. The CRD may be designed to have the capability to reset a latched output command by processing a RESET command.

b. The RESET command capability shall be erased from the flight CRD prior to launch.

4.8.3.3.11 Secure Decoder Memory Life. Following coded message loading into the receiver, the codes shall remain in memory for a period of not less than 120 days without primary DC power being applied.

4.8.3.3.12 Secure Decoder Channel Deviation Threshold and Ranges.

a. The RF deviation threshold for each channel shall be between plus and minus 9 and between plus and minus 18 kHz per tone.

b. The decoder shall not provide any output at

deviation levels of less than plus and minus 9 kHz per tone.

c. Each decoder channel shall provide proper, intermittent free output when the tones are deviated over the range of plus and minus 27 kHz to plus and minus 33 kHz per tone and at a two tone deviation of plus and minus 54 to 66 kHz.

4.8.4 FTS Wiring Design

a. Twisted shielded pairs shall be used unless other configurations such as coaxial leads can be shown to be more effective.

b. For low voltage circuits, the insulation resistance between the shield and conductor shall be greater than 2 megohms at 500 Vdc minimum.

c. For high voltage circuits, the insulation resistance between the shield and conductor shall be greater than 50 megohms at 150 percent of the rated output voltage or 500 Vdc whichever is greater.

d. Wiring and harness shall be capable of withstanding 1500 Vac (RMS) 60 Hz at sea level pressure between mutually insulated points and the case or housing.

e. Wire shall be of sufficient size to adequately handle 150 percent of the design load for continuous duty signals of 100 sec or more. For

signals of less than 100 sec duration, the wire and insulation shall be selected to conform to the insulation temperature class of wire.

f. Splicing of firing circuit wires or overbraid shields is prohibited.

g. The use of wire wrap to connect wires or shields is prohibited.

h. Wires and cables shall be given support and protection against abrasion or crimping.

4.8.5 FTS Fiber Optic Cable Design

a. Fiber optic cable (FOC) design shall preclude stray energy sources such as photostrobe, magnified sunlight, arc welding, xenon strobe, lightning, static electricity, and RF from causing interference that would inhibit system function or cause an undesired output.

b. The requirement in paragraph *a* above shall be demonstrated during development and qualification testing.

c. Fiber optic cable minimum bend radius shall be specified and demonstrated during development and qualification testing.

d. Fiber optic cable fatigue characteristics and cable ability to survive compressive and impact loads experienced during handling shall be specified and demonstrated during development and qualification testing.

e. Materials selected for use in fiber optic cables shall not degrade the optical performance of the cable, laser, or other optical devices due to outgassing onto optical surfaces during its service life.

f. Fiber optic cable shall withstand an axial pull of 100 lb for a minimum of 1 min. **NOTE:** This requirement may be relaxed to 30 lb for 1 min if a final continuity test is performed prior to final closeout and just prior to launch.

g. The fiber optic cable shall be hermetically sealed to the equivalent of 5×10^{-6} standard cubic centimeter/second(s) (scc/sec) helium.

h. Fiber optic cable shall be given support and protection against abrasion and crimping.

4.8.6 FTS Electrical and Optical Connector Design

4.8.6.1 FTS Electrical Connectors

4.8.6.1.1 FTS Electrical Connector General Design Requirements

a. FTS connectors shall be designed in accordance with the requirements of MIL-C-38999J or the equivalent and the requirements of this section.

b. Plug and socket type connectors are required.

c. Outer shells of connectors shall be made of metal.

d. Connectors shall be selected to eliminate the possibility of mismating. **NOTE:** Mismating includes improper installation as well as connecting wrong connectors.

e. Connectors shall be of the self-locking type or lock wiring shall be used to prevent accidental or inadvertent demating.

f. Connector design shall ensure that the shielding connection is complete before the pin connection.

g. Source circuits shall terminate in a connector with female contacts.

h. Connectors relying on spring contact shall not be used.

i. The mated connectors shall withstand an axial pull on the cable or harness of at least 30 lb for a minimum of 1 min.

4.8.6.1.2 FTS Electrical Connector Pins

a. Circuit assignments and isolation of pins within a connector shall be such that any single short circuit occurring as a result of a bent pin shall not result in more than 10 percent of the all fire current on the firing circuit or does not have an adverse effect on the FTS.

b. A bent pin analysis shall be performed on all FTS connectors.

c. There shall be only one wire per pin.

d. In no case shall a connector pin be used as a terminal or tie-point for multiple connections.

4.8.6.1.3 FTS Electrical Connector Redundancy

a. Where redundant circuits are required by Range Safety, separate cables and connectors shall be used.

b. Redundant circuits shall meet the following criteria:

1. The elements of a redundant circuit shall not be terminated in a single connector where the loss of such cable or connector will negate the redundant feature.

2. Redundant circuits shall be separated to the maximum extent possible.

3. All firing circuit harnesses shall be isolated from other harnesses.

4.8.6.1.4 FTS Electrical Connector Capacity.

a. Connectors shall be capable of adequately handling 150 percent of the design load for continuous duty signals of 100 sec or more.

b. For continuous duty signals less than 100 sec duration, the connector shall be selected to conform to the insulation temperature class of the inert materials.

4.8.6.1.5 FTS Electrical Connector Unverifiable Connection.

a. Electrical connections that cannot be subjected to a continuity or functional test following the final mate shall be designed to meet the following criteria:

1. A straight pin within specifications cannot be misaligned during the mating process so that the circuit is no longer functional.

2. A connector with a bent or misaligned pin out of specification will prevent the connector from mating.

b. A qualification test program shall be developed by the Range User to demonstrate compliance with these requirements.

c. The qualification test plan and test results shall be submitted to Range Safety for review and approval.

4.8.6.2 FTS Optical Connectors

a. Optical connectors shall be of the self-locking type or lockwiring shall be used to prevent accidental or inadvertent demating.

b. Optical connectors shall be designed to eliminate misalignment and minimize attenuation.

c. Optical connectors shall be selected to eliminate the possibility of mismating. **NOTE:** Mismating includes improper installation as well as connecting wrong connectors.

d. Optical connectors and receptacles shall be provided with self-locking protective covers or caps that shall be installed except when the connector or receptacle is in use.

e. Protective covers or caps shall provide protection against environmental damage during transportation, storage, installation, and handling.

f. An absolute minimum of connectors shall be used in a fiber optic cable system.

g. Mated connectors shall have a leak rate of no greater than the equivalent of 5×10^{-6} scc/sec helium. **NOTE:** This requirement may be relaxed under the following conditions: (1) if a continuity test is performed after final closeout and just prior to launch; (2) if contamination sensitivity testing during qualification and acceptance testing shows that this level of cleanliness is not a concern.

h. Mated connectors shall withstand an axial pull on the cable of at least 100 lb for a minimum of 1 min. **NOTE:** This requirement may be relaxed to 30 lb for 1 min if a continuity test is performed after final closeout and just prior to launch.

i. Performance margin, misalignment such as gap or offset, and contamination sensitivity of each fiber optic cable connector interface shall be specified and demonstrated by tests.

j. All connectors shall be capable of being mated and/or demated at least five times the number of planned cycles, but not less than 100 cycles, and still be within the performance requirements of the connector specification.

k. Optical cables shall use single fiber connectors. **NOTE:** The use of multiple optical fiber connectors requires specific Range Safety approval.

4.8.7 FTS Battery Design

4.8.7.1 FTS Battery Design Life

a. Batteries shall be of sufficient capacity to allow for load and activation checks, launch countdown checks, and any necessary hold time.

b. Sufficient battery life shall be available for 150 percent of the mission time for which Range Safety has flight safety responsibility or 30-min hang-fire hold time plus mission time. The mission time includes the minus count time starting when the FTS has switched to the final internal power configuration (battery) through normal flight, with two ARM and DESTROY commands at the end of the time period. **NOTE:** The 30-min, hang-fire hold time applies only to vehicles using solid propellants and vehicles using solid propellant ignition systems.

c. An analysis shall be provided to demonstrate compliance with sufficient battery life availability at launch prior to the qualification test.

d. Battery Storage Life

1. The battery shall meet design requirements of this section after a storage life of a minimum of two years from date of manufacture.

2. Lot buys shall include enough cells to provide a continuous data base throughout the life of the lot in accordance with Appendix 4B4.

4.8.7.2 FTS Battery Electrical Characteristics

a. Batteries used to provide power to EED initiators shall be capable of meeting the following criteria:

1. Delivering (1) 1.5 times the all-fire current (qualification test level) or (2) 2 times the Bruceton current or (3) manufacturer recommended sure-fire current, whichever is greater.

2. The pulse duration of the current pulse shall be two times greater than the duration required to fire the initiator or 100 msec, whichever is greater.

3. This pulse capacity shall include the expected number of command sets (ARM and DESTROY) planned during the destruct end-to-end test but not less than 4 command sets plus flight commands and ground processing pulses including load checks, conditioning, and firing of initiators.

4. The current shall be delivered to the ordnance initiator at the lowest system battery voltage, using the worst case system tolerances.

b. The lowest system battery voltage, including all load conditions, shall be the FTS electrical components' minimum acceptance-test voltage. *EXCEPTION: The minimum voltage during pulse applications due to firing low voltage initiators shall be FTS electrical components' minimum qualification-test voltage.*

c. The resistance between all battery terminals and between each terminal or pin to case shall be 2 megohms or greater when measured at a potential of 500 ± 25 VDC prior to activation of the battery.

4.8.7.3 FTS Battery Electrical Protection

a. Battery connectors shall be designed to prevent reverse polarity.

b. Diodes shall be used to prevent reverse current. **NOTE:** The diodes may be placed in the battery or in external circuitry.

c. If a battery is not connected to the system, the battery terminals or connector plug shall be taped, guarded, or otherwise given positive protection against shorting.

d. The battery shall be capable of accepting without damage or degradation an overcharge. The percentage overcharge based on nominal capacity rating of the battery and cell shall be specified. This shall include a maximum time limit based on the nominal charging rate.

4.8.7.4 FTS Battery Monitoring Capability

a. The voltage of each battery shall have the capability to be monitored within 2 percent accuracy via telemetry and hardline.

b. Batteries requiring heating or cooling to sustain performance shall have monitoring capability indicating the temperature of each battery. **NOTE:** The temperature sensor and telemetry combined measurement tolerance should be less than 1.0°F . This will allow qualification temperature margins to be reduced from 10°C to 10°F .

c. The battery current shall have the capability to be monitored via telemetry or hardline.

4.8.7.5 FTS Battery Pressure Relief

a. Battery cases shall be designed to a 3:1 ultimate safety factor with respect to worst case pressure build-up for normal operations.

b. The battery case pressure build-up shall take into account hydraulic and temperature extremes.

c. Sealed batteries and cells shall have pressure relief capability.

d. Pressure relief devices for sealed batteries and cells shall be set to operate at a maximum of 1.5 times the operating pressure and sized such that the resulting maximum stress of the case does not exceed the yield strength of the case material.

4.8.7.6 FTS Battery Accessibility

a. Batteries shall be easily accessible for inspection and replacement.

b. Provisions shall be made in the battery design to permit open circuit voltage and load testing of each cell when assembled in the battery case. **NOTE:** This testing shall take place at the Range.

4.8.7.7 FTS Secondary Batteries

a. Batteries used in the secondary mode shall have a cycle life greater than the number of cycles to be experienced during normal processing and flight.

b. Battery charging circuits shall be external to the launch vehicle.

c. Battery charging shall be designed to prevent a runaway battery temperature and adjust current rates accordingly with a high temperature limit cutoff.

d. The temperature-based control shall be in addition to other methods of charge control.

e. An analysis shall be provided to demonstrate compliance with the battery charging temperature and current control.

4.8.7.8 FTS Battery Initiators

The battery initiator and associated firing circuitry shall meet the requirements of the **FTS Low Voltage EED System Circuitry Design** section of this Chapter.

4.8.7.9 Battery Identification

Each battery shall be permanently identified with the following information:

- a.* Component name
- b.* Type of construction/chemistry
- c.* Manufacturer identification
- d.* Part number
- e.* Lot and serial number
- f.* Date of manufacture
- g.* Shelf Life

4.8.7.10 FTS Silver Zinc Cell and Battery Unique Requirements

a. Batteries shall consist of cells made from electrodes plates with the same lot date code.

b. Silver zinc cells that will be used for EED systems shall be optimized for pulse loading with voltage regulation above the qualification low voltage of the other electrical portions of the FTS.

c. Separator material shall be designed that a positive margin of useful material is available after the end of wet stand time and electrical use.

d. Electrolyte additives shall be specified.

e. Batteries shall be designed to allow activation of cells within the battery.

f. Electrode plate connection to cell terminals shall be maintained when exposed to qualification environments.

g. Heaters shall be designed to insure consistent heating of all cells.

h. Cell cases shall be designed to not leak when exposed to qualification environments.

i. Cell and battery manufacturing process shall be documented. This documentation shall include identification of all processes used from receipt of materials to final assemble. No changes to the process shall be allowed without Range Safety concurrence.

j. Silver zinc batteries only used in the primary mode shall have a minimum wet stand time of 60 days. Silver zinc batteries used in the secondary mode shall have:

1. A maximum number of secondary cycles specified

2. A charge retention life for each secondary cycle specified

3. An activated service life (total activated time) specified.

k. Silver zinc batteries shall provide the capability to individually charge each cell if the battery is to be used in the peroxide state or is used in the monoxide state but requiring electrically conditioning of the electrodes.

l. Minimum soak time shall be specified for both vacuum fill or gravity fill of electrolyte.

m. Absorption devices shall be provided to accommodate electrolyte release. This device shall not provide a conductive path between cell terminals or the cell terminals and the battery box.

n. Silver zinc cells that will be used in the monoxide state shall have a specified peroxide removal process.

4.8.7.11 FTS Nickel Cadmium Cell and Battery Unique Requirements (Reserved)

4.8.8 FTS Arming Device Design

4.8.8.1 FTS Arming Device General Design Requirements

Arming devices used on FTSs include electromechanical safe and arm devices (S&As), high voltage exploding bridgewire firing units (EBW-FUs), and laser firing units/optical S&As/ordnance S&As.

a. Arming devices are required on all FTSs.

b. All arming devices shall be capable of being functionally tested by ground test equipment at the launch site.

c. Test equipment shall be designed to simulate

input signals to the arming device and to verify that subsequent arming device outputs are within performance specifications.

d. No arming device shall produce a destruct output as the result of a single component failure.

e. All FTS arming device designs shall comply with the system arming and safing requirement sections contained within this Chapter.

f. Each arming device shall be designed for a service life of at least 10 years after passing its acceptance test.

g. FTS arming devices shall not require adjustment throughout their service life.

4.8.8.2 FTS Electromechanical S&A Design

4.8.8.2.1 Electromechanical S&A General Design Requirements.

a. When the S&A device is in the SAFE position, it shall provide mechanical isolation of the EED from the explosive train and electrical isolation of the firing circuit from the EEDs by means of:

1. The power and return lines of the firing circuit shall be disconnected.

2. The bridgewire shall be shorted and grounded through a resistor having a resistance value between 10 kilohms and 100 kilohms.

3. The explosive train shall be interrupted by a mechanical barrier capable of containing the output energy of the EED without initiating the explosive.

b. SAFE to ARM Transition.

1. Transition from the SAFE to ARM position shall require 90° of rotation of the mechanical barrier for rotating S&As containing ordnance in the barrier.

2. SAFE to ARM transition tolerances for other electromechanical S&A devices require specific Range Safety approval.

c. When the S&A device is in the ARM position, it shall meet the following criteria:

1. Connect power and return line of the firing circuit

2. Align the explosive train with the receptor ordnance and allow reliable initiation of 0.999 at the 95 percent confidence level

3. Bruceton type testing or other statistical methods acceptable to Range Safety shall be performed to establish initiation reliability.

d. Detonation Propagation.

1. The S&A device shall not be capable of

propagating the detonation with the barrier rotated at least 50° from SAFE for a 90° rotational barrier.

2. The S&A device shall not be capable of propagating the detonation with the barrier at 50 percent of the travel distance between ARM and SAFE for sliding barriers.

3. The S&A device shall contain fragments when functioned in both arm and safe configurations.

e. Electromechanical S&A device locations on the vehicle shall be accessible to facilitate installation and/or removal of electrical and/or ordnance connections during final vehicle closeout.

f. S&A electrical contacts (firing circuit) should be designed not to chatter when exposed to flight loads (acoustic, shock, and vibration).

NOTE: If chattering is experienced during environmental testing, the acceptability of this chatter shall be demonstrated by analysis.

g. Shielding Cap.

1. The S&A device shall have shielding caps attached to the firing connectors during storage, handling, transportation, and installation up to firing line connection.

2. The shielding caps shall have a solid metal outer shell that make electrical contact with the firing circuit case in the same manner as the mating connector.

h. Motor Stalling.

1. The S&A devices shall be designed to meet all performance requirements after the application of maximum operational arming voltages continuously for periods of up to 5 min with the safing pin installed.

2. Stalling shall not create a hazardous condition when arming voltages are applied continuously for 1 h with the safing pin installed.

i. The S&A device shall be required to propagate a detonation after a 6-ft drop on to a steel plate if the effects of the drop are not detectable.

j. The S&A shall not initiate and shall be safe to handle for subsequent disposal after subjected to a 20-ft drop on to a steel plate.

k. The electromechanical S&A device sealing shall be designed to survive exposure to environments such as humidity, salt fog, fungus resistance, explosive atmosphere, and fine salt described in Appendix 4B1 without degradation.

4.8.8.2.2 Electromechanical S&A ARM and

SAFE Mechanisms.

a. The S&A device shall be designed to incorporate provisions to safe the ordnance train from any rotor and/or barrier position.

b. The time required to ARM or SAFE an electromechanical S&A device shall not exceed 1 sec after application of the actuation signal.

c. All S&A devices shall be designed to withstand repeated cycling from ARM to SAFE for at least 1,000 cycles, or at least five times the expected number of cycles, whichever is greater, without any malfunction, failure, or deterioration in performance.

d. A mechanical lock within the S&A shall prevent inadvertent transfer from the arm to safe position (or vice versa), under all operational environments without the application of any electrical signal.

e. S&As shall be capable of being remotely safed and armed.

f. S&As shall not be capable of being manually armed, but shall be capable of being manually safed.

g. Electromechanical S&A remote and manual safing shall be accomplished without passing through the armed position.

4.8.8.2.3 Electromechanical S&A Status Indicators.

a. The electrical continuity of one status circuit of the electromechanical S&A device (SAFE or ARM) shall completely break prior to the time that the electrical continuity is established for the other status circuit (ARM or SAFE).

b. Electromechanical S&A Remote and Visual Status Indicators.

1. A remote status indicator shall be provided to show the armed or safed condition.

2. A visual status indicator shall also be provided to show the armed or safe condition by simple visual inspection.

3. Easy access to the visual status indicator shall be provided throughout ground processing.

4. During checkout, the remote status indicator circuits shall be capable of being monitored by Range ground support equipment.

c. The S&A ARM signal shall only be indicated visually or remotely when the device is in a position that aligns the explosive train with the receptor ordnance and allows reliable initiation.

d. The S&A SAFE signal shall not be indicated

visually or remotely unless the device is less than 10° from the SAFE position for rotating systems or 10 percent from the SAFE position for sliding barriers.

e. No visual indication of SAFE or ARM shall appear if the device is in between the SAFE and ARM positions. **NOTE:** The S&A will be considered "not safe" or armed if the indicator does not show SAFE.

4.8.8.2.4 Electromechanical S&A Safing Pins.

A safing pin shall be used in the S&A device to prevent movement from the SAFE to the ARM position when arming power is applied.

a. Rotation and/or transition of the mechanical barrier to the aligned explosive train and electrical continuity of the firing circuit to the EED shall not be possible with the safing pin installed.

b. The safing pin shall be accessible through final launch complex clear.

c. When inserted and rotated, the safing pin shall manually safe the device.

d. The force required for safing pin insertion shall be between 20 and 40 lb and/or 20 to 40 in. lb of torque.

e. Removal of the safing pin shall not be possible if the arming circuit is energized. The retention mechanism of the safing pin shall be capable of withstanding an applied force of at least 100 lb tension or a torque of 100 in-lb without failure.

f. Removal of the safing pin shall not cause the device to automatically arm.

g. Removal of the safing pin shall be inhibited by a locking mechanism requiring 90° rotation of the pin. The removal force shall be 3 to 10 in. lb of torque.

h. Warning Streamers

1. The safing pin shall provide a means of attaching warning streamers.

2. When installed, all safing items shall be marked by a red streamer.

4.8.8.2.5 Electromechanical S&A Explosive Devices.

a. Each explosive device such as an EED, booster charge, or rotor leads in an S&A assembly shall be designed in accordance with each applicable section in this Chapter.

b. Each explosive device such as an EED, booster charge, or rotor leads in an S&A assembly shall be hermetically sealed to the equivalent of 5 X

10^{-6} scc/sec helium or other leak rate approved by Range Safety.

c. Each explosive device such as an EED, booster charge, or rotor leads in an S&A assembly shall be individually subjected to qualification and acceptance testing.

4.8.8.3 FTS High Voltage Exploding Bridge-wire Firing Units Design

4.8.8.3.1 EBW-FU General Design Requirements.

a. The EBW-FU shall provide circuits for capacitor charging, bleeding, charge interruption, and triggering.

b. The EBW-FU charged capacitor circuit shall have a dual bleed system with either system capable of independently bleeding off the stored capacitor charge.

c. EBW-FU design shall provide a positive, remotely controlled means of interrupting the capacitor charging circuit.

d. The EBW-FU shall be capable of being remotely safed and armed.

e. A gap tube shall be provided to interrupt the discharge of the high voltage capacitor in the output circuit.

f. The insulation resistance between each EBW-FU high voltage output circuit and the case shall be designed to be not less than 50 megohms at two times the maximum operating voltage or 500 Vdc whichever is greater.

g. The isolation resistance between EBW-FU output circuits and any other circuits shall be not less than 50 megohms.

h. EBW-FUs shall be designed to be discriminatory to spurious signals in accordance with the requirements in MIL-STD-461.

i. EBW-FUs shall have an operating life of at least five times the expected number of firings required for checkout and operations or 1,000 firings without degradation.

j. The EBW-FU shall be capable of a power ON duty cycle of not less than 45 min with a power OFF period of not more than 2 min.

k. The EBW-FU shall be hermetically sealed to the equivalent of 5×10^{-6} scc/sec helium or other leak rate approved by Range Safety.

l. The FTS shall be designed so that all high voltage capacitors in the EBW-FUs can be functionally tested using EBW simulators within 24 h of launch.

4.8.8.3.2 EBW-FU Monitor Circuits.

a. At a minimum, EBW-FU monitor circuits shall provide the status of the trigger capacitor, high voltage capacitor, arm and destruct input, inhibit input (if used), and power.

b. EBW-FU monitor circuits shall allow for fault isolation and failure diagnosis of assembled units.

c. The electrical continuity of one status circuit shall completely break prior to the time that the electrical continuity is established for the other status circuit.

4.8.8.3.3 EBW-FU Remote DISCHARGED and CHARGED Indicators.

a. EBW-FU Remote DISCHARGED Indicators.

1. Remote DISCHARGED indicators for EBW-FUs shall not appear unless the capacitor bank voltage is one-half or less of the No-Fire voltage of the EBW.

2. The EBW-FU shall be considered "not safe" if the indicator does not show DISCHARGED.

b. EBW-FU Remote CHARGED Indicators.

1. Remote CHARGED indicators for EBW-FUs shall not appear unless the capacitor bank voltage is at least 95 percent of the capacitor's nominal operating voltage.

2. The exact voltage used to establish the CHARGED indication shall be determined by the Range User and Range Safety after evaluating the EBW-FU firing performance characteristics.

4.8.8.4 Laser Firing Unit, Optical Barrier, Optical S&A, and Ordnance S&A Design

a. The following Laser Firing Unit, Optical Barrier, Optical S&A, and Ordnance S&A design requirements shall be applied according to the safing device used.

b. The conceptual configuration of the safing devices to be used shall be coordinated with Range Safety as early as possible to ensure that the configuration is acceptable.

4.8.8.4.1 Laser Firing Units.

a. *Laser Firing Unit General Design Requirements.*

1. Laser firing units (LFUs) shall provide a positive, remotely controlled means of interrupting the power to the firing circuit.

2. Capacitor charging circuits shall have a

dual bleed system with each system capable of independently bleeding off the stored charge.

3. A gap tube shall be provided that interrupts the discharge of a high voltage capacitor in the output circuit in a high voltage LFU.

4. LFUs shall be designed to be discriminatory to spurious signals in accordance with MIL-STD-461.

5. Low voltage LFUs shall provide a continuous spurious energy monitor and/or detection circuit on the input firing line capable of indicating a minimum of one-tenth of the minimum input firing voltage or current level.

6. LFUs shall have an operating life of at least five times the expected number of cycles required for checkout and operations or 1,000 firings without degradation.

7. The LFU shall be capable of a power ON duty cycle of not less than 45 min with a power OFF period of not more than 2 min.

8. The LFU shall be hermetically sealed to the equivalent of 5×10^{-6} scc/sec helium or other leak rate approved by Range Safety.

b. Laser Firing Unit Monitor Circuits.

1. At a minimum, LFU monitor circuits shall provide the status of the trigger capacitor, high voltage capacitor, arm and destruct input, barrier position, barrier locked/unlocked, inhibit input, and power as applicable.

2. LFU monitor circuits shall allow for fault isolation and failure diagnosis of assembled units.

3. The electrical continuity of one status circuit shall completely break prior to the time that the electrical continuity is established for the other status circuit.

c. Laser Firing Unit Remote CHARGED and DISCHARGED Indicators

1. A remote DISCHARGED indicator for LFUs that use a capacitor bank shall not appear unless the capacitor bank voltage is 50 percent or less of the no-fire voltage of the LID. **NOTE:** The LFU will be considered "not safe" if the indicator does not show DISCHARGED.

2. A remote CHARGED indicator for LFUs that use a capacitor bank shall not appear unless the capacitor bank is at least 95 percent of the capacitor's nominal operating voltage.

3. The exact voltage used to establish the CHARGED indication shall be determined by the Range User and Range Safety after evaluating the

LFU firing performance characteristics.

4.8.8.4.2 Optical Barriers.

a. Optical Barrier General Design Requirements.

1. The safe position of the optical barrier shall be capable of absorbing or redirecting the complete optical energy source to a safe receiver.

(a) The barrier shall be capable of absorbing and/or redirecting 100 times the maximum energy that the laser can generate.

(b) Depending on barrier design, the safety factor shall be calculated using several possible variables such as distance from nominal beam spot to the edge of the barrier or edge of aperture, distance or degrees between ARM and SAFE, laser energy deflected, and mechanical tolerances.

2. The optical barrier shall maintain the safety margin and function nominally after being pulsed by the main laser a minimum of four times the expected lifetime number of pulses or 10 pulses whichever is greater at the maximum firing rate and power of the laser.

3. The control of barriers, mechanical locks and monitors shall be independent of the firing circuit.

4. A constant 5 min application of arming voltage with the mechanical lock of the barriers engaged shall not cause the optical train to go to the ARM position.

5. All optical barriers shall be designed to withstand repeated cycling from the ARM to the SAFE positions for at least 1,000 cycles without any malfunction, failure, or deterioration in performance. **NOTE:** If the device is to be used for a program with a known operating life cycle, Range Safety may accept a design cycle life of at least five times the expected number of cycles.

b. Optical Barrier Status Indicators.

1. A remote status indicator of the optical barriers located in LFU or optical S&A shall be provided.

2. A visual indicator of optical barrier status shall also be provided on the device or at a nearby location so that it is easily seen by operating personnel.

(a) If a visual indicator is provided on the barrier, it shall be readily accessible to personnel on the complex and/or facility.

(b) If a visual indicator on the LFU or

S&A device is not provided, redundant electronic remote status indicators shall be provided at the launch pad and launch control center to show the armed or safe status of the LFU or S&A barriers.

3. ARM and SAFE position.

(a) The ARM position shall not be indicated unless the optical barriers are in a position that will align the optical train and allow initiation of the LID with the required 0.999 reliability at a 95 percent confidence level.

(b) The SAFE position shall not be indicated unless the optical barriers are in the SAFE position that will not align the optical train and not allow initiation of the LID with a reliability of 0.999 at 95 percent confidence.

(c) Bruceton-type testing or other statistical methods acceptable to Range Safety shall be performed to establish ARM and SAFE reliability.

(d) The optical barrier will be considered not safe or armed if the indicator does not show SAFE.

4.8.8.4.3 Optical S&As.

a. When an optical safe and arm device is in the laser safe position, the following criteria shall be met:

1. The optical transfer assembly shall be interrupted by a minimum of two mechanical barriers that can be mechanically locked in place.

2. The main laser power circuit shall be electrically disconnected. **NOTE:** This main laser power interrupt capability will not be required if the power circuit to the mechanical barriers is interrupted by an Arm/Safe plug.

3. Optical S&As shall be capable of being remotely safed and armed.

4. Optical S&As shall not be capable of being manually armed but they shall be capable of being manually safed.

5. Remote and manual safing shall be accomplished without passing through the armed position.

b. The optical S&A barriers shall meet the requirements of the **Optical Barriers** section of this Chapter.

c. Optical S&A shall be hermetically sealed to the equivalent of 5×10^{-6} scc/sec helium or other leak rate approved by Range Safety.

d. The electrical continuity of one status circuit shall completely break prior to the time that the electrical continuity is established for the other

status circuit.

e. The S&A shall provide status of the optical barriers (ARM, SAFE), barriers locked/unlocked, and electrical inhibits.

f. The insulation resistance between each S&A circuit and the case shall not be less than 2 megohms at 500 Vdc.

g. All S&A devices shall be designed to withstand repeated cycling from ARM to SAFE for at least 1,000 cycles, or at least five times the expected number of cycles, whichever is greater, without any malfunction, failure, or deterioration in performance.

h. A constant 5 min application of S&A arming voltage shall not cause malfunction, failure, or deterioration in performance.

i. The time required to ARM or SAFE an S&A device shall not exceed 1 sec after application of the actuation signal.

4.8.8.4.4 Ordnance S&A.

a. FTS Ordnance S&A General Design Requirements.

1. When the S&A device is in the SAFE position, the explosive train shall be interrupted by a mechanical barrier capable of containing the output energy of the explosive.

2. SAFE to ARM Transition.

(a) Transition from the SAFE to ARM position shall require 90° of rotation of the mechanical barrier for rotating S&As containing ordnance in the barrier.

(b) SAFE to ARM transition tolerances for other electromechanical S&A devices require specific Range Safety approval.

3. When the S&A device is in the ARM position, it shall meet the following criteria:

(a) Alignment of the explosive train with the receptor ordnance and allow reliable initiation of 0.999 at 95 percent confidence level.

(b) Bruceton type testing or other statistical methods acceptable to Range Safety shall be performed to establish initiation reliability.

4. Detonation Propagation.

(a) The S&A device shall not be capable of propagating the detonation with the barrier rotated at least 50° from SAFE for a 90° rotational barrier.

(b) The S&A device shall not be capable of propagating the detonation with the barrier at 50 percent of the travel distance between ARM and

SAFE for sliding barriers.

(c) The S&A device shall contain fragments when functioned in both ARM and SAFE configurations.

5. Ordnance S&A device locations on the vehicle shall be accessible to facilitate installation and/or removal ordnance connections during final vehicle closeout.

6. Motor Stalling.

(a) The S&A devices shall be designed to meet all performance requirements after the application of maximum operational arming voltages continuously for periods of up to 5 min with the safing pin installed.

(b) Stalling shall not create a hazardous condition when arming voltages are applied continuously for 1 h with the safing pin installed.

7. The S&A device shall be required to propagate a detonation after a 6-ft drop on to a steel plate if the effects of the drop are not detectable.

8. The S&A shall not initiate and shall be safe to handle for subsequent disposal after being subjected to a 20-ft drop on to a steel plate.

9. The ordnance S&A device sealing shall be designed to survive exposure to environments such as humidity, salt fog, fungus resistance, explosive atmosphere, and fine salt described in Test Appendix 4B1.

b. Ordnance S&A Arm and Safe Mechanisms.

1. The S&A device shall be designed to incorporate provisions to safe the ordnance train from any rotor and/or barrier position.

2. The time required to ARM or SAFE an electromechanical S&A device shall not exceed 1 sec after application of the actuation signal.

3. All S&A devices shall be designed to withstand repeated cycling from ARM to SAFE for at least 1,000 cycles, or at least five times the expected number of cycles, whichever is greater, without any malfunction, failure, or deterioration in performance.

4. A mechanical lock in the S&A shall prevent inadvertent transfer from the ARM to SAFE position (or vice versa), under all operational environments without the application of any electrical signal.

5. S&As shall be capable of being remotely safed and armed.

6. S&As shall not be capable of being

manually armed, but shall be capable of being manually safed.

7. Ordnance S&A remote and manual safing shall be accomplished without passing through the armed position.

c. Ordnance S&A Status Indicators.

1. The electrical continuity of one status circuit of the electromechanical S&A device (SAFE or ARM) shall completely break prior to the time that the electrical continuity is established for the other status circuit (ARM or SAFE).

2. Ordnance S&A Remote and Visual Status Indicators.

(a) A remote status indicator shall be provided to show the armed or safed condition.

(b) A visual status indicator shall also be provided to show the armed or safe condition by simple visual inspection.

(c) Easy access to the visual status indicator shall be provided throughout ground processing.

(d) During checkout, the remote status indicator circuits shall be capable of being monitored by Range ground support equipment.

3. The S&A ARM signal shall only be indicated visually or remotely when the device is in a lock position that aligns the explosive train with the receptor ordnance and allows reliable initiation.

4. The S&A SAFE signal shall not be indicated visually or remotely unless the device is less than 10° from the SAFE position for rotating systems or 10 percent from the SAFE position for sliding barriers.

5. No visual indication of SAFE or ARM shall appear if the device is in between the SAFE and ARM positions. **NOTE:** The S&A will be considered "not safe" or armed if the indicator does not show SAFE.

d. Ordnance S&A Safing Pins. A safing pin shall be used in the S&A device to prevent movement from the SAFE to the ARM position when arming power is applied.

1. Rotation and/or transition of the mechanical barrier to the aligned explosive train shall not be possible with the safing pin installed.

2. The safing pin shall be accessible through final launch complex clear.

3. When inserted and rotated manually, the safing pin shall manually safe the device.

4. The force required for safing pin insertion shall be between 20 and 40 lb and/or 20 to 40 in. lb

of torque.

5. Removal of the safing pin shall not be possible if the arming circuit is energized. The retention mechanism of the safing pin shall be capable of withstanding an applied force of at least 100 lb tension or a torque of 100 in. lb without failure.

6. Removal of the safing pin shall not cause the device to automatically ARM.

7. Removal of the safing pin shall be inhibited by a locking mechanism requiring 90° rotation of the pin. The removal force shall be 3 to 10 in. lb of torque.

8. Warning Streamers

(a) The safing pin shall provide a means of attaching warning streamers.

(b) When installed, all safing items shall be marked by a red streamer.

e. Ordnance S&A Explosive Devices.

1. Each explosive device such as an LID, booster charge, or rotor leads in an S&A assembly shall be designed in accordance with each applicable section of this document.

2. Each explosive device such as an LID, booster charge, or rotor leads in an S&A assembly shall be hermetically sealed to the equivalent of 5×10^{-6} scc/sec helium or other leak rate approved by Range Safety.

3. Each explosive device such as an LID, booster charge, or rotor leads in an S&A assembly shall be individually subjected to qualification and acceptance testing.

4.8.8.5 FTS Arming and Safing Plugs Design

a. Safing plugs shall be designed to be manually installed to provide electrical isolation of the input power from the EBW-FU or LFU.

b. Arming plugs shall be designed to be manually installed to provide electrical continuity from the input power to the EBW-FU or LFU.

c. Arming and Safing plugs shall be designed to be positively identifiable by color, shape, and name.

d. The design of arming and safing plugs and their location shall ensure easy access for plug installation and removal just prior to final launch complex clear.

4.8.9 FTS Ordnance Components Design

4.8.9.1 FTS EEDs

4.8.9.1.1 EED All-Fire and No-Fire Levels.

a. The all-fire current level design shall be at 99.9 percent firing level with a 95 percent confidence level.

b. The no-fire current level design shall be at 0.1 percent firing level with 95 percent confidence level.

c. The all-fire and no-fire current level shall be demonstrated using the Bruceton test or other statistical testing methods acceptable to Range Safety.

4.8.9.1.2 EED General Design Requirements.

a. Carbon bridgewires and conductive mixes without bridgewires are prohibited.

b. The EED autoignition temperature shall not be less than 150°C.

c. Insulation resistance between pin-to-case shall not be less than 2 megohms at 500 Vdc.

d. EEDs shall be designed to withstand a constant direct current firing pulse of 1 ampere minimum and 1 watt power minimum for a period of 5 min minimum duration without initiation or deterioration of performance.

e. EEDs shall be designed to withstand electrostatic discharge without being fire, dud or deteriorate in performance when subjected to the following conditions:

1. As a result of being subjected to an electrostatic discharge of 25 kV (kilovolt) from a 500 picofarad capacitor applied in the pin-to-case mode without a series resistor

2. As a result of being subjected to an electrostatic discharge of 25 kV from a 500 picofarad capacitor applied in the pin-to-pin mode with a 5 kilohms resistor in series

f. EEDs shall be designed to survive the RF environments as defined in the testing criteria described in Appendix 4B6.

g. The outer case of the EED main body shall be made of conductive material.

h. The EED main body shall not rupture or fragment when the device is fired. **NOTE:** Displacement or deformation of the connector and main housing is permissible; rupture or deformation of the outer end is permissible.

i. The EED shall not initiate and will perform to specification after being subjected to a 6-ft drop onto a steel plate.

j. The EED shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate. **NOTE:** The EED is not required to function after the 40-ft

drop test.

k. EED initiator pins (terminals) shall withstand an axial pull of at least 18 lb for not less than 1 min or meet an alternate specification acceptable to Range Safety.

l. The EED shall be hermetically sealed to the equivalent of 5×10^{-6} scc/sec helium or other leak rate approved by Range Safety.

4.8.9.2 FTS EBWs

4.8.9.2.1 EBW All-Fire and No-Fire Levels.

a. The all-fire current and voltage level design shall be at 99.9 percent firing level with a 95 percent confidence level.

b. The no-fire current and voltage level design shall be at 0.1 percent firing level with 95 percent confidence level.

c. The all-fire and no-fire current and voltage level shall be demonstrated using the Bruceton test or other statistical testing methods acceptable to Range Safety.

4.8.9.2.2 EBW General Design Requirements.

a. Explosive materials shall be a secondary explosive such as PETN or RDX.

b. Autoignition temperature of the EBW shall not be less than 150°C.

c. The insulation resistance pin-to-case design shall not be less than 50 megohms at two times the maximum operating voltage or 500 Vdc, whichever is greater.

d. EBW designed shall include a voltage blocking gap.

1. The gap breakdown voltage shall not be less than 650 Vdc when discharged from a 0.025 ± 10 percent microfarad capacitor.

2. The nominal gap breakdown voltage tolerance shall be specified and approved by Range Safety.

e. The EBW shall not fire, dud or deteriorate in performance upon being subjected to a voltage of 125 Vac (RMS) at 60 Hz applied across the terminals or between the terminals and the EBW body for 5 min.

f. The EBW shall not fire or degrade to the extent that it is unsafe to handle when 230 Vac (RMS) at 60 Hz is applied across the terminals or between the terminals and EBW body for 5 min.

g. The EBW shall not fire, dud, or deteriorate in performance upon being subjected to a source of 500 Vdc having an output capacitance of 1.0 ± 10

percent microfarads applied across the terminals or between the terminals and the EBW body for 60 sec.

h. The EBW shall be designed to withstand electrostatic discharge without being fire, dud or deteriorate in performance when subjected to the following conditions:

1. As a result of being subjected to an electrostatic discharge of 25 kV from a 500 picofarad capacitor applied in the pin-to-case mode without a series resistor

2. As a result of being subjected to an electrostatic discharge of 25 kV from a 500 picofarad capacitor applied in the pin-to-pin mode with a 5 kilohms resistor in series

i. The EBW shall not fire, dud, or deteriorate in performance after exposure to that level of power equivalent to absorption by the test item of 1.0 watt average power at any frequency within each RF energy range specified in Table 4-4. The RF energy shall be applied across the input terminals of the EBW detonator for 5 sec.

Table 4-4
RF Sensitivity

Frequency (in Megahertz)	Type
5 - 100	Continuous Wave
250 - 300	Continuous Wave
400 - 500	Continuous Wave
800 - 1000	Continuous Wave
2000 - 2400	Continuous Wave
2900 - 3100	Continuous Wave
5000 - 6000	Continuous Wave
9800 - 10000	Continuous Wave
16000 - 23000	Pulse Wave ^a
32000 - 40000	Pulse Wave ^a

^aPulsed repetition frequency shall be not less than 100 Hertz and the pulse width shall be a minimum of 1.0 microsecond.

j. The EBW shall not initiate and will perform to specification after being subjected to a 6-ft drop onto a steel plate.

k. The EBW shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate. **NOTE:** The EBW is not required to function after the 40-ft drop test.

l. EBW initiator pins (terminals) shall withstand an axial pull of at least 18 lb for not less than 1 min or meet an alternate specification acceptable to Range Safety.

m. EBW initiators shall be hermetically sealed

to the equivalent of 5×10^{-6} scc/sec helium or other leak rate approved by Range Safety.

4.8.9.3 FTS LIDs

4.8.9.3.1 LID All-Fire and No-Fire Levels.

a. The all-fire energy level design shall be at 99.9 percent firing level with a 95 percent confidence level.

b. The no-fire energy level design shall be at 0.1 percent firing level with 95 percent confidence level.

c. The all-fire energy level shall be at least ten times the no-fire energy level.

d. The all-fire and no-fire energy level shall be demonstrated using the Bruceton test or other statistical testing methods acceptable to Range Safety.

e. The all-fire and no-fire energy level shall also, shall take into account the effects of the temperature of the explosive as well as effects caused by manufacturing variations in explosive grain size and pressure.

f. The LID shall also be designed to withstand the no-fire energy level for a minimum of 5 min without firing or dudging the LID.

g. LIDs in flight configuration shall be tested to determine their susceptibility to all stray energy sources such as strobe, sunlight, arc welder, flash-lamps, lightning, RF, AC and DC electrical energy present during prelaunch processing and the flight environment.

1. The susceptibility to stray energy applies to both inadvertent firing and dudging.

2. LID sensitivity characteristics to these energy sources shall be established by testing a minimum of 45 LIDs per the Bruceton test or other statistical testing method acceptable to Range Safety.

3. At a minimum, statistical testing shall include spot size, pulse width, energy density, and wave length.

4. A correlation between the test specified in paragraph 2 above and the no-fire level established for the LID shall be provided to Range Safety for review and approval. At a minimum, the LID no-fire energy shall be 10^4 greater than any credible stray energy source.

5. If the LID sensitivity requirements stated above are not met, the explosive train shall remain disconnected until just prior to final pad evacuation for launch or an ordnance S&A device shall be re-

quired between the LID and explosive transfer system. compliance with this requirement.

4.8.9.3.2 LID General Design Requirements.

a. The autoignition temperature of the LID shall not be less than 150°C.

b. LIDs shall not use primary explosives.

1. If modified secondary (composition) explosives are used, their sensitivity characteristics shall be established by test in accordance with MIL-STD-1751, ADA 086259, or the equivalent.

2. The test requirements and test report shall be reviewed and approved by Range Safety.

c. LIDs shall have specific energy density, spot size, pulse width, and wavelength characteristics with specified tolerance level for each characteristic.

d. The LID shall be designed to function normally when subjected to a firing pulse of at least 2 times the operational pulse energy including worst-case LFU, fiber optic cable assembly (FOCA), and connector loss tolerances.

e. LIDs shall be designed to withstand electrostatic discharge without being fired, dudded, or deteriorating in performance when subjected to a discharge of 25 kV from a 500 picofarad capacitor. The test configuration shall be approved by Range Safety.

f. LIDs shall not initiate and will perform to specification after being subjected to a 6-ft drop test onto a steel plate.

g. The LID shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop test onto a steel plate.
NOTE: The LID is not required to function after the 40-ft drop test.

h. LIDs shall be hermetically sealed to the equivalent of 5×10^{-6} scc/sec helium or other leak rate approved by Range Safety.

i. LIDs shall have a capability of shielding the energy density levels greater than 1/10,000 of the no-fire level of the ordnance initiator during prelaunch processing, shipment, storage, handling, installation, and testing. This energy constraint shall be applied at the end of the fiber optic cable just prior to its entrance into the laser ordnance initiator and/or reflective coating.

j. LIDs shall have a capability to dissipate heat faster than single failure conditions can input into the device without initiating or dudding. An analysis shall be provided to demonstrate

k. Optical Shielding and Protection Caps.

1. Optical shielding and protective caps shall be provided for LIDs during prelaunch processing, including shipment, storage, handling, installation and testing.

2. These devices shall prevent exposure of the LID to energy density levels greater than 1/10,000 of the no-fire level of the LID.

3. Reflective coatings of the LID shall not be considered part of the shield.

4. The shielding cap shall be designed to accommodate the tool used during installation without the removal of the cap.

l. For LID that incorporate fiber optic cable as an integral part of the LID (Pigtail). The pigtail design shall be capable of withstanding an axial pull of 100 lb for 1 min. This requirement may be relaxed to 30 lb if a final continuity test is performed prior to final close out and just prior to launch.

4.8.9.4 FTS Percussion Activated Devices

a. Percussion Activated Device (PAD) lanyard pull system shall provide for a protective cover over the lanyard to prevent inadvertent pulling.

b. The PAD shall contain fragments when functioned.

c. The PAD location on the vehicle shall be accessible to facilitate installation and/or removal of ordnance connection during final vehicle close out.

d. The PAD shall be required to perform to specifications after being subjected to a 6-ft drop onto a steel plate if the effects of the drop are undetectable.

e. The PAD shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate. **NOTE:** The device is not required to function after this test.

f. Lanyard breaking strength shall be at least 5 times the operating tension.

g. The PAD shall be sealed. The leak rate through the PAD seal shall not be greater than 10^{-4} scc/sec helium.

h. The operating energy delivered by the firing mechanism shall be at least 2 times the all fire energy of the primer.

i. The firing mechanism and primer shall reliably function with an impact of at least 2 times the operational energy (4 times all-fire).

j. The firing mechanism shall be designed to meet

the following criteria:

1. The firing pin mechanism shall be designed such that it does not come in contact with the primer unless it is pulled to the all-fire distance.

2. After the firing pin mechanism is pulled the all-fire distance, the mechanism shall automatically release and allow the firing pin to strike the primer.

k. The minimum no-fire pull force level shall be 50 lb. Releasing the lanyard with a 50 lb pull force shall not cause firing or degradation of the PAD. **NOTE:** This is the force that is guaranteed to not allow the firing pin mechanism to release.

l. The spring constant of the firing spring shall be specified. The PAD shall be designed to allow testing to verify the specified spring constant.

m. A safing pin for the PAD is required that prevents movement of the firing pin mechanism.

1. When the pin is installed, it shall be capable of preventing a 200 lb pull on the lanyard from causing the fire mechanism to move.

2. The force required for safing pin insertion and removal shall be between 20 to 40 lb and/or 20 to 40 inch-pounds of torque when the lanyard is unloaded.

3. With a preload of 50 lb applied to the lanyard, the pin shall not be capable of being removed when subjected to two times the required force for safing pin insertion/removal in paragraph m 2 above.

4. A positive verification shall be designed to ensure the safing pin is installed correctly.

n. The safing pin shall be accessible until final clearance of the launch pad.

o. The safing pin shall have a red warning streamer.

p. Ordnance used in the PAD shall be hermetically sealed to the equivalent of 5×10^{-6} scc/sec Helium or other leak rate approved by Range Safety.

q. Each explosive device contained within the PAD shall be individually subjected to qualification and acceptance testing.

4.8.9.5 FTS Explosive Transfer System

Explosive transfer systems (ETS) are used to transmit the initiation reaction from the initiator to the destruct charge. Most explosive transfer system (ETS) harnesses contain flexible confined detonation cord (FCDC), mild detonating cord (MDC), or a mild detonating fuse (MDF) terminated by end booster caps or manifolds.

a. Explosives used in ETS lines shall be secondary explosives.

b. The end booster caps and manifolds design shall contain the necessary explosive charges to transfer the reaction from one interface to another in the system.

c. Flexible confined detonating cord (FCDC) shall not fragment or separate from end fittings upon initiation. **NOTE:** Gaseous emission is permissible.

d. All ETS donor and receptor interface components shall support the overall FTS reliability goal.

e. The flexible portion of the ETS shall have its minimum bend radius specified so that the system reliability is maintained.

f. ETS fittings shall be designed and located to facilitate installation of the destruct system ordnance components in the launch vehicle as late as practical.

g. All ETS interconnections shall be capable of being visually inspected to verify proper connection.

h. Fittings that must not be reversed or interchanged shall be designed so that reverse installation or interchange is not possible.

i. Fitting placement on the launch vehicle shall not create a potential for installation misalignment.

j. All ETS interconnections shall provide for safety (lock) wiring or a Range Safety approved equivalent.

k. All ETS interconnections shall be capable of connection and disconnection at least 5 times the number of planned cycles.

l. Exposed end fittings shall be equipped with protective caps.

m. An electrically conductive path shall exist between the metallic sheath and end fitting, and between end fittings connected by a manifold type components. As a goal, the bonding resistance should be designed to be 2.5 milliohms but in no case shall it exceed 5 ohms.

n. ETS components shall be capable of withstanding an axial pull of at least 100 lb for 1 min without degradation.

o. The ETS shall be capable of performing its function after being subjected to a 6-ft drop onto a steel plate if the effects of the drop are not detectable.

p. The ETS shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate. **NOTE:** The ETS

is not required to function after the 40-ft drop test.

q. ETS components shall be hermetically sealed to the equivalent of 5×10^{-6} scc/sec helium or other leak rate approved by Range Safety.

4.8.9.6 FTS Destruct Charge

Destruct charges may be linear shaped charges, conical shaped charges, pancake charges, explosively formed projectiles (EFPs), or primacord (detonating cord).

a. Explosive Composition.

1. Destruct charges shall use secondary high explosives such as PETN, RDX, HMX, or HNS.

2. Explosives shall be non-hygroscopic.

3. Specific approval from Range Safety is required for all explosive compositions.

b. Destruct charges shall be compatible with the initiator and ETS to ensure reliable initiation consistent with the overall FTS reliability goal.

c. Destruct charge initiation shall result in the appropriate flight termination action as described in the **Flight Termination Action Requirements** section of this Chapter.

d. Destruct charges shall be designed to sever or penetrate the required maximum thickness of the specified material. The following margin shall be demonstrated:

1. Five charges shall be test fired using 1.5 times the maximum thickness of the specified material at the maximum stand-off.

2. For Range Users using Class 1.1 propellant, the required margin will be determined on a case-by-case basis to avoid detonation of the propellant.

e. Linear Shaped Charge.

1. Flexible or non-flexible linear shaped charges (LSC) shall be designed so that at their minimum bend radius, the sheath shall not crack nor expose the explosive core, and the charge shall function reliably along its total length.

2. LSC shall be designed and manufactured to ensure that outer sheath and explosive charge asymmetries are minimized.

f. Impression stamping for identification or warnings shall not be used on destruct charges and associated fittings.

g. Destruct charge holders and/or brackets shall be designed for stiffness and strength to ensure proper charge orientation such as distance and alignment during flight.

h. Destruct charges and associated fittings shall be capable of withstanding an axial pull of at least

50 lb for a 1-min minimum without degradation.

i. The destruct charge shall not detonate and both detonation and target severance shall function properly after a 6-ft drop on to a steel plate if the effects of the drop are not detectable.

j. The destruct charge shall not initiate or be damaged to the extent it is unsafe to handle after being subjected to a 40-ft drop onto a steel plate.

NOTE: The destruct charge is not required to function after the 40-ft drop test.

k. Destruct charges shall be hermetically sealed to the equivalent of 5×10^{-6} scc/sec helium or other leak rate approved by Range Safety.

4.8.10 FTS Shock and Vibrational Mounted Isolation Systems Design

a. Any system that uses a shock and/or vibrational isolation system such as vibrational mounts, foam rubber, rubber washers or gaskets that are essential to ensure the induced environmental survivability of a component shall be approved by Range Safety.

b. The shock and/or vibrational isolator shall be designed and controlled to the following criteria:

1. Isolator characteristics shall be specified in the source control drawing.

2. The allowable variation of the resonant amplification factor (Q), isolator resonant frequency (f_n) and the product of the square root of f_n and Q about nominal values shall be stated in all three principal axes.

3. When elastomeric isolators are used, they shall be bonded to the supporting hardware, minimizing the variations in the f_n and Q .

4. When metallic isolators such as spring or steel mesh types are used, they shall be in a container to prevent contamination.

4.8.11 Miscellaneous FTS Components Design

Proposed concepts for electrical, electronic, mechanical, ordnance, and other components and/or boxes used in the FTS and not presently identified in this Chapter shall be submitted to Range Safety for evaluation and determination of minimum design and testing requirements.

4.8.12 FTS Component Identification

At a minimum, each FTS component shall be identified with the following information:

a. Component name

b. Manufacturer identification

c. Part number

d. Lot and serial number

e. Date of manufacture

4.9 RANGE TRACKING SYSTEM GENERAL REQUIREMENTS

4.9.1 Range Tracking System Ground Rules

a. All vehicles launched from the Range or under Range Safety control shall be equipped with a transponder system or a Global Positioning System (GPS) for flight safety applications.

b. Ballistic missiles that fly close to the Kwajalein Atoll or impact in the Kwajalein lagoon shall use a coherent transponder.

c. The RTS requirements stated in this Chapter apply to coherent and non-coherent C-band (5400-5900 MHz) transponders except as noted.

4.9.2 Transponder System

a. The transponder system shall be capable of operating within the parameters established for normal operation of the associated ground tracking facilities. **NOTE:** Specific radar locations and characteristics, including effective radiated power and minimum reply flux densities, can be obtained from the Range.

b. The Range selects the radars required to provide adequate flight safety support for each specific launch.

c. The Range assigns carrier frequencies and interrogation pulse code parameters to individual launch agencies to facilitate multiple launch operations and prevent electromagnetic interference.

d. The design, manufacture, installation, and testing of the transponder system shall conform to the requirements in this Chapter.

4.9.3 GPS

a. The use of a GPS translator or receiver shall be considered on a case-by-case basis until adequate experience has been gained to define these requirements.

b. GPS airborne systems include L-Band antenna systems, translators and/or receivers, power combiners and dividers, diplexers, cabling, connectors, and power.

c. If the airborne GPS system shares common components with vehicle telemetry systems, shared

components shall comply with GPS system design and test requirements. Examples of shared components include telemetry transmitters, S-Band down-link antennas, and associated cabling and power dividers.

d. The GPS system, including ground processing equipment for translator systems, shall provide a state vector, in accordance with the **Tracking Source Adequacy** section in Chapter 2 of this document.

4.10 RTS DESIGN REQUIREMENTS

4.10.1 RTS General Design Requirements

4.10.1.1 RTS Design Simplicity

The number of piece/parts shall be kept to an absolute minimum.

4.10.1.2 RTS Software and Firmware

a. All software and firmware used in RTS shall be subjected to independent verification and validation (IV&V) in accordance with DoDI 5000.2 AF, Sup 1, paragraph 3-9 and AFSC/AFLC Pam-phlet 800-5 or equivalent.

b. Approval shall be obtained from Range Safety prior to production of the component or system.

c. Once approved, any modification shall be validated in the same manner and approved by Range Safety prior to further production.

4.10.1.3 RTS Failure Modes, Effects, and Criticality Analysis

A Failure Modes, Effects, and Criticality Analysis (FMECA) shall be performed in accordance with MIL-STD-1543 (Task 204) or equivalent. Any tailoring shall be accomplished by Range Safety and the Range User.

4.10.1.4 RTS Component Maximum Predicted Environment

4.10.1.4.1 Determining RTS Component Maximum Predicted Environment Levels.

a. An analytical approach for determining RTS component maximum predicted environment (MPE) levels such as shock, thermal, and vibration shall be developed by the Range User and submitted to Range Safety for review and approval.

b. The analytical approach shall use existing flight data from other similar vehicles (if available), analysis, computer modeling, and subsystem testing such as bracket and truss vibration testing.

c. If there are fewer than three existing flight

data samples, a minimum 3 decibel (dB) margin for vibration, 4.5 dB for shock, and 11°C for thermal shall be added to the analytical environment to obtain the predicted MPE.

4.10.1.4.2 Validating the Predicted RTS MPE.

The predicted MPE shall be validated by actual environmental load measurements taken during launch and flight of at least three vehicles. If all data does not correlate then additional load measurements on additional vehicles shall be taken.

4.10.2 RTS Environmental Design Margin

4.10.2.1 RTS Environmental Design Margin General Requirements

a. RTS components, including methods of attachment, mounting hardware, and cables and wires, shall be designed to function within performance specifications when exposed to environmental levels that exceed the ground transportation, prelaunch processing, checkout, and launch through end of Range Safety responsibility.

b. RTS design shall take into consideration the test requirements in Appendixes 4B1, 4B2, 4B4, 4B5, 4B12, and 4B13.

4.10.2.2 RTS Component Thermal Environment

a. Unless otherwise specified by Range Safety, RTS components shall be designed to function normally in thermal environments 10°C higher and 10°C lower than the predicted thermal range.

b. The minimum design thermal range shall be minus 34°C to +71°C. *EXCEPTION: Batteries shall meet the requirements in paragraph a above.*

c. The components shall be designed to survive the thermal environment for a minimum of 24 qualification cycles and 8 acceptance cycles. *EXCEPTION: Batteries shall meet the requirement as stated in Appendix 4B4.*

4.10.2.3 RTS Component Random Vibration Environment

a. Unless otherwise specified by Range Safety, RTS components shall be designed to survive random vibration environments that are 4.5 dB above the MPE level or 12.2 Grms, whichever is greater.

b. The minimum design duration shall be:

1. Three times the expected flight exposure time or 3 min per axis, whichever is greater, for qualification

2. The flight exposure time or 1 min per axis, whichever is greater, for acceptance

c. The minimum frequency range shall be 20 to 2000 Hz.

4.10.2.4 RTS Component Acoustic Noise Environment

a. Unless otherwise specified by Range Safety, RTS components shall be designed to survive acoustic noise that are 4.5 above the MPE level or a minimum 144 dB overall sound pressure for acoustic, whichever is greater.

b. The minimum design duration shall meet the following criteria:

1. Three times the expected flight exposure time or 3 min, whichever is greater, for qualification

2. The flight exposure time or 1 min, whichever is greater, for acceptance

4.10.2.5 RTS Component Shock Environment

a. Unless otherwise specified by Range Safety, RTS components shall be designed to a margin of 6 dB above the MPE level or a minimum of 1300 G, whichever is greater.

b. The duration shall simulate the actual shock environment.

c. The maximum frequency range shall be from 100 to 10,000 Hz.

d. The minimum number of shocks shall be 3 shocks per axis for each direction, positive and negative, for a total of 18 shocks.

4.10.2.6 RTS Component Acceleration Environment

a. Unless otherwise specified by Range Safety, RTS components shall be designed to 2 times the MPE level or a minimum of 20 G, whichever is greater, in each direction.

b. The minimum duration for acceleration shall be 5 min per axis.

4.10.2.7 Other RTS Component Environments

a. Other environments applicable to RTS components are humidity, salt fog, dust, fungus, explosive atmosphere, thermal vacuum, EMC, EMI, sinusoidal vibration, and other nonoperational environments.

b. Tests and test levels for these environments are described in Appendixes 4B1, 4B2, 4B4, 4B5, 4B12, and 4B13.

4.10.3 RTS Reliability

a. The overall RTS reliability goal shall be as follows:

1. 0.995 at the 95 percent confidence level for the transponder system

2. 0.999 at the 95 percent confidence level for the GPS

b. This reliability goal shall be satisfied by combining the design approach and testing requirements described in this Chapter.

c. A reliability analysis shall be performed in accordance with guidelines set forth in MIL-STD-785 to demonstrate the reliability design was used in the concept and detailed design of the components and/or system.

4.10.4 RTS Design Life

a. Electrical components shall have their operating and storage life specified.

b. The operating and storage life for electrical components starts at completion of the initial acceptance test.

c. Range Safety shall be notified if the operating and storage life of an RTS component expires prior to launch.

d. If required, expired component retest shall be determined by mutual agreement between Range Safety and the Range User.

4.10.5 RTS Electrical and Electronics Systems Design

4.10.5.1 RTS Piece/Part Selection Criteria

a. Piece/parts selected for use in RTS electronic systems shall be consistent with the launch vehicle reliability requirements.

b. Addition, subtraction, or replacement of piece/parts within a Range Safety approved RSS component shall require specific approval.

4.10.5.2 RTS Voltage and Current Parameters

a. The input voltage range of each component shall be specified, and the current in the stand-by and operating modes shall be noted in the specification.

b. The components shall meet the requirements of this Chapter at any voltage level between the minimum and maximum specified.

c. The components shall not be damaged because of low or fluctuating input voltage.

4.10.5.3 Transient Voltage Generation

All RTS and vehicle system interface components containing reactive elements such as relays, electrical motors or similar devices, that are capable of producing transient voltages shall be provided with suppression circuitry to prevent interference or damage to other RTS components.

4.10.5.4 RTS Voltage Protection

a. RTS components shall not be damaged by the application of up to 45 Vdc or the open circuit voltage of the power source, whichever is greater.

b. This voltage shall be applied in both normal and reverse polarity modes to the component power input ports for a period not less than 5 min.

4.10.5.5 RTS Switch and Relay Selection Criteria

a. Any power transfer switch and/or assembly shall not change state as a result of input power drop-out for a period of 50 milliseconds minimum.

b. Relays shall be designed and/or selected to prevent chatter.

4.10.5.6 RTS Continuity and Isolation

a. The resistance from each pin to common return and case ground shall be specified.

b. Measurements that are polarity sensitive, such as those containing diodes, shall be identified.

c. Significant pin-to-pin measurements shall be included where their inclusion will provide meaningful data relative to the reliability of the component.

4.10.5.7 RTS Circuit Isolation

a. RTS circuitry shall be shielded, filtered, grounded, or otherwise isolated to preclude energy sources such as electromagnetic energy from the Range or launch vehicle causing interference that would inhibit the functioning of the system.

b. There shall be only one interconnection (single point ground) with other circuits.

4.10.5.8 RTS Repetitive Functions

All circuitry, elements, components, and subsystems of the RTS shall be capable of withstanding, without degradation, repetitive functioning for 100 times or five times the expected number of cycles required for checkout and operation, whichever is greater.

4.10.5.9 RTS Watchdog Circuits

Unless otherwise agreed by Range Safety, watchdog circuits that automatically shutdown or disable RTS circuitry when certain parameters are violated are disallowed.

4.10.5.10 RTS Testability

RTS and associated ground support and monitoring equipment design shall provide the capability to perform the testing described in the **RSS Test Requirements** section of this Chapter.

4.10.5.11 RTS Self-Test Capability

a. If the component uses a microprocessor, it shall have the capability to perform a self-test (error detection) at power ON.

b. When possible or feasible, the results of the self-test shall be an output function and observable from the vehicle telemetry.

c. Failure of a self-test shall not intentionally disable the component.

d. The execution of a self-test shall not inhibit the processing intended function of the unit.

4.10.5.12 Interference Protection

The RTS shall be designed to meet the requirements of MIL-STD-461 or the equivalent.

4.10.5.13 Output Response Time

The time needs for the RTS to satisfy all performance requirements after final power application shall be specified.

4.11 RTS COMPONENT DESIGN REQUIREMENTS

4.11.1 RTS Transponder

4.11.1.1 Transponder Antenna System

4.11.1.1.1 Transponder Antenna System General Design Requirements.

a. The antenna system shall provide adequate gain coverage over 95 percent of the radiation sphere.

b. The antenna system shall minimize variations in phase due to changes in the angular orientation of the vehicle with respect to the radar in both roll and pitch coordinates.

c. The antenna system shall operate at the frequencies selected by the Range for the specific program between 5.4 and 5.9 GHz and have 3 dB bandwidths of at least ± 20 MHz with respect to the selected frequencies.

d. The antenna system shall display a voltage standing wave ratio (VSWR) less than 1.5:1 or 4 percent power reflected when excited from a source with the same impedance as the planned cable installation at the assigned frequencies.

e. The antenna system shall operate within specifications, with no arcing or damage, at twice the normal RMS and peak excitation power at any atmospheric pressure between 0.0001 and 760 Torr (mm of Hg).

f. Antenna gain and phase patterns shall be provided to Range Safety for each new airborne tracking system.

g. The gain of the antenna system relative to an isotropic radiator and the phase of the far field radiation relative to the antenna excitation shall be measured at 1° increments over the radiation sphere at the Range assigned frequencies and required polarizations.

h. If antenna heat shields are used, they shall be considered part of the antenna system and shall be subjected to all the antenna system requirements for design, test, pattern measurements, and approval. **NOTE:** All antenna heat shields shall be subjected to a fly-off analysis that includes test data reflecting antenna performance with and without the heat shields.

4.11.1.1.2 Transponder Antenna System Electrical Performance.

a. The antenna system shall provide adequate gain coverage over 95 percent of the radiation sphere to yield a link margin of 0 dB or greater for the following conditions:

1. Interrogation uplink
2. The reply downlink with the radars selected by the Range
3. Anytime the vehicle is physically capable of impacting an inhabited land mass

b. Antenna gain variation shall be no greater than ± 5 dB in the roll plane and 10 dB between 10° and 170° in the pitch plane.

c. Antenna phase angle variation shall be no greater than 50° in the roll plane and twice the distance of farthest radiation element from the roll axis divided by the wave length multiplied by 360 equals the maximum permitted phase variation in degrees between the pitch angles of 10° and 170° in the pitch plane.

d. Antenna phase rate variation shall be 30° per degree of roll maximum.

e. The pitch phase variation rate maximum in degrees phase per degree pitch shall be no greater than the 6.284 times the distance of the farthest radiating element from the roll axis divided by the carrier wave length in the same units at any pitch angle more than 5° from the roll axis.

4.11.1.1.3 Transponder RF Link Analysis.

a. A complete RF link analysis shall be performed by the Range User to verify adequate gain coverage over 95 percent of the radiation sphere.

b. The antenna patterns shall be provided in accordance with RCC 253 and shall be used in the RF link analysis.

c. The RF link margin shall be no less than 0 dB relative to the required signal power for the individual radars selected by the Range.

4.11.1.1.4 Transponder Antenna Analysis and Evaluation Data Requirements.

a. *ER Antenna Analysis and Evaluation Requirements.* Antenna analysis and evaluation data requirements shall be coordinated with the Range.

b. *WR Antenna Analysis and Evaluation.* At a minimum, the following shall be provided for evaluation and analysis:

1. Power gain relative to an isotropic radiator over the entire radiation sphere at 1° increments
2. Relative phase between excitation and far-field radiation over the entire radiation sphere at 1° increments
3. Input reflection coefficient (VSWR) versus frequency over a span of 20 MHz centered on each of the WR assigned frequencies the antenna is intended to operate
4. Items b through e of the **Transponder Antenna System Electrical Performance** section of this Chapter.

4.11.1.2 Transponder

4.11.1.2.1 Transponder General Design Requirements.

a. *Non-Coherent Transponder Frequency Separation.* The reply carrier frequency of the non-coherent transponder shall be separated from the assigned interrogation carrier frequency by a minimum of 50 MHz.

b. *Transponder Antenna RF Impedance Mismatch Considerations.* The transponder shall suffer no damage and shall meet all requirements after operating with the antenna connector open or

shorted.

c. Transponder Pulse Repetition Frequency (PRF) Response. The transponder shall meet all performance requirements when replying to valid interrogations at any rate between 160 and 2600 pulses per second.

d. Transponder Interrogation Response. The transponder shall reply to at least 99 percent of valid interrogations at signal powers equal to or above the measured RF threshold sensitivity under all operating conditions.

e. Transponder Power Source Switching. The operational performance of the transponder shall not be degraded by its internal or external power supply nor by repetitive switching between them. **NOTE:** If it is necessary to protect the transponder, a Range Safety approved power delay timer may be used. The time between power loss and recycle of the delay timer shall be the maximum and the warm-up time shall be the minimum needed to protect the transponder.

f. Transponder Random Triggering. Transponder random triggering shall be no greater than 5 pulses per sec under all uninterrogated and interrogated operational conditions.

g. Transponder System Delay.

1. The transponder shall have a minimum of one fixed reply delay setting of 2.5 ± 0.1 microseconds.

2. The delay variation versus input signal (dBm) shall be less than 30 nanoseconds for input signal levels of 0 dBm to -65 dBm. **NOTE:** The minimum test measurement data points are at 0, -10, -20, -30, -40, -50, -57, -60, -62, -65 -67, and -70 dBm.

3. The delay variation versus input frequency (MHz) shall be less than 30 nanoseconds for input frequency changes of ± 1.5 MHz. **NOTE:** The minimum test measurement data points are at -1.5, -1.0, -0.5, +0.5, +1.0 and +1.5 MHz.

4. The delay variation versus pulse repetition frequency (PRF) pulse per second (PPS) shall be less than 30 nanoseconds for changes in PRF from 160 pps to 1600 pps. **NOTE:** The minimum test measurement data points are at 160, 480, 800, 960, 1440, and 1600 pps.

5. The delay variation versus operating voltage shall be less than 30 nanoseconds for changes in voltage from 24 to 32 volts. **NOTE:** The minimum test measurement data points are at 24, 26, 28, 30 and 32 volts.

h. Coherent Transponder Phase Coherence Accuracy.

1. For ballistic missiles, the contribution of the transponder to Doppler errors shall be less than 200° per sec root mean square (RMS) over the particular electrical, thermal, and mechanical operational environment.

2. For space vehicles, the contribution of the transponder to Doppler errors shall be less than 20° per second RMS over the particular electrical, thermal, and mechanical operational environment.

4.11.1.2.2 Transponder Receiver.

a. Transponder Receiver Frequency Range. The receiver shall operate at the program assigned frequency that is within the allocated frequency range of 5.4 to 5.9 GHz.

b. Transponder Receiver Frequency Variation Acceptance. The receiver shall meet all performance requirements to any valid interrogation that is within ± 2 MHz from the tuned center frequency.

c. Transponder Receiver Off Frequency Rejection. The transponder receiver shall provide at least 80 dB of rejection from 0.15 to 10 GHz excluding the tuning range.

d. Transponder Receiver Image Rejection. The response of a superheterodyne receiver to a signal at its image frequency shall be a minimum of 60 dB relative to the tuned center frequency.

e. Transponder Receiver Bandwidth.

1. The transponder receiver 3 dB bandwidth shall be 11 MHz ± 3 MHz.

2. The transponder receiver 40 dB bandwidth shall be 60 MHz maximum.

f. Transponder Receiver RF Sensitivity. The transponder receiver measured RF threshold sensitivity level shall be -70 dBm or lower. **NOTE 1:** The guaranteed RF threshold sensitivity is the level specified in the procurement document and is the minimum level where the transponder will meet all performance specifications. **NOTE 2:** The measured RF threshold sensitivity level is that RF level where at least 99 percent response to valid interrogations and less than 5 pps response to system noise. **NOTE 3:** Additional delay variation beyond 30 nanoseconds is permitted beyond -65 dBm as specified in **Transponder System Delay** section of this Chapter and this requirement.

g. Transponder Receiver Dynamic Range.

1. The transponder receiver dynamic range shall be between 0 and -65 dBm.

2. The transponder receiver shall respond to valid interrogations with less than 30 nanoseconds delay variation and less than 10 nanoseconds delay jitter while meeting all other performance requirements.

h. Transponder Receiver Maximum Input Signal. The transponder receiver shall not be damaged when subjected to input signals of +20 dBm at the assigned interrogation frequency.

i. Transponder Receiver Pulse Width Acceptance. The transponder receiver shall respond to an interrogation pulse width between 0.25 to 1.5 microseconds.

j. Transponder Receiver Risetime and Fall-time Acceptance.

1. The transponder receiver shall respond to valid interrogations with pulse rise times less than 200 nanoseconds under all operating conditions.

2. The transponder receiver shall respond to valid interrogations with fall times of 0.5 microseconds or less under all operating conditions.

k. Transponder Receiver Pulse Code Spacing.

1. Transponder receiver pulse code spacing shall be between 3 and 12 microseconds with a setting tolerance of ± 25 nanoseconds. **NOTE:** Pulse code spacing shall be established by the Range on an individual program basis.

2. The interrogation pulse code spacing shall be between 150 and 300 nanoseconds and the receiver shall reject all others outside these limits.

l. Transponder Receiver Decoder Immunity. No response is permitted to 100 microsecond pulse width coded or uncoded pulse trains nor unmodulated continuous wave (CW) signals within the dynamic signal strength range between 0 and -65 dBm. The transponder receiver shall respond only to double pulse coded interrogations unless approved by Range Safety.

4.11.1.2.3 Transponder Transmitter.

a. Transponder Transmitter Frequency Range. The transponder transmitter shall operate at the program assigned frequency that is within the allocated frequency range of 5.4 to 5.9 GHz.

b. Transponder Transmitter Frequency Stability.

1. The non-coherent transponder transmitter frequency stability shall be ± 3 MHz from the assigned frequency after the minimum stabilization

period.

2. The coherent transponder transmitter frequency stability shall be no greater than the maximum drift that will permit the transponder to reply coherently to valid interrogations at the assigned frequency ± 3 MHz and satisfy all other operational requirements.

c. Transponder Transmitter Frequency Drift Rate. The transponder transmitter frequency drift rate shall be 1 MHz per min maximum under all operating conditions.

d. Transponder Transmitter Duty Cycle. The transponder transmitter duty cycle shall be capable of sustaining a constant 2600 interrogations per sec minimum.

e. Transponder Transmitter Recovery Time. The transponder transmitter recovery time shall be 50 microseconds maximum with no reduction in reply power, change in frequency, or reply pulse shape. **NOTE:** Replies may be inhibited during the transponder recovery period.

f. Transponder Transmitter Overinterrogation Protection. Transponder transmitter overinterrogation protection shall meet the following criteria:

1. The response shall be restricted to duty cycle limitations.

2. The overinterrogation protection shall prevent damage to the transponder.

3. The overinterrogation protection shall prevent excessive power consumption.

4. The overinterrogation protection shall recover to normal operation in no more than 500 microseconds after the interrogation rate falls to or below 2600 valid interrogations per sec.

g. Transponder Transmitter Peak Power Output.

1. The transponder transmitter peak power output shall be of sufficient amplitude to provide a downlink margin of 0 dB based on the RF link analysis.

2. The RF link analysis shall include the following data:

(a) 95 percent radiation sphere antenna power gain

(b) Vehicle cable loss

(c) Polarization loss

(d) Atmospheric attenuation

(e) Plume attenuation

(f) Uplink and downlink free space attenuation using the least sensitive radar assigned by the Range at the limit of Range Safety responsibility.

h. Transponder Transmitter Spectral Characteristics.

1. The transponder transmitter pulsed RF spectrum shall not exceed 3.0 divided by the pulse width in microseconds at the quarter power points.

2. Coherent transponder transmitter central fine line jitter shall not exceed 1 Hz, and the central line 3dB bandwidth shall not exceed 40 Hz (as measured in a 10 Hz resolution bandwidth and 30 Hz video bandwidth).

3. Coherent transponder transmitter interline noise and spurs shall be a minimum of 20 dB below the central fineline power.

i. Transponder Transmitter Pulse Characteristics.

1. Non-coherent transponder transmitter pulse width shall be no greater than 500 ± 100 nanoseconds.

2. Transponder transmitter pulse width jitter standard deviation (one sigma) shall not exceed 10 nanoseconds measured at the half power points.

3. Transponder transmitter pulse amplitude variation shall not exceed 1 dB over the operating PRF range.

4. Transponder transmitter pulse amplitude jitter shall not exceed 0.5 dB peak-to-peak measured on a pulse-to-pulse basis.

5. Transponder transmitter pulse transition times shall not exceed a rise time of 100 nanoseconds and a fall time of 150 nanoseconds. **NOTE 1:** A design goal is to have equal rise and fall times. **NOTE 2:** Transition times are measured between the 10 percent and 90 percent levels.

4.11.2 Global Positioning System

4.11.2.1 GPS Antenna System

4.11.2.1.1 GPS Antenna System General Design Requirements.

a. The GPS receive antenna system (L-Band GPS satellite to vehicle) shall provide adequate gain over the complete radiation sphere to ensure that the GPS system provides uninterrupted vehicle tracking (the GPS solution can be continuously maintained) from before lift-off through end of Range Safety responsibility.

b. The GPS receive antenna system shall minimize variations in phase noise and slope.

c. A GPS transmit (missile to ground) RF link analysis shall be performed by the Range User using the power gain specification for 95% of the radiation sphere.

1. The link margin shall be no less than 0 dB

relative to the required signal power for the individual telemetry receiving systems selected by the Range.

2. Antenna and trajectory data required to perform the link analysis shall be submitted.

3. The antenna patterns shall be provided in accordance with the RCC document 253, RCC Standard Coordinate System and Data Formats for Antenna Patterns.

4. S-Band downlink dropouts due to liftoff and staging events must be addressed in the RSSR. Description of dropouts shall include anticipated duration and causes such as plume attenuation and multipaths.

d. In all cases, the GPS receive and transmit link margins shall be sufficient to ensure uninterrupted vehicle tracking from before liftoff through end of Range Safety responsibility. This requirement applies to all possible unplanned and erratic paths that the vehicle may fly without mandatory destruct.

4.11.2.1.2 GPS Receive Antenna System (GPS Satellite to Launch Vehicle). This system is used to receive L-Band signals (L1 and/or L2) from GPS satellites and pass RF energy to the GPS translator or receiver.

a. The antenna shall have 3 dB bandwidths of at least the channel code main lobe bandwidth.

b. The antenna system shall display a voltage standing wave ratio (VSWR) of less than 2.5:1 or 4 percent power reflected when excited from a source with the same impedance as the planned cable installation at the assigned frequencies.

c. Antenna gain and phase patterns shall be provided to Range Safety for each program. The gain of the antenna system relative to an isotropic radiator and the phase of the far field radiation relative to the antenna excitation shall be measured at two degree increments over the complete radiation sphere at the operational L-Band frequencies and polarizations.

d. The GPS receive (GPS satellite to missile) antenna systems shall provide adequate gain throughout 100 percent of the radiation sphere to ensure uninterrupted tracking.

e. Antenna Pattern Data. The following pattern data is the minimum required for evaluation and analysis:

1. Power gain relative to a right circular polarized isotropic radiation over the entire radiation sphere at two degree increments.

2. Relative phase excitation and far-field radiation over the entire radiation sphere at two degree increments.

3. Input reflection coefficient (VSWR) versus frequency over a span described as 3 dB points in paragraph *a* above.

4. GPS antennas shall be tested in accordance with Appendix 4B2.

4.11.2.1.3 GPS Transmit Antenna System (Missile to Ground). This system is used to transmit (downlink - typically S-Band) GPS translator signals/state vectors and GPS dedicated telemetry to ground telemetry receiving station(s). The GPS transmit system may share a S-Band antenna system if GPS transmit system and other S-Band functions such as missile telemetry are not degraded below respective requirements.

a. The antenna shall have 3 dB bandwidth sufficient to pass the output of the GPS translator/receiver.

b. The antenna system shall display a voltage standing wave ratio (VSWR) of less than 1.5:1 or 4 percent power reflected when excited from a source with the same impedance as the planned cable installation at the assigned frequencies.

c. The antenna system shall operate within required specifications, with no arcing or damage, at twice the normal RMS and peak excitation power at any atmospheric pressure between 0.0001 and 760 Torr (mm. of Hg).

d. Antenna gain and phase patterns shall be provided to Range Safety for each program. The gain of the antenna system relative to an isotropic radiator and the phase of the far field radiation relative to the antenna excitation shall be measured at two degree increments over the complete radiation sphere at the operational S-Band frequencies and polarizations.

e. The GPS transmit (missile to ground) antenna system shall provide adequate gain throughout 95 percent of the radiation sphere to ensure closure of the RF link with sufficient margin to provide uninterrupted data.

f. Antenna Pattern Data. The following pattern data is the minimum required for evaluation and analysis:

1. Power gain relative to a right circular polarized isotropic radiation over the entire radiation sphere at two degree increments

2. Relative phase excitation and far-field

radiation over the entire radiation sphere at two degree increments

3. Input reflection coefficient (VSWR) versus frequency over a span described as 3 dB points in paragraph *a* above

4. GPS antennas shall be tested in accordance with System Appendix 4B2.

4.11.2.2 GPS System

4.11.2.2.1 GPS Translator and Receiver General Design Requirements.

a. Operational Life. The translator and receiver shall meet all operational requirements from receipt through end of mission.

b. Stabilization Time. The time needed after power application for the translator/receiver to satisfy all performance requirements shall be minimized, measured, and shall be specified and then documented during development, qualification, and acceptance testing.

c. Antenna RF Impedance Mismatch. The translator/receiver shall suffer no damage and meet all requirements after operating with the antenna connector open or shorted.

d. Power Source Switching. The operational performance of the translator/receiver shall not be degraded by its internal or external power supply or by repetitive switching between them

4.11.2.2.2 GPS Digital Translator.

a. Probability of Bit Error. The bit probability error shall be less than or equal to 10^{-6} .

b. Delay Time. The input-to-output delay time for the digital translator and associated GPS ground equipment shall be less than 250 milliseconds or TBD.

c. Delay Time Consistency. The overall GPS input-to-output time delay shall be constant across in-band frequencies to within plus or minus 40 nanoseconds.

d. Delay Time Stability. The average time delay through the GPS channel shall be stable or calibrate to within plus or minus 40 nanoseconds over the operational (mission) period. Stability shall be achieved after a 2 minute warm up. These requirements shall be met for all input signals from -110 dBm to -145 dBm.

e. Frequency Accuracy. The frequency accuracy of the S-Band and RF output shall remain within 20 parts-per-million of design center frequency.

f. Frequency Drift. The frequency drift of the

S-Band RF output shall maintain a 0.1 sec double Allan variance of better than 1 part in 10 to the 10th.

g. Frequency Stability. Frequency stability for the S-Band carrier shall be specified.

h. Noise Figure. The noise figure shall be no greater than 3.5 dB.

i. Contribution to Error. The translator shall not contribute to error in pseudo-range calculation.

j. S-Band Spectral Characteristics and Spurious Emissions. S-Band spectral characteristics shall comply with Range Commander's Council document 106-93.

k. Suppression. For translators that use suppressed carrier for the S-Band downlink suppression shall be specified.

l. Phase Linearity. Phase Linearity from 1574 to 1576 MHz and 1226 to 1228 MHz shall be specified.

m. L_1/L_2 Bandpass Characteristics. L_1/L_2 bandpass characteristics shall be specified.

n. Phase Jitter. Phase jitter shall be specified for maximum predicted vibration environment.

o. Peak Input Voltage. The translator shall be able to withstand a 45 Vdc input.

p. RF Overload. Susceptibility to combinations of up to three out-of-band continuous wave signals shall be specified. The translator must be able to withstand an in-band RF overload of 10 dBm for one minute without degradation after the overload is removed.

4.11.2.2.3 GPS Receiver.

a. System Noise. The system noise figure established by the preamplifier shall be established in the receiver specification. In no case shall the noise figure exceed 3.5 dB.

b. Immunity to In-Band Interfering Signal. Receiver immunity to in-band interfering signals shall be specified as a function of tracking and signal acquisition levels (3 dB reduction).

c. State Vector. The receiver shall provide a state vector of required accuracy under all dynamic conditions of the vehicle.

d. Rapid Re-Lock Capability. The re-lock time after loss of a satellite shall be specified and approved by the Range.

e. Time to First Fix. Time to first fix shall be specified and approved by the Range.

f. State Vector Data Rate. State vector updates shall be provided to the Range at a rate of not less than 20 Hz.

g. Delay Time. The input-to-output delay time shall be less than 250 milliseconds or TBD.

h. De-Selection of Faulty Satellites. The receiver must have an inherent capability to identify and de-select faulty satellites. The satellite selection/de-selection routine must be approved by Range Safety.

i. Telemetry. The receiver shall provide the following data to the Range via telemetry: satellite assignments, lock status, ephemeris ready, currency of ephemeris, pseudo and delta range, state vector, state vector quality, PDOP, GDOP, signal quality, C/N_0 , satellite health bit, and age of data.

j. Phase Linearity. Phase linearity from 1574 to 1576 MHz and 1226 to 1228 MHz shall be specified.

k. L_1/L_2 Bandpass Characteristics. L_1/L_2 bandpass characteristics shall be specified.

l. Phase Jitter. Phase jitter shall be specified for maximum predicted vibration environment.

m. Sensitivity. Sensitivity of the receiver must be TBD dBm or greater.

n. Out-of-Band Signals. Immunity to out-of-band signals shall be specified.

o. Peak Input Voltage. The receiver shall be able to withstand a 45 Vdc input.

p. RF Overload. Susceptibility to combinations of up to three out-of-band continuous wave signals shall be specified. The receiver must be able to withstand an in-band RF overload of 10 dBm for 1 min without degradation after the overload is removed.

4.11.2.2.4 Integrated GPS/Inertial System. TBD

4.11.3 RTS Wiring Design

a. The insulation resistance between the shield and conductor shall be greater than 2 megohms at 500 Vdc minimum.

b. Wiring and harness shall be capable of withstanding 1500 Vac (RMS) 60 Hz at sea level pressure between mutually insulated points and the case or housing.

c. Wire shall be of sufficient size to adequately handle 150 percent of the design load.

d. Wires and cable shall be given support and protection against abrasion or crimping.

4.11.4 RTS Electrical Connector Design

4.11.4.1 RTS Electrical Connector General Design Requirements

- a. RTS connectors shall be designed in accordance with the requirements of MIL-C-38999J or the equivalent and the requirements of this section.
- b. Plug and socket type connectors are required.
- c. Outer shells of connectors shall be made of metal.
- d. Connectors shall be selected to eliminate the possibility of mismating. **NOTE:** Mismating includes improper installation as well as connecting wrong connectors.
- e. Connectors shall be of the self-locking type or lock wiring shall be used to prevent accidental or inadvertent demating.
- f. Connector design shall ensure that the shielding connection is complete before the pin connection.
- g. Source circuits shall terminate in a connector with female contacts.
- h. Connectors relying on spring contact shall not be used.
- i. The mated connectors shall withstand an axial pull on the cable or harness of at least 30 lb for a minimum of 1 min.

4.11.4.2 RTS Electrical Connector Pins

- a. There shall be only one wire per pin.
- b. In no case shall a connector pin be used as a terminal or tie-point for multiple connections.

4.11.4.3 RTS Connector Capacity

Connectors shall be capable of adequately handling 150 percent of the design load.

4.11.5 RTS Battery Design

4.11.5.1 RTS Battery Independence

RTS batteries shall be independent of the batteries for the FTS and TDTS.

4.11.5.2 RTS Battery Design Life

- a. Batteries shall be of sufficient capacity to allow for load and activation checks, launch countdown checks, and any necessary hold time.
- b. Sufficient battery life shall be available for 150 percent of the mission time for which Range Safety has flight safety responsibility or 30-min, hang-fire hold time plus mission time. Mission time includes the minus count time starting when the

RTS has switched to the final internal power configuration (battery) through normal flight. **NOTE:** The 30-min, hang-fire hold time applies only to vehicles using solid propellants and vehicles using solid propellant ignition systems.

- c. An analysis shall be provided to demonstrate compliance with sufficient battery life availability at launch prior to the qualification test.

d. Battery Storage Life

1. The battery shall meet design requirements of this section after a storage life of a minimum of two years from date of manufacture.

2. Silver zinc batteries shall have a minimum wet stand time of 60 days.

3. Lot buys shall include enough cells to provide a continuous data base throughout the life of the lot in accordance with Appendix 4B4.

4.11.5.3 RTS Battery Electrical Characteristics

- a. Batteries used to provide power to the RTS shall be capable of delivering 1.5 times the expected maximum current draw.

1. The current shall be delivered to the RTS at the lowest system battery voltage, using the worst case system tolerances. The lowest system battery voltage shall be based on the RTS component voltage range.

2. The lowest system battery voltage including all load conditions shall be the RTS electrical components' minimum acceptance test voltage.

- b. The resistance between all battery terminals and between each terminal or pin to case shall be 2 megohms or greater when measured at a potential of 500 ± 25 Vdc prior to activation of the battery.

4.11.5.4 RTS Battery Electrical Protection

- a. Battery terminal connectors shall be designed to prevent reverse polarity.

- b. Diodes shall be used to prevent reverse current. **NOTE:** The diodes may be placed in the battery or in external circuitry.

- c. If a battery is not connected to the system, the battery terminals or connector plug shall be taped, guarded, or otherwise given positive protection against shorting.

- d. The battery shall be capable of accepting without damage or degradation an overcharge. The percentage overcharge based on nominal capacity rating of the battery and cell shall be specified. This shall include a maximum time limit based on the nominal charging rate.

4.11.5.5 RTS Battery Monitoring Capability

a. The voltage of each battery shall have the capability to be monitored within 2 percent accuracy via telemetry and hardline.

b. Batteries requiring heating or cooling to sustain performance shall have a telemetry channel indicating the temperature of each battery. **NOTE:** The temperature sensor and telemetry combined measurement tolerance should be less than 1.0°F. This will allow qualification temperature extremes to be reduced from 10° C to 10° F.

c. The battery current shall have the capability to be monitored via telemetry or hardline.

4.11.5.6 RTS Battery Pressure Relief

a. Battery cases shall be designed to a 3:1 ultimate safety factor with respect to worst case pressure build-up for normal operations.

b. The battery case pressure build-up shall take into account hydraulic and temperature extremes.

c. Sealed batteries and cells shall have pressure relief capability.

d. Pressure relief devices for sealed batteries and cells shall be set to operate at a maximum of 1.5 times the operating pressure and sized such that the resulting maximum stress of the case does not exceed the yield strength of the case material.

4.11.5.7 RTS Battery Accessibility

a. Batteries shall be easily accessible for inspection and replacement.

b. Provisions shall be made in the battery design to permit open circuit voltage and load testing of each cell when assembled in the battery case. **NOTE:** This testing shall take place at the Range.

4.11.5.8 RTS Secondary Batteries

a. Batteries used in the secondary mode shall have a cycle life greater than the number of cycles to be experienced during normal processing and flight.

b. Battery charging circuits shall be external to the launch vehicle.

c. Battery charging shall be designed to prevent a runaway battery temperature and adjust current rates accordingly with a high temperature limit cutoff.

d. The temperature-based control shall be in addition to other methods of charge control.

e. An analysis shall be provided to demonstrate compliance with the battery charging temperature

and current control.

4.11.5.9 RTS Battery Initiators

The initiator and associated firing circuitry shall meet the requirements of the **FTS Low Voltage EED System Circuitry Design** section of this Chapter.

4.11.5.10 RTS Battery Identification

Each battery shall be permanently identified with the following information:

- a. Component name
- b. Type of chemistry
- c. Manufacturer identification
- d. Part number
- e. Lot and serial number
- f. Date of manufacture
- g. Shelf Life

4.11.5.11 RTS Silver Zinc Cell and Battery Unique Requirements

a. Batteries shall consist of cells made from electrodes plates with the same lot date code.

b. Batteries shall be designed to allow activation of cells within the battery.

c. Electrode plate connection to cell terminals shall be maintained when exposed to qualification environments.

d. Heaters shall be designed to insure consistent heating of all cells.

e. Cell cases shall be designed to not leak when exposed to qualification environments.

f. Cell and battery manufacturing process shall be documented. This documentation shall include identification of all processes used from receipt of materials to final assemble. No changes to the process shall be allowed without Range Safety concurrence.

g. Silver zinc batteries only used in the primary mode shall have a minimum wet stand time of 60 days. Silver zinc batteries used in the secondary mode shall have:

1. A maximum number of secondary cycles specified
2. A charge retention life for each secondary cycle specified
3. An activated service life (total activated time) specified.

h. Silver zinc batteries shall provide the capability to individually charge each cell if the battery is to be used in the peroxide state or is used in the

monoxide state but requiring electrically conditioning of the electrodes.

i. Minimum soak time shall be specified for both vacuum fill or gravity fill of electrolyte.

j. Absorption devices shall be provided to accommodate electrolyte release. This device shall not provide a conductive path between cell terminals or the cell terminals and the battery box.

k. Silver zinc cells that will be used in the monoxide state shall have a specified peroxide removal process.

4.11.5.12 RTS NiCad Cell and Battery Unique Requirements (Reserved)

4.12 TELEMETRY DATA TRANSMITTING SYSTEM REQUIREMENTS

4.12.1 Telemetry Data Transmitting System General Description

Telemetered data, particularly data concerning the status of the RSS components and the launch vehicle performance, form an integral part of the missile flight control system. These components and subsystems are subject to the same level of scrutiny as other portions of the RSS. The determination of which portions of the TDTS that will be subjected to this scrutiny is made on a program-by-program basis as early in the program as possible.

4.12.2 TDTS General Design Requirements

a. The TDTS operating frequency shall be compatible with the Range Ground Support Stations.

b. The TDTS design shall have adequate capacity to transmitting the required status of the RSS components and/or functions.

c. Piece/parts selected for use in TDTS electronic systems shall be consistent with launch vehicle reliability requirements.

d. Calibration data on each demodulated telemetry measurement shall be provided by the Range User. **NOTE:** The telemetry measurements received shall be within the actual output of the item monitored for all non-discrete outputs.

e. The transmitter shall be tested in accordance with the requirements in Appendix 4B14.

4.12.3 TDTS Component Maximum Predicted Environment

a. An analytical approach for determining TDTS component maximum predicted environment (MPE) levels such as shock, thermal, and vibration

shall be developed by the Range User and submitted to Range Safety for review and approval.

b. The analytical approach shall use existing flight data from other similar vehicles (if available), analysis, computer modeling, and subsystem testing such as bracket and truss vibration testing.

c. If there are fewer than three existing flight data samples, a minimum 3 decibel (dB) margin for vibration, 4.5 dB for shock, and 11°C for thermal shall be added to the analytical environment to obtain the predicted MPE.

4.12.4 TDTS Environmental Design Margin

4.12.4.1 TDTS General Environmental Design Margin

a. TDTS components, including methods of attachment, mounting hardware, and cables and wires, shall be designed to function within performance specifications when exposed to environmental levels that exceed the ground transportation, prelaunch processing, checkout, and launch through end of Range Safety responsibility.

b. TDTS design shall take into consideration the test requirements in Appendix 4B14.

4.12.4.2 TDTS Component Thermal Environment

a. Unless otherwise specified by Range Safety, TDTS components shall be designed to function normally in thermal environments 10°C higher and 10°C lower than the predicted thermal range.

b. The minimum design thermal range shall be minus 34°C to +71°C. *EXCEPTION: Batteries shall meet the requirements in paragraph a above.*

c. The components shall be designed to survive the thermal environment for a minimum of 24 qualification cycles and 8 acceptance cycles. *EXCEPTION: Batteries shall meet the requirement as stated in Appendix 4B4.*

4.12.4.3 TDTS Component Random Vibration Environment

a. Unless otherwise specified by Range Safety, TDTS components shall be designed to survive random vibration environments that are 4.5 dB above the MPE level or 12.2 Grms, whichever is greater.

b. The minimum design duration shall be:

1. Three times the expected flight exposure time or 3 min per axis, whichever is greater for qualification

2. The flight exposure time or 1 min per axis, whichever is greater, for acceptance

c. The minimum frequency range shall be 20 to 2000 Hz.

4.12.4.4 TDTs Component Acoustic Noise Environment

a. Unless otherwise specified by Range Safety, TDTs components shall be designed to survive acoustic noises that is 4.5 dB above the MPE level or a minimum 144 dB overall sound pressure for acoustic, whichever is greater.

b. The minimum design duration shall meet the following criteria:

1. Three times the expected flight exposure time or 3 min, whichever is greater, for qualification

2. The flight exposure time or 1 min, whichever is greater, for acceptance

4.12.4.5 TDTs Component Shock Environment

a. Unless otherwise specified by Range Safety, TDTs components shall be designed to a margin of 6 dB above MPE level or a minimum of 1300 G, whichever is greater.

b. The duration shall simulate the actual shock environment.

c. The minimum frequency range shall be from 100 to 10,000 Hz.

d. The minimum number of shocks shall be 3 shocks per axis for each direction, positive and negative, for a total of 18 shocks.

4.12.4.6 TDTs Component Acceleration Environment

a. Unless otherwise specified by Range Safety, TDTs components shall be designed to 2 times the MPE level or a minimum of 20 G in each direction, whichever is greater.

b. The minimum duration for acceleration shall be 5 min per axis.

4.12.4.7 Other TDTs Component Environments

a. Other environments applicable to TDTs components are humidity, salt fog, dust, fungus, explosive atmosphere, thermal vacuum, electro-

magnetic compatibility (EMC), electromagnetic interference (EMI), sinusoidal vibration, and other non-operational environments.

b. Tests and test levels for these environments are described in Appendix 4B1.

4.12.4.8 TDTs RF Link Analysis

a. A complete RF link analysis shall be performed by the Range User to verify adequate gain coverage over 95 percent of the radiation sphere.

b. The antenna patterns shall be provided in accordance with RCC 253 and shall be used in the RF link analysis.

c. The RF link margin shall be no less than 0 dB relative to the required signal power for the individual TM receiving stations selected by the Range to reliably decode the TM signal.

4.12.5 TDTs In-Flight RSS Telemetry Data

a. Sufficient TDTs data shall be telemetered to determine the adequacy of the RSS throughout powered flight and to aid in preflight and post-flight analysis.

b. The Range User shall provide a telemetry measurements list and Range Safety shall identify any further mandatory measurements.

c. At a minimum, the following telemetry data shall be provided to the ground receiving station.
NOTE: The TDTs data requirements listed below are not necessarily all inclusive:

1. An analog channel for SSTO voltage for each CRD

2. All decoder outputs for each CRD

3. Status of each arming device (ARM or SAFE)

4. An analog channel for voltage monitoring for each RSS battery

5. An analog channel for current monitoring for each RSS battery

6. Status of any special RSS electrical inhibits

7. Each firing unit logic for EBW and laser ordnance systems such as ARM input, power, high and low capacitor voltage, and trigger voltage

8. Automatic Destruct System (ADS) status

9. A separate analog channel for each RSS battery temperature if the battery is temperature sensitive

10. Power switch status (INTERNAL and EXTERNAL)

4.13 RSS GROUND SUPPORT AND MONITORING EQUIPMENT DESIGN REQUIREMENTS

Ground support equipment includes, but is not limited to, the ER Operations Safety Console, the WR Safety Console, the FTS console, other blockhouse consoles, antenna couplers (hats), RF sensitivity, and insertion loss test equipment

4.13.1 RSS Ground Support and Monitoring Equipment General Design Requirements

a. Design requirements for ground support and test equipment used to perform mandatory Range Prelaunch Tests shall be reviewed and approved by Range Safety.

b. All RSS ground support and test equipment shall be designed to meet industry safety requirements such as those defined in American National Standards Institute (ANSI), Occupational Safety and Health Act Administration (OSHA), National Fire Protection Association (NFPA), and other applicable standards.

c. Ground Support Equipment (GSE) Maintenance

1. All GSE used for checkout and monitoring of the RSS shall be verified on a periodic basis.

2. The verification pass/fail criteria and frequency of verification shall be documented in a formal procedure.

d. Test Equipment Calibration

1. All test equipment used for testing and monitoring of the RSS shall be periodically calibrated by a laboratory whose standards are traceable to the National Institute of Standards and Testing (NIST).

2. All test equipment shall bear evidence of current calibration when in use.

4.13.2 Destruct Initiator Simulator

A destruct initiator simulator shall be provided for all command and automatic destruct system tests, Wet Dress Rehearsals, Countdown Demonstration Tests, or similar tests including Range prelaunch tests.

4.13.2.1 Destruct Initiator Simulator Description

The destruct initiator simulator is a device whose electrical and optical characteristics match as closely as possible the electrical and optical char-

acteristics of the actual destruct initiator.

4.13.2.2 Destruct Initiator Simulator Design

a. The destruct initiator simulator shall be design-ed to simulate the actual destruct initiator.

b. The destruct initiator simulator shall also be capable of monitoring the firing circuit output current, voltage, or energy and latch on when the operating current, voltage, or energy for the initiating device is outputted from the firing circuit.

c. An analysis shall be provided to demonstrate compliance with this requirement.

d. The destruct initiator simulator shall be capable of remaining connected throughout ground processing until the electrical connection of the actual initiators is accomplished.

e. The destruct initiator simulator designed shall provide an interlock capability to permit the issuance of destruct commands by test equipment only if the simulator is installed and connected to the firing lines.

f. For low voltage initiators, the simulator shall provide a stray current monitoring device such as fuse or automatic recording system capable of indicating a minimum of 1/10 of the maximum no-fire current. This stray current monitoring device shall be installed in the firing line.

4.13.3 Laser Test Equipment

a. All laser test equipment that has the capability to directly or indirectly fire the LID shall be assessed and approved by Range Safety.

b. Laser test equipment shall be designed to meet the following criteria:

1. The energy level shall be less than 1/10,000 of the no-fire level of the LID.

2. The single failure mode energy level of the test equipment shall be less than 1/100 of the no-fire level of the LID.

3. The test source shall emit a different wave length than the firing unit laser.

4.13.4 ER Operations Safety Console

4.13.4.1 ER Operations Safety Console Description

The ER Operations Safety Console (OSC) is located in the launch control center (blockhouse). It contains indication devices showing the status of the FTS and vehicle-peculiar functions critical to flight safety during prelaunch and up to lift-off.

4.13.4.2 ER OSC Design

a. An ER OSC design shall be developed and submitted to Range Safety for review and approval. (See the **Operations Safety Console Requirements** section in Chapter 3 of this document for additional non-FTS related ER OSC requirements.)

b. There shall be no SFP components in the ground support equipment or Firing Room systems that will cause the loss of a safety critical system monitor (as determined by Range Safety) at the OSC.

c. The OSC shall be designed in accordance with the requirements in MIL-STD-1472, or equivalent.

d. When applicable, the following vehicle FTS status shall be provided continuously to the OSC during prelaunch and up to lift-off:

1. Signal Strength Telemetry Output voltage for each CRD

2. Power for each CRD (ON/OFF, External/Internal power)

3. Monitors for all decoder outputs for each CRD

4. Status of all arming devices and all inhibits

(*a*) Optical S&A Devices. Barrier position (SAFE/ARM), barrier locked/unlocked, and electrical power status of the main laser

(*b*) Ordnance S&A Devices. SAFE and ARM

(*c*) Electromechanical S&A Devices. SAFE and ARM

(*d*) Other electronic arming devices or inhibits. **NOTE:** The exact circuits to be monitored will be determined by Range Safety.

(*e*) EBW FU. Trigger capacitor voltage, high voltage capacitor voltage, arm and destruct input, inhibit input and power

(*f*) Laser High Voltage Firing Unit. Trigger capacitor voltage, high voltage capacitor voltage, arm and destruct input, inhibit input, barrier positions, barriers locked/unlocked and power

5. Laser power status

6. Battery status

(*a*) Voltages of each FTS airborne battery and FTS ground command and automatic power supply

(*b*) Battery temperature of each FTS airborne battery and FTS ground command and automatic power supply

(*c*) Battery current of each FTS airborne battery and FTS ground command and automatic

power supply

(*d*) Provisions for monitoring battery life, operating time, or other means of monitoring energy remaining for flight

7. Proper functioning of destruct initiator simulators

8. FTS power transfer switch status (ON/OFF and AIRBORNE/GROUND)

9. Monitors for vehicle-peculiar functions critical to flight safety and other vehicle peculiar functions critical to FTS as identified by Range Safety

10. Status of the Range Command Transmitter carrier (ON/OFF)

4.13.5 WR Safety Console and RSS Repeater System

4.13.5.1 WR Safety Console General Design

a. A WR Safety Console design shall be developed and submitted to Range Safety for review and approval.

b. An FTS control console shall be provided and maintained by the Range User.

c. The FTS control console shall be located in the launch control center in a position that provides a viewing capability of the countdown time indicator and either the launch controller consoles or the launch sequencer control consoles, as applicable.

d. The FTS control console shall provide seating accommodations for two persons with access to the console controls and monitors by either person. **NOTE:** This console is designed to provide monitor and control capability for one person designated by the Range User to perform tasks defined by approved test procedures including countdown and launch manuals. The second position at this console is occupied by the Flight Safety Project Officer (FSPO). The FSPO supports test operations by analyzing RSS performance and evaluating RSS flight readiness and also acts as the Range User interface for resolution of RSS problems. The FSPO also provides coordination of the final ready-to-launch system acceptance issued by the Mission Flight Control Officer (MFCO). This requirement may be satisfied by providing two separate consoles to perform the required functions (The FSPO will require only the monitor capability).

4.13.5.2 WR Safety Console FTS Pre-Flight and In-Flight Telemetry Monitors and Controls

As applicable, the following FTS pre-flight and in-

flight telemetry monitors and controls shall be provided continuously during prelaunch and through lift-off by the Range User:

flight tests and missile flight.

a. Signal Strength Telemetry Output voltage for each CRD

b. Controls and power status for each CRD (ON/OFF, External/Internal power)

c. Monitors for all decoder outputs for each CRD

d. Status and controls of all arming devices and all inhibits

1. Optical S&A Devices. Barrier position (SAFE/ARM), barrier locked/unlocked, and electrical power status of the main laser

2. Ordnance S&A Devices. SAFE/ARM

3. Electromechanical S&A Devices. SAFE/-ARM

4. Other electronic arming devices. The exact circuits to be monitored shall be determined by Range Safety.

e. EBW FU. Trigger capacitor voltage, high voltage capacitor voltage, arm and destruct input, inhibit input and power

f. Laser High Voltage Firing Unit. Trigger capacitor voltage, high voltage capacitor voltage, arm and destruct input, inhibit input, barrier positions, barriers locked/unlocked and power

g. Laser power status

h. Sensors to monitor voltages of each FTS airborne battery and FTS ground command and automatic power supply

i. Battery temperature

j. Battery current

k. Provisions for monitoring battery life, operating time, or other means of monitoring energy remaining for flight

l. Proper functioning of destruct initiator simulators

m. FTS power transfer switch status (ON/OFF and AIRBORNE/GROUND)

n. Monitors for vehicle-peculiar functions critical to flight safety. Controls in the console shall be capable of being locked or safed to the OFF position if they are considered to be a safety hazard by Range Safety.

o. Status and alert signaling system to activate status and alert remote display on the MFCO console to indicate GO or NO-GO status of the airborne FTS

p. In all cases, the provided monitors shall be continuously available to the FSPO during pre-

4.13.5.3 WR Safety Console RTS Pre-Flight and In-Flight Telemetry Monitors

Provisions shall be made by the Range User to provide the following RTS pre-flight and in-flight telemetry monitors:

- a. RTS power mode monitors (ON/OFF, external or internal)
- b. Sensors to Monitor RTS Applied Voltage. **NOTE:** CRT displays for this purpose are preferred; however, the option exists to provide either voltmeters or voltage comparator circuits with status lights.
- c. Sensors to monitor RTS current consumption for quiescent and interrogation modes. The sensors shall be compatible with those described in paragraph *b* above.
- d. Provisions for monitoring battery life or operating time
- e. Additional monitors may be required depending on the nature of the system and individual components. If required, the additional monitors will be identified at the appropriate design review.
- f. In all cases, the provided monitors shall be continuously available to the Safety representative.

4.13.5.4 WR Safety Console Communications

The following communications capability shall be provided at the FSPO console and shall be available continuously throughout any simulated countdown tests, countdown and flight:

- a. Primary Voice Direct Line (VDL) to Mission Flight Control Officer (MFCO) in Building 7000
- b. Backup VDL to MFCO
- c. VDL to Range Control Officer (RCO) in Building 7000
- d. One class "A" telephone dial line
- e. Countdown Net (monitor only)
- f. Backup Countdown Net (monitor only), if required by Range User
- g. Any other net used for updating and/or changing the status of the FTS or RTS. **NOTE:** More communications capability may be required
- h. The FSPO console shall have the capability to monitor one or more nets while simultaneously talking on another.
- i. More communications capability may be required depending on specific vehicle design and monitoring requirements. An example of this

would be an additional VDL from the FSPO console to the Telemetry Instrumentation Processing System (TIPS) area of the WR in Building 7000.

4.13.5.5 WR Launch Facility RSS Repeater System

a. If the RF propagation path from the vehicle antenna to the Range instrumentation site (radar, command transmitter, telemetry receiving station) is not adequate to ensure a good RF interface of the vehicle RSS prior to launch, an RF repeater system shall be provided.

b. Provisions shall be made for direct connection of the Range test van(s) to the vehicle RSS through the repeater system.

4.13.6 RSS Components Provided by the Range User

4.13.6.1 ER RSS Components Provided by the Range User

a. If secure CRDs are used, the Range User shall supply three flight configured secure CRDs to 45 SW. **NOTE:** The three flight configured secure CRDs are required for verification of secure flight code load, testing and trouble shooting throughout the program.

b. Two of the secure CRDs shall be supplied to the Range Contractor for Range system tests and calibrations.

c. The third secure CRD (Code Insertion Verification Unit) shall be used by the Range User to verify that the same secure code has been loaded into the launch vehicle CRDs as well as the command transmitter Message Storage Units.

4.13.6.2 WR RSS Components Provided by the Range User

a. CRDs. The Range User shall provide two flight configured CRDs for compatibility testing and troubleshooting throughout the life of the program. **NOTE:** One CRD may be a qualification unit and the other can be a production unit.

b. Range Tracking System. The Range User shall provide two flight configured transponders and/or GPS units for compatibility and type testing and troubleshooting throughout the life of the program. **NOTE:** One unit can be a qualification unit and the other a production unit.

c. Test Sets. The 30 SW RF Measurement Lab has a variety of test sets to perform certification testing of CRDs and transponders. If the CRD,

transponder, and/or GPS is not compatible with existing radio frequency measurement laboratory (RFML) test sets, the Range User shall provide test sets for this purpose or provide funding to modify existing test sets, if required.

4.14 RSS ANALYSES REQUIREMENTS

4.14.1 RSS Analyses

4.14.1.1 RSS Failure Analysis

A failure analysis and corrective actions shall be performed for each RSS component that fails to meet specifications, tolerances, or test procedure requirements.

4.14.1.2 RSS Similarity Analyses

a. As required, qualification by similarity analysis shall be performed.

b. If qualification by similarity is not approved, qualification testing shall be performed in accordance with the requirements of this Chapter.

c. If component or piece part A is to be considered as a candidate for qualification by similarity to a component or piece part B that has already been qualified for use, all of the following conditions shall apply:

4.14.1.2.1 Component (Black Box) Similarity Analysis.

a. Component A shall be a minor variation of component B. Dissimilarities shall require understanding and evaluation in terms of weight, mechanical configuration, thermal effects, and dynamic response.

b. Components A and B shall perform similar functions, with A having equivalent or better capability and variations only in terms of performance such as accuracy, sensitivity, formatting, and input/output characteristics.

c. Components A and B shall be produced by the same manufacturer in the same location, using identical tools and manufacturing processes.

d. The environments encountered by component B during its qualification or flight history shall have been equal to or more severe than the qualification environments intended for component A.

e. Component B shall have successfully passed a post-environmental functional test series indicating survival of the qualification stresses.

f. Component B shall have been a representative flight article.

g. Component B shall not have been qualified by similarity or analysis.

h. In cases where all the criteria in the above paragraphs is not satisfied, qualification based on engineering analysis plus partial testing may be permissible.

4.14.1.2.2 Piece/Parts Similarity Analysis.

Addition, subtraction, or replacement of piece/parts within a Range Safety approved RSS component shall require specific approval.

a. Piece part A shall have similar electrical and mechanical specifications such as weight, mounting configuration, power rating, switching speed, and leakage rate as piece part B. **NOTE:** Technical justification showing design qualification by similarity shall be submitted to Range Safety for review and approval for any differences in specification between piece part A and B.

b. Environments such as shock, thermal, and vibration encountered by piece part B during its qualification or flight history shall have been equal to or more severe than the qualification environments intended for piece part A.

c. Piece part B shall have successfully passed a post-environmental functional test series indicating survival of qualification stresses.

d. Piece part B shall not have been qualified by similarity.

4.14.2 FTS Analyses

4.14.2.1 FTS Reliability Analysis

A reliability analysis shall be performed in accordance with the requirements in MIL-STD-785 to demonstrate the reliability goal was used in the concept and detailed design of the components and/or system and shall include the following data:

a. A discussion of how the FTS meets the design requirements of single fault tolerance and the design goal of .999 reliability at the 95 percent confidence level

b. Identification of FTS reliability model input and apportionment

c. Predicted reliability computations for all FTS subsystems and components

d. A description of the effects of storage, transportation, handling, and maintenance on FTS component reliability.

4.14.2.2 FTS Failure Modes, Effects, and Criticality Analysis

A Failure Modes, Effects, and Criticality Analysis (FMECA) shall be performed in accordance with MIL-STD-1543, Task 204 or equivalent.

4.14.2.3 FTS Single Failure Point Analysis

A single failure point (SFP) analysis shall be performed to verify that no single failure can cause FTS activation or disable the FTS.

4.14.2.4 FTS Battery Analyses

a. Prior to the qualification test, an analysis shall be performed to demonstrate that sufficient FTS battery life is available at launch.

b. An analysis shall be also performed to demonstrate compliance with the FTS battery charging temperature and current control.

4.14.2.5 FTS Fratricide Analyses

An analysis may be required to verify that the flight termination action of a stage will not sever inter-connecting FTS circuitry or ordnance to other stages until other stage FTSs have been initiated.

4.14.2.6 FTS RF Link Analysis

a. The entire ground and airborne command FTS shall be subjected to an RF link analysis that shall show a minimum of 12 dB margin.

b. The RF link analysis shall include path losses due to plume or flame attenuation, aspect angle, vehicle trajectory with or without heat shields, ground system RF characteristics, and other attenuation factors.

4.14.2.7 FTS Antenna Heat Shield Fly-Off Analysis

An Antenna heat shield fly-off analysis shall be performed to ensure that the RF link margin would not be adversely affected.

4.14.2.8 FTS CRD Radiation Analysis

Launch vehicle and payload systems shall be analyzed to ensure that CRD radiation profiled are not greater than the environment the CRD is tested to.

4.14.2.9 FTS Bent Pin Analysis

A bent pin analysis shall be performed to verify that any single short circuit occurring as a result

of a bent pin shall not result in more than 10 percent of the all-fire current on the firing circuit or does not have an adverse effect on the FTS.

4.14.2.10 FTS LID Heat Dissipation Analysis

An analysis shall be performed to demonstrate that the LIDs dissipate heat faster than single failure conditions can input into the device without initiating or dudding.

4.14.2.11 FTS Breakup Analysis

NOTE: The purpose of the breakup analysis is to determine where and when a vehicle is most likely to break up under the credible failure scenarios. This data is used to ensure FTS components and separation detection systems are properly designed and located to maximize FTS survivability in the analyzed failure scenarios. An FTS breakup analysis (with and without destruct action) may be required to determine the design of the FTS. If required, the following breakup scenarios shall be considered in the breakup analysis:

a. Breakup due to aerodynamic loading effects at high angle of attack trajectories during early stages of flight at 5 second increments

b. An engine hard-over nozzle induced tumble during various phases of flight of each stage

c. Vehicle events/sequencing that, when activated, can result in damaging the FTS hardware or inhibit the functionality of the FTS

4.14.2.12 FTS Tip-Off Analysis

An FTS tip-off analysis may be required to determine the design of the FTS.

4.14.2.13 ADS Timing Analysis

An ADS timing analysis shall be performed to calculate the worst case time between ADS triggering and final destruct action.

4.14.2.14 Destruct Initiator Simulator Analysis

An analysis shall be performed to demonstrate that the destruct initiator simulator monitors the firing circuit output current, voltage, or energy and latch on when the operating current, voltage, or energy for the initiating device is outputted from the firing circuit.

4.14.3 RTS Analyses

4.14.3.1 RTS Reliability Analysis

A reliability analysis shall be performed in accordance with the requirements in MIL-STD-785 to

demonstrate the reliability goal was used in the concept and detailed design of the components and/or system and shall include the following data:

- a.* A discussion of how the RTS meets the design requirements of single fault tolerance and the design goal
- b.* Identification of RTS reliability model input and apportionment
- c.* Predicted reliability computations for all RTS subsystems and components
- d.* A description of the effects of storage, transportation, handling, and maintenance on RTS component reliability.

4.14.3.2 RTS Failure Modes, Effects, and Criticality Analysis

A Failure Modes, Effects, and Criticality Analysis (FMECA) shall be performed in accordance with MIL-STD-1543, Task 204 or equivalent.

4.14.3.3 RTS Battery Analysis

- a.* Prior to the qualification test, an analysis shall be performed to demonstrate that sufficient RTS battery life is available at launch.
- b.* An analysis shall be performed to demonstrate compliance with the RTS battery charging temperature and current control.

4.14.3.4 RTS RF Link Analysis

- a.* The entire ground and airborne command RTS shall be subjected to an RF link analysis that shall show a greater than 0 dB margin.
- b.* The RF link analysis shall include path losses due to plume or flame attenuation, aspect angle, vehicle trajectory, with and without heatshield, ground system RF characteristics, and other attenuation factors.

4.14.3.5 RTS Antenna Analyses

4.14.3.5.1 ER RTS Antenna Analysis. RTS antenna analysis and evaluation requirements shall be coordinated with the Range.

4.14.3.5.2 WR RTS Antenna Analysis and Data Requirements. At a minimum, the following data shall be provided for evaluation and analysis:

- a.* Power gain relative to an isotropic radiator over the entire radiation sphere at 1° increments
- b.* Relative phase between excitation and far-field radiation over the entire radiation sphere at 1° increments
- c.* Input reflection coefficient (VSWR) versus

frequency over a span of 20 MHz centered on each of the WR assigned frequencies the antenna is intended to operate.

4.14.3.6 RTS Antenna Heat Shield Fly-Off Analysis

Antenna heat shield fly-off analysis shall be performed to ensure that the RF link margin would not be adversely affected.

4.14.4 TDTs Analyses

4.14.4.1 TDTs RF Link Analysis

- a.* The entire ground and airborne TDTs shall be subjected to an RF link analysis that shall show a greater than 0 dB margin.
- b.* The TDTs link margin calculations and loss considerations shall be patterned after the requirements in RCC 253.

4.14.4.2 TDTs Antenna Heat Shield Fly-Off Analysis

Antenna heat shield fly-off analysis shall be performed to ensure that the RF link margin would not be adversely affected.

4.15 RSS TEST REQUIREMENTS

4.15.1 RSS General Test Requirements

- a.* The RSS, including all of its components and methods of attaching fittings or installing the system, shall be tested to certify to Range Safety that the complete system and individual components function within performance specifications when exposed to environmental levels that exceed the maximum predicted or actual flight levels during their service life.

- b.* All test plans shall include instructions on how to handle procedural deviations.
- c.* The instructions shall describe test failure reaction requirements in detail.
- d.* All test schedules shall be provided to Range Safety.

1. The test schedules shall be updated as applicable.

2. Qualification testing shall not begin without Range Safety or a designated representative being present and approving the start of the test unless otherwise agreed in writing by Range Safety.

4.15.1.1 Development Tests

Development tests validate hardware design concepts and assist in the evolution of designs from the

conceptual phase to the operational phase. An objective of these tests is to identify hardware problems early in their design evolution so that any required actions can be taken prior to starting formal qualification testing and fabrication of production hardware.

Range Safety review and approval of development test plans and procedures may not be required if the components and systems under development are considered by Range Safety to be a non-unique application of existing technology. This determination will be made by Range Safety on a case-by-case basis.

4.15.1.2 Qualification Tests

a. RSS components may be qualified by qualification testing or by similarity analysis as described in the **RSS Analyses Requirements** section of this Chapter.

b. Qualification tests involve two types of tests: component tests and subsystem tests. These tests demonstrate that adequate margin exists in the final product to ensure the design specifications and the environmental design margin requirements of this Chapter are met.

c. Qualification test levels are established to exceed the range of environments and stresses expected from acceptance testing through flight.

d. The following requirements shall be met in qualification testing:

1. Except for ordnance, batteries, and safe and arm devices, component qualification tests shall be performed on a minimum of 3 test articles (actual flight units).

2. Test articles subjected to qualification testing are considered expended and shall not be used for flight.

3. All qualification testing shall use flight hardware (flight connectors, cables, cable clamping scheme, attaching hardware such as vibration and shock isolators, brackets, and bolts) in-flight configuration.

4.15.1.3 Acceptance Tests

Acceptance tests are conducted to demonstrate that each production end item is acceptable for delivery. Acceptance tests are designed to reveal inadequacies in the manufacturing process such as workmanship, material, and quality. The following requirements shall be met for acceptance tests:

a. The acceptance test environmental levels shall

be at the maximum predicted or actual environments for ground transportation, pre-launch processing, check-out, launch, through end of Range Safety responsibility.

b. The performance parameter measurements shall establish a baseline that can be used to ensure that there are no data trends present in successive tests that indicate a degradation of performance within specification limits that could result in unacceptable performance in flight.

c. Acceptance testing shall be performed on 100 percent of all RSS components.

4.15.1.4 Age Surveillance Tests

Age surveillance tests are performed periodically to ensure that ordnance components have not degraded over time.

The following requirement shall be met for age surveillance testing: Age Surveillance Tests shall be conducted on each production lot to demonstrate that each ordnance component will perform satisfactorily during its specified service life.

4.15.1.5 Range Prelaunch Tests

Range Prelaunch tests involve component, system or subsystem tests. These tests are conducted at the Range to ensure that ground and airborne RSS components and systems are functioning properly prior to launch.

4.15.1.6 Requalification or Delta Qualification Tests

Requalification or delta qualification tests are required for components that incorporate changes in vendor, vendor location, design, manufacturing, processing, environmental levels, or other requirements.

4.15.1.7 Reuse Tests

Reuse tests are performed on previously flown and recovered RSS components. These tests are conducted to demonstrate that each reused RSS component meets the design requirements specified in the component specification. The following requirements shall be met for reuse testing:

a. Performance parameter measurements shall establish a baseline that can be used to ensure there are no data trends present in successive tests that indicate a constant degradation of performance within specification limits that could result in unacceptable performance in subsequent flights.

b. Design margins, environments, and reuse and refurbishment plans shall be addressed early in the design cycle when reuse is desired.

4.15.1.8 Other Tests

a. Other tests are those special tests that Range Safety requires based on unique use or design. The requirement for and definition of these tests will be identified by Range Safety during the design review process.

b. At a minimum, RF compatibility between the FTS and other airborne systems and Range transmitters shall be tested in the flight configuration. Exact RF test requirements will be determined by Range Safety on a case-by-case basis.

4.15.2 FTS Component Tests

4.15.2.1 FTS Antenna System Qualification and Acceptance Tests

a. Antennas and their coaxial cables shall be qualification tested in accordance with Appendixes 4B1 and 4B2.

b. Antennas and all of their coaxial cables shall be acceptance tested in accordance with Appendixes 4B1 and 4B2.

c. Antennas shall also be tested to obtain the pattern data in accordance with RCC 253.

d. Components such as hybrid couplers, ring couplers, and power dividers shall be qualification and acceptance tested in the same manner as required for antennas.

4.15.2.2 FTS CRD Qualification and Acceptance Tests

a. CRDs shall be qualification tested in accordance with Appendixes 4B1 and 4B3.

b. CRDs shall be acceptance tested in accordance with Appendixes 4B1 and 4B3.

4.15.2.3 FTS Battery Qualification, Storage Life Verification, and Acceptance Tests

a. A minimum of 3 complete battery assemblies, 12 individual cells, and a lot sample of vent and safety devices such as fuses and diodes shall be qualification tested in accordance with Appendixes 4B1 and 4B4.

b. Storage life verification testing of 2 cells per year of the manufacturer stated dry life capability shall be performed in accordance with Appendixes 4B1 and 4B4.

c. All batteries shall be acceptance tested in ac-

cordance with Appendixes 4B1 and 4B4.

4.15.2.4 FTS Electromechanical S&A Device, EED and Rotor Lead Qualification, Acceptance, and Age Surveillance Tests

a. A minimum of 8 electromechanical S&A devices shall be qualification tested in accordance with Appendixes 4B1 and 4B6.

b. Three additional electromechanical S&A devices or simulated units shall be tested to demonstrate the safety of the S&A barrier in accordance with Appendixes 4B1 and 4B6.

c. All electromechanical S&A devices shall be acceptance tested in accordance with Appendixes 4B1 and 4B6.

d. Explosive components such as EED and Rotor Lead in electromechanical S&As shall be subjected to individual qualification, acceptance, and age surveillance testing in accordance with Appendix 4B1 and 4B6.

4.15.2.5 FTS EBW-FU Qualification and Acceptance Tests

a. EBW-FUs shall be qualification tested in accordance with Appendixes 4B1 and 4B7.

b. All EBW-FUs shall be acceptance tested in accordance with Appendixes 4B1 and 4B7.

4.15.2.6 FTS EBW Qualification, Acceptance, and Age Surveillance Tests

All EBWs shall be qualification, acceptance, and age surveillance tested in accordance with Appendixes 4B1 and 4B7.

4.15.2.7 FTS Laser Firing Unit, Optical S&A, and Ordnance S&A Qualification and Acceptance Tests

a. Laser firing units, optical S&As, and ordnance S&As shall be qualification tested in accordance with Appendixes 4B1 and 4B8.

b. Laser firing units, optical S&As, and ordnance S&As shall be acceptance tested in accordance with Appendixes 4B1 and 4B8.

4.15.2.8 FTS Laser Fiber Optic Cable Assembly Qualification and Acceptance Tests

a. Laser FOCAs shall be qualification tested in accordance with Appendixes 4B1 and 4B8.

b. All laser FOCAs shall be acceptance tested in

accordance with Appendixes 4B1 and 4B8.

4.15.2.9 FTS LID Qualification, Acceptance, and Age Surveillance Tests

LIDs shall be qualification, acceptance, and age surveillance tested in accordance with Appendixes 4B1 and 4B8.

4.15.2.10 FTS Percussion Activated Devices

Percussion activated devices, including primer and booster charges shall be qualification, acceptance, and age surveillance tested in accordance with Appendixes 4B1 and 4B10.

4.15.2.11 FTS Explosive Transfer Component Qualification, Acceptance, and Age Surveillance Tests

All explosive transfer components (and subassemblies, if required by Range Safety) shall be qualification, acceptance, and age surveillance tested in accordance with Appendixes 4B1 and 4B9.

4.15.2.12 FTS Destruct Charge Qualification, Acceptance, and Age Surveillance Tests

a. All destruct charges shall be qualification, acceptance, and age surveillance tested in accordance with Appendixes 4B1 and 4B9.

b. In addition, a minimum of two tests shall be conducted to demonstrate compliance with each of the following requirements.

1. Destruct charge action shall not detonate the liquid and/or solid propellant.

2. Destruct charge action on toxic liquid propellant targets shall ignite the hydrazine-based fuel.

NOTE: These special destruct charge tests in paragraph *b* above may be combined with Range approved development tests or may be waived all together by Range Safety if test data already exists demonstrating compliance.

4.15.2.13 FTS Ordnance Subsystem Tests

a. Full scale, subscale, segment, or coupon ordnance subsystem testing may be required to demonstrate destruct action on new or untested targets such as new propellant, new case and tank material, and new configurations.

b. Range Safety shall identify the requirement for ordnance subsystem tests as early in the conceptual design phase as possible.

c. Ordnance subsystem tests may be combined with the development test.

4.15.2.14 FTS Shock and Vibrational Mounted Isolation Systems Qualification and Acceptance Tests

a. Shock and vibration isolators shall be qualification tested as an assembly with the specific component using them.

b. Shock and vibration isolators shall be 100 percent acceptance tested in accordance with Appendix 4B11.

4.15.2.15 Miscellaneous FTS Component Qualification and Acceptance Tests

a. Miscellaneous FTS components that have not been identified in this Chapter shall be qualification tested in accordance with Appendixes 4B1 and 4B5.

b. The number of miscellaneous FTS components to be qualification tested shall be determined by Range Safety on a case-by-case basis.

c. All components shall be acceptance tested in accordance with Appendixes 4B1 and 4B5.

4.15.3 RTS Component Tests

4.15.3.1 RTS Antenna System Qualification and Acceptance Tests

a. Antennas and their coaxial cables shall be qualification tested in accordance with Appendixes 4B1 and 4B2.

b. Antennas and all of their coaxial cables shall be acceptance tested in accordance with Appendixes 4B1 and 4B2.

c. Antennas shall also be tested to obtain the pattern data in accordance with RCC 253.

d. Components such as hybrid couplers, ring couplers, and power dividers shall be qualification and acceptance tested in the same manner as required for antennas.

4.15.3.2 RTS Transponder Qualification and Acceptance Tests

a. Transponders shall be qualification tested in accordance with Appendixes 4B1 and 4B12.

b. Transponders shall be acceptance tested in accordance with Appendixes 4B1 and 4B12.

c. Transponders that have been previously certified for use on a particular vehicle at the Range may require additional qualification testing

(environmental, survivability, and electromagnetic compatibility) if the transponder is to be used on a different type or model vehicle.

d. Qualification testing may be performed by an independent agency or the transponder vendor.

e. The identification of the test agency shall be determined on a case-by-case basis through a joint Range and Range User agreement.

f. The maximum time between acceptance tests shall be three years or one-half the shelf life of the unit, whichever is less.

g. At the WR, certain tests are performed by the WR RF Measurements Laboratory in accordance with a test plan developed in joint agreement between the WR and the Range User.

4.15.3.3 GPS Qualification and Acceptance Tests

a. GPS translators and receivers shall be qualification tested in accordance with Appendix 4B13.

b. GPS translators and receivers shall be acceptance tested in accordance with Appendix 4B13.

c. GPS translators and receivers that have been previously certified for use on a particular vehicle at the Range may require additional qualification testing (environmental, survivability, and electromagnetic compatibility) if the unit is to be used on a different type or model vehicle.

d. Qualification testing may be performed by an independent agency or the GPS unit vendor.

e. The identification of the test agency shall be determined on a case-by-case basis through a joint Range and Range User agreement.

f. The maximum time between acceptance tests shall be three years or one-half the shelf life of the unit, whichever is less.

g. At the WR, certain tests are performed by the WR RF Measurements Laboratory in accordance with a test plan developed in joint agreement between the Range and the Range User.

4.15.3.4 RTS Battery Qualification, Storage Life Verification, and Acceptance Tests

a. A minimum of 3 complete battery assemblies, 12 individual cells, and a lot sample of vent and safety devices such as fuses and diodes shall be qualification tested in accordance with Appendixes 4B1 and 4B4.

b. Storage life verification testing of 2 cells per year of the manufacturer stated dry life capability shall be performed in accordance with Appendixes 4B1 and 4B4.

c. All batteries shall be acceptance tested in accordance with Appendixes 4B1 and 4B4.

4.15.4 TDTs Component Test Requirements

The TDTs transmitter shall be qualification and acceptance tested in accordance with Appendix 4B14.

4.15.5 RSS Range Prelaunch Tests

4.15.5.1 RSS Range Prelaunch Tests General Requirements

a. The RSS component, system, and subsystem prelaunch tests described in this section shall be conducted at the Range following the qualification and acceptance testing.

b. Range Safety shall review and approve all Range prelaunch test procedures.

c. Range Safety or a designated representative shall be present during the performance of prelaunch tests unless otherwise agreed to by Range Safety in writing.

4.15.5.2 FTS Range Prelaunch Component Tests

4.15.5.2.1 FTS Battery Prelaunch Tests.

a. Bench testing shall be conducted on all FTS batteries prior to installation on the launch vehicle.

b. The following tests shall be included:

1. Open circuit voltage testing of the battery and each cell

2. Load testing of the completed battery assembly

3. Continuity and isolation testing of connectors

4. Pin to case voltage, to insure no electrolyte spillage during manual activation of batteries

5. Acceptance testing in accordance with Appendix B4 if not accomplished by the manufacturer

c. The time interval between these tests and launch shall be minimized in order not to exceed the activated stand time of the battery.

4.15.5.2.2 FTS Electromechanical S&A Prelaunch Tests.

a. Bench testing shall be conducted on all FTS S&A prior to installation on the launch vehicle.

b. The following tests shall be included:

1. Visual check for signs of physical defects

2. Electrical tests that arm and safe the S&A

3. Continuity and resistance checks of the EED circuit in both ARM and SAFE positions

4. Tests to verify that the device cannot be electrically armed when the safing pin is installed

5. Safing pin removal resistance tests

c. S&A bench tests shall be performed within 10 calendar days of launch.

d. If the FTS S&A devices have been electrically connected and the launch subsequently scrubbed, removal and retest may be required by Range Safety.

4.15.5.2.3 FTS EBW Prelaunch Tests.

a. Bench testing shall be conducted on all FTS EBWs prior to installation on the launch vehicle.

b. The following tests shall be included:

1. Visual checks for physical defects

2. Bridgewire continuity test using a grid dip analyzer

3. High voltage static gap breakdown tests

c. EBW bench tests shall be performed within 10 calendar days of launch.

4.15.5.2.4 FTS LID Prelaunch Tests.

a. Bench testing shall be conducted on all FTS LIDs prior to installation on the launch vehicle.

b. The tests to be performed shall be determined by Range Safety based on the design of the LIDs.

c. LID bench tests shall be performed within 10 calendar days of launch.

4.15.5.2.5 FTS Optical S&A Prelaunch Tests.

a. Bench testing shall be conducted on all FTS Optical S&As prior to installation on the launch vehicle.

b. The tests to be performed shall be determined by Range Safety based on the design of the Optical S&As.

c. Optical S&A bench tests shall be performed within 10 calendar days of launch.

4.15.5.2.6 FTS LIOS Ordnance S&A Prelaunch Tests.

a. Bench testing shall be conducted on all FTS Ordnance S&As prior to installation on the launch vehicle.

b. The tests to be performed shall be determined by Range Safety based on the design of the Ordnance S&As.

c. Ordnance S&A bench tests shall be performed within 10 calendar days of launch.

4.15.5.2.7 FTS CRD Prelaunch Bench Tests.

a. ER Prelaunch Bench Tests.

1. Bench testing shall be conducted on all FTS CRDs prior to vehicle installation.

2. These tests include all CRD parameters at ambient temperature.

3. The CRD bench test shall be performed within 180 calendar days of the launch.

4. Vendor acceptance tests may be substituted for this bench test.

b. WR Prelaunch Bench Tests.

1. Bench testing shall be conducted on all FTS CRDs in a laboratory-type environment at the 30 SW RF Measurement Laboratory by RFML personnel prior to final installation of the units into the launch vehicle. **NOTE:** These tests provide additional verification that each CRD complies with the performance requirements of this Chapter.

2. WR certification following this test is valid for 120 calendar days.

4.15.5.3 FTS Range Prelaunch System and Subsystem Tests

Systems and subsystem tests shall be repeated in whole or in part under the following conditions:

a. If, at any time subsequent to the prelaunch test, the integrity of the system is suspect or compromised by a configuration change, lightning strikes, mate/demate of any connectors, or other event

b. The launch is delayed by extended holds or recycles

4.15.5.3.1 FTS Antenna Systems Prelaunch Tests.

a. Installed FTS antennas and associated RF transmission components shall be tested on each vehicle to determine antenna VSWR and transmission line insertion loss.

b. Calibrated antenna terminations (covers) and couplers (hats) shall be provided for all FTS antennae. **NOTE:** Covers and hats are mandatory for all in-vehicle closed-loop testing required in this Chapter.

c. The antenna termination and coupler calibration data shall be used in the in-vehicle system pass/fail criteria analysis.

d. If FTS antenna heat shields are used, they shall be installed during all in-vehicle system testing.

4.15.5.3.2 FTS CRD System Prelaunch Tests.

a. ER CRD Prelaunch Systems Tests.

1. After installation in the launch vehicle, each CRD shall be tested at nominal voltage for threshold sensitivity and operating bandwidth.

2. Tests shall be performed to obtain calibration curves for the signal strength telemetry monitor on each CRD.

3. These tests shall be conducted within 90 calendar days of launch.

4. These tests are performed by Range User personnel in accordance with Range Safety approved procedures.

b. WR CRD Prelaunch System Tests.

1. An in-vehicle CRD system level performance test shall be conducted at the WR.

2. This test shall be performed as late in the receipt-through-launch readiness sequence as possible.

3. The test shall be performed by RFML personnel using the RFML mobile test van.

4. The performance characteristics derived from this test shall be compared with the characteristics derived from the bench level test.

5. If no significant differences are noted, the radio command system will be considered acceptable.

6. Depending on any unique or addition missile system or receiver and decoder requirements, other test areas may be required.

4.15.5.3.3 FTS Standard Receiver and Decoder Prelaunch Tests.

a. FTS Command Open-Loop and Automatic End-to-End Tests.

1. After installation of the FTS up to, but not including, the electrical and/or optical connection of the flight destruct initiators, an End-to-End Verification Test of the entire command and automatic FTS shall be performed.

2. The End-to-End Verification Test is conducted to prove the integrity of the ground and airborne FTS system including Range command control and transmitter systems, antenna transmission system, CRDs, flight batteries, engine shutdown valves, and automatic destruct system up to the point at which the flight destruct initiators will be electrically connected.

3. The End-to-End Verification Test shall be conducted as late in the Range User countdown as possible but not earlier than 48 h prior to launch if the FTS access compartment can be closed out.

NOTE: If the FTS access compartment cannot be closed out 48 h prior to launch, the end-to-end veri-

fication test shall be performed later in the countdown at a time when the FTS component access compartment can be closed out.

4. The configuration and performance requirements for this test are as follows:

(a) Destruct initiator simulators shall be installed in place of the flight initiators to verify that sufficient energy is delivered by both command and automatic circuits to initiate destruct.

(b) FTS command and automatic systems shall be powered by flight batteries.

(c) All receiver and decoder commands shall be transmitted to the vehicle open-loop by Range transmitters.

(d) All primary and redundant components and circuits in the vehicle command and automatic FTS system and the Range Command transmitter system shall be verified as operational.

b. Final CRD RF Open-Loop Test.

1. After removal of the destruct initiator simulators and electrical and/or optical connection of all flight destruct initiators, an RF open-loop test of the CRDs shall be performed.

2. The Open-Loop test is conducted to provide final prelaunch assurances that the Range Command transmitter systems, FTS antenna and transmission systems, and CRDs are functioning properly.

3. The Open-Loop test shall be performed as late in the Range User countdown as possible but not earlier than 60 min prior to launch.

4. The configuration and performance requirements for this test are as follows:

(a) All FTS arming devices are to remain in the SAFE position.

(b) All CRDs are powered by flight batteries.

(c) All receiver and decoder commands except DESTRUCT shall be transmitted open-loop to the vehicle by Range Command transmitters.

(d) All CRDs and primary and backup Range Command transmitters shall be tested and verified as operational.

5. Following a successful Open-Loop test, the CRDs (powered from flight batteries) and primary Range Command transmitter shall remain on through launch.

6. The WR requires that the Range Command transmitter transmit the CHECK CHANNEL command continuously through lift-off.

4.15.5.3.4 FTS Secure Receiver and Decoder Prelaunch Tests.

a. Initial CRD RF Open-Loop Tests.

1. After installation of the command and automatic FTS up to, but not including, electrical and/or optical connection of flight destruct initiators and loading of the CRDs with secure flight codes, an RF Open-Loop test of the FTS command system shall be performed.

2. The Open-Loop test is conducted to prove the integrity of the ground and airborne command transmitter system (including the Range Command transmitter systems, vehicle antenna systems, and CRDs) up to the point at which the flight destruct initiators will be electrically and/or optically connected.

3. These tests shall be conducted as late in the Range User launch vehicle processing as practical.

4. The configuration and performance requirements for this test are as follows:

(a) Destruct initiator simulators shall be installed in place of the flight initiators to verify that sufficient energy is delivered by the FTS command system to initiate destruct.

(b) The FTS command system can be powered by either flight or ground power.

(c) Each CRD on the vehicle shall be loaded with the appropriate maintenance codes.

(d) All CRD commands required by the program shall be transmitted to the vehicle open-loop by Range Command transmitters using maintenance codes.

(e) All CRDs and primary and backup components in the Range Command transmitter system shall be verified as operational.

b. Command Closed-Loop and Automatic End-to-End Tests.

1. Following the loading of the CRDs with the required secure flight codes, but prior to electrical and/or optical connection of the flight destruct initiators, a Command Closed-Loop and Automatic End-to-End test of the entire command and automatic FTS shall be performed.

2. The Command Closed-Loop and Automatic End-to-End test is conducted to prove the integrity of the airborne FTS system including CRDs, flight batteries, engine shutdown valves, and the automatic destruct system up to the point at which the flight destruct initiators will be electrically and/or optically connected.

3. The Command Closed-Loop and Automatic End-to-End Test shall be conducted as late in the Range User countdown as possible but not earlier than 48 h prior to launch if the FTS access compartment can be closed out. **NOTE:** If the FTS access compartment cannot be closed out 48 h prior to launch, the Command Closed-Loop Automatic End-to-End test shall be performed later in the countdown at a time when the FTS component access compartment can be closed out.

4. The configuration and performance requirements for the Command Closed-Loop and Automatic End-to-End test are as follows:

(a) Destruct initiator simulators shall be installed in place of the flight initiators to verify that sufficient energy is delivered by both command and automatic circuits to initiate the initiators.

(b) FTS command and automatic systems shall be powered by flight batteries.

(c) All secure CRD commands required by the program shall be transmitted to the airborne CRDs closed-loop by Range User provided ground signal generators located at the launch pads.

(d) All primary and redundant components and/or circuits in the vehicle command and automatic FTS system shall be verified as operational.

c. Command CRD Closed-Loop Test.

1. After removal of the destruct initiator simulators and electrical and/or optical connections of all flight destruct initiators, a Command CRD Closed-Loop test shall be performed.

2. The Command CRD Closed-Loop test is conducted to provide final pre-launch assurance that the airborne command destruct system (CRDs and flight batteries) is functioning properly.

3. The Command CRD Closed-Loop test shall be performed as late in the Range User countdown as possible but not earlier than 60 min prior to launch or just prior to launch support tower rollback.

4. The configuration and performance requirements for this test are as follows:

(a) All FTS arming devices are to remain in the SAFE position.

(b) All CRDs are powered by flight batteries.

(c) All secure CRD commands required by the program except DESTRUCT shall be transmitted to the airborne CRD closed-loop by Range User provided ground signal generators

located at the launch pads.

(d) Each CRD shall be tested and verified as operational.

d. Final CRD RF Open-Loop Test.

1. Prior to launch, a final RF open-loop test of the CRD shall be performed.

2. The Final CRD RF Open-Loop test is conducted to provide final prelaunch assurance that the Range Command transmitter systems, FTS antenna systems, and CRDs are functioning properly.

3. The Final CRD RF Open-Loop test shall be performed after the command closed-loop test but prior to launch.

4. The configuration and performance requirements for this test are as follows:

(a) All FTS arming devices are to remain in the SAFE position.

(b) The CRDs are powered by flight batteries.

(c) The only command that will be transmitted open-loop to the vehicle CRDs by the Range Command transmitters will be the TEST command. **NOTE:** If the CRD successfully receives and decodes this command, it will initiate a self-test.

(d) All CRDs and primary and backup Range Command transmitter systems shall be tested and verified as operational.

(e) Following a successful open-loop test, the CRDs (powered from flight batteries) and primary Range Command transmitter shall remain on through launch. **NOTE:** The WR requires that the Range Command transmitter transmit PILOT TONE continuously through lift-off.

e. WR Secure CRD Post-Flight Open-Loop Verification Test.

1. A Post-Flight Open-Loop Verification test shall be performed at the WR following a successful launch and flight. **NOTE:** Secure FTS codes are declassified following a successful flight.

2. The Post-Flight Open-Loop Verification test is conducted to demonstrate that the Range Command transmitter system would have been able to generate and transmit flight termination commands if the vehicle had required destruct action. **NOTE:** This verification test provides assurances that the secure code loading procedures and the closed and open-loop testing performed pre-flight were written and executed properly. The exact time for this post-flight test shall be

established by Range Safety and Range User agreements.

3. The configuration and performance requirements for this test are as follows:

(a) Prior to launch, the post-flight verification CRD under RFML control shall be loaded with the same secure FTS codes that are loaded into the vehicle CRDs.

(b) As soon as possible after a successful flight, the Range shall issue and transmit open-loop all FTS command functions as applicable.

(c) The post-flight verification CRD, located in a mobile van under the control of RFML personnel, shall receive and decode all functions.

4.15.5.4 RTS Range Prelaunch Component Tests

4.15.5.4.1 RTS Battery Prelaunch Test.

a. Bench testing shall be conducted on all RTS batteries prior to installation on the launch vehicle.

b. The following tests shall be included:

1. Open circuit voltage testing of the battery and each cell

2. Load testing of the completed battery assembly

3. Continuity and isolation testing of connectors

4. Pin to case voltage to insure no electrolyte spillage during manual activation of batteries

5. Acceptance testing in accordance with Appendix 4B if not accomplished by the manufacturer

c. The time interval between these tests and launch shall be minimized in order not to exceed the activated stand time of the battery.

4.15.5.4.2 RTS Transponder Prelaunch Bench Tests.

NOTE: At the WR, in the interest of economy and testing standardization, the WR provides a portable test station operated by the 30 SW RF Measurements Laboratory to test the transponder.

a. At the WR, each transponder shall be performance tested in the bench test mode by the 30 SW RF Measurements Laboratory prior to its installation in the vehicle.

b. The WR RTS Transponder Bench test shall be conducted as late in the individual receipt-through-launch sequence as possible, consistent with the time requirements for test result data accumulation.

c. Certification is valid for 120 calendar days

after which recertification by bench test is required.

d. The WR RTS Transponder Bench test shall be performed according to a plan developed in joint agreement between Range Safety and the Range User.

e. In addition to those tests required to complete the WSMC Form 5625, Standard Tracking Transponder Performance Test, transponder performance characteristics to be tested shall be determined in a joint agreement between Range Safety and the Range User.

4.15.5.4.3 RTS GPS Prelaunch Bench Test. TBD

4.15.5.5 RTS Range Prelaunch System and Subsystem Tests

4.15.5.5.1 RTS System Compatibility Test.

a. An RTS system compatibility verification test, based on a Range Safety approved procedure, shall be performed.

b. The compatibility verification test is limited to the steps involved with controlling and monitoring the airborne system.

4.15.5.5.2 RTS Antenna System Prelaunch Test.

a. Installed RTS antennas and associated RF transmission components shall be tested on each vehicle to determine antenna VSWR and transmission line insertion loss.

b. Calibrated antenna terminations (covers) and couplers (hats) shall be provided for all RTS antennae. **NOTE:** Covers and hats are mandatory for all in-vehicle closed-loop testing required in this Chapter.

c. The antenna termination and coupler calibration data shall be used in the in-vehicle system pass/fail criteria analysis.

d. If RTS antenna heat shields are used, they shall be installed during all in-vehicle system testing.

4.15.5.5.3 RTS Transponder System Level Performance Test.

a. The RTS transponder shall be tested at the Range prior to launch.

b. The RTS Transponder System Level Performance test shall be performed as late in the individual vehicle receipt-through-launch readiness sequence as possible consistent with the time requirements for test result data submission.

c. The RTS Transponder System Level Per-

formance test shall be conducted in an RF closed-loop system mode.

d. The transponder shall not be removed from either the vehicle or the instrumentation wafer without Range Safety approval.

e. The transponder shall not be disconnected without Range Safety approval.

f. Specific requirements applicable to the RF closed-loop mode performance test are as follows:

1. RF loss factors shall be provided by the Range User for the RF cables, antennas of the transponder system, and the antenna couplers.

2. This test shall be performed in accordance with a plan developed in joint agreement between Range Safety and the Range User and shall furnish sufficient measurement data to allow completion of each applicable data item of WSMC Form 5625 or 5678, as applicable.

3. An RF closed-loop antenna and transponder system sensitivity and operational characteristics test shall be required at the Range if any connection in the antenna system, including transponder connections, are disconnected after completion of the transponder system level performance test.

4. The test shall be repeated after final connections to the antenna system and transponder are complete.

4.15.5.5.4 RF Open-Loop Tracking System Compatibility Verification Test.

a. An RF Open-Loop Tracking System Compatibility Verification test shall be conducted as late in the launch countdown as possible. **NOTE:** The purpose of the RF Open-Loop Tracking System Compatibility Verification test is to prove the integrity of both the airborne RTS and the ground system.

b. The verification test shall be conducted on airborne power and included in the launch agency countdown procedure.

c. The RF Open-Loop Tracking System Compatibility Verification test results are valid for a maximum of 12 h.

d. If the system or any portion of the system is compromised at any time after the initial test, the RF Open-Loop Tracking System Compatibility Verification test shall be repeated.

e. At the WR, if the test is inconclusive, a retest shall be performed using a Range portable transponder test system.

f. At the WR, the test results shall be documented on WSMC Form 5678, Standard Tracking Transponder Evaluation/Compatibility Test.

4.15.5.5.5 RTS GPS System Prelaunch Test.
TBD**4.15.5.5.6 RTS GPS Open-Loop Verification Test.** TBD

APPENDIX 4A RANGE SAFETY SYSTEM REPORT REQUIREMENTS

4A.1 INTRODUCTION

4A.1.1 Purpose

a. The Range Safety System Report (RSSR) provides a detailed description of the RSS. It is the medium through which RSS approval is obtained from the launch Range.

b. The RSSR is a detailed description of the FTS system design specification data, reliability data, component design data, ground support systems data, and test data; the RTS; and the TDTS.

NOTE: All schematics, functional diagrams, and operational manuals shall have well defined, standard Institute of Electrical and Electronics Engineers (IEEE) or MIL-SPEC terminology and symbols.

c. Where applicable, previously approved documentation shall be referenced throughout the package.

4A.1.2 Content

This Appendix contains the content preparation instructions for the data generated by the requirements delineated in Chapter 4 of Eastern and Western Range 127-1, Range Safety Requirements.

4A.1.3 Applicability

This Appendix is applicable to all launch vehicles that require an RSS.

4A.1.4 Submittal Process

The RSSR submittal periods are as follows:

a. A preliminary draft of the RSSR shall be provided 45 calendar days prior to each design review meeting (conceptual, Preliminary, and Critical).

b. The final RSSR shall be submitted at least four months prior to the first scheduled launch.

4A.1.5 Final Approval

The formal acceptance of the RSS will be granted after approval of the final RSSR and its appendices.

4A.1.6 Format

Contractor format is acceptable provided the information described in 4A.2 is provided.

4A.2 RSSR

The RSSR shall include:

- a.* RSSR main body.
- b.* Appendixes
 1. FTS Appendix
 2. RTS Appendix
 3. TDTS Appendix

4A.2.1 RSSR Main Body

The main body of the RSSR shall focus on the FTS with the exception of the general RSS.

4A.2.1.1 Table of Contents and Glossary

The RSSR shall contain a table of contents and a glossary.

4A.2.1.2 Introduction

The introduction shall address the scope and purpose of the RSSR.

4A.2.1.3 FTS General System Description

The general system description section shall present a brief description of the launch vehicle and the FTS. The following items are included in this section:

- a.* A brief and general description of the launch vehicle
- b.* A brief and general description of the FTS, including a block diagram showing the location of all FTS components on the vehicle and the interfaces with other systems
- c.* A cable diagram of the FTS
- d.* A complete line schematic of the entire FTS from antenna to the destruct charge, including telemetry pick-off points and ground (umbilical) interfaces

4A.2.1.4 FTS Detailed Component and System Descriptions

The detailed system description section includes a complete and detailed narrative description of all of the major components of the FTS. The following items are included in this section:

- a.* Narrative Description.
 1. A complete and detailed description of the FTS operation including all possible scenarios and discussion of how FTS components function at the system and piece part level

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2. A complete and detailed description of each FTS component and how it functions, including specifications and schematics, mechanical and piece part specifications, and operating parameters

b. Detailed Schematics and Drawings.

1. Detailed schematics of the complete FTS showing component values such as resistance, capacitance, and wattage; tolerance; shields; grounds; connectors and pin numbers; and telemetry pick-off points

2. The schematics shall include all vehicle components and elements that interface with or share common use with the FTS.

3. All pin assignments shall be accounted for.

4. Drawings showing the location of all FTS system and subsystem components on the vehicle, including the following descriptions:

(a) Descriptions of element siting, mounting (attach points), and cable routing for physical isolation

(b) Descriptions of electrical connectors and connections and the electrical isolation of the FTS

5. An illustrated parts breakdown of all mechanically operated FTS components

4A.2.1.5 FTS Analysis Results

As applicable, a summary of the results of the following analyses shall be included and the analyses shall be submitted separately:

- a.* Failure Analysis
- b.* Qualification by Similarity Analysis
- c.* Reliability Analysis
- d.* Failure Modes, Effects, and Criticality Analysis
- e.* Single Failure Point Analysis
- f.* Battery Analysis
- g.* Fratricide Analysis
- h.* RF Link Analysis
- i.* Antenna Heat Shield Fly-Off Analysis
- j.* CRD Radiation Analysis
- k.* Bent Pin Analysis
- l.* LID Heat Dissipation Analysis
- m.* Breakup Analysis
- n.* Tip-Off Analysis
- o.* ADS Timing Analysis
- p.* Destruct Simulator Analysis

4A.2.1.6 FTS Ordnance Classification

The ordnance classifications for each ordnance device in accordance with DOT, DoD or UN and supporting documentation shall be included in this

section.

4A.2.1.7 FTS Development, Qualification, Acceptance, Age Surveillance, and Reuse Test Plans, Procedures, and Reports

The following data shall be included in the body of the RSSR:

a. A list of test plans, procedures, and reports by title, number, and revision date

b. The maximum predicted flight loads for all anticipated environmental forces such as shock, vibration, and thermal for each FTS component, subsystem, and system,

c. A summary of the analyses or measurements used to derive the maximum predicted environments for each component

d. A matrix of the actual qualification and acceptance test levels used for each component, sub-system, and system in each test versus the predicted flight levels for each environment. The test tolerance allowed for each operational qualification test shall be included (for example, shock test at 6 dB over MPE with a ± 3 dB test tolerance)

e. A clear identification of those components qualified by similarity analysis or a combination of analysis and test

f. A summary of each applicable test report.

NOTE: The actual test report shall be submitted as a stand-alone document.

4A.2.1.8 Software and Firmware Independent Verifications and Validations

A summary of software and firmware independent verification and validation shall be included.

4A.2.1.9 FTS Modifications

The FTS modifications section shall include all proposed final modifications to an approved FTS, its associated equipment, component identification, test procedures, or any changes affecting the configuration and integrity of the FTS.

4A.2.1.10 FTS Ground Support and Monitoring Equipment

The ground support and monitoring equipment section shall include a complete description of the ground test equipment used to checkout the FTS including contractor-peculiar tests. This section shall also include specifications and schematics for all test equipment.

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- a. Destruct initiator simulator
- b. RF Ground Support System
- c. RF Repeater system
- d. ER OSC and WR Safety console layout, display arrangement, and function of each monitor
- e. ER OSC and WR Safety console terminations including the following:

1. Schematics of all FTS monitor circuits from the FTS component pick-off points to the console termination

2. Calibration data for all monitor circuit terminations provided to the console

- f. Any other ground support and monitoring equipment as required by Range Safety.

4A.2.1.11 FTS Installation and Checkout

The installation and checkout section shall include the following information:

- a. A list of procedures for checkout, calibration, and installation of all components, systems, and subsystems of the FTS and its associated ground checkout equipment, including launch day countdown

- b. A task summary of each procedure, including:

1. Each separate task
2. The responsible agency
3. The objective of the procedure
4. Initial and final configuration
5. Equipment and support required
6. Description of task
7. Figures, as required

- c. A flowchart indicating expected time sequence and location of each FTS procedure and task

4A.2.1.12 FTS Unique Configuration

The unique configuration section shall include any information relevant to unique program requirements necessary to satisfy the Range.

4A.2.1.13 FTS Noncompliances

The noncompliance section shall include all required and existing deviations, waivers, MICs, technical agreements, and understandings concerning the FTS.

4A.2.1.14 FTS Changes to the RSSR

The change section shall include a summary of all changes to the last edition of the RSSR. All changes shall be highlighted using change bars or similar means of identification.

4A.2.2 Appendixes

4A.2.2.1 FTS Appendix

- a. FTS Development, Qualification, and Age Surveillance Test Reports Development, Qualification, and Age Surveillance Test Reports shall be included as stand-alone appendixes.

- b. FTS compliance Checklist. The compliance checklist section shall include a checklist of all design, test, and data submittal requirements in Chapter 4. The following items are included in this section:

1. Criteria/Requirement
2. System
3. Compliance
4. Noncompliance
5. Not applicable
6. Resolution

- 7. References for compliance, noncompliance, not applicable. **NOTE:** The rationale for noncompliance and not applicable shall be included.

- 8. Copies of all Range Safety approved non-compliances including deviations, waivers, and formal Meets Intent Certifications (MICs) shall be included.

4A.2.2.2 RTS Appendix

4A.2.2.2.1 RTS General System Description.

The general system description section shall present a brief description of the RTS. The following items are included in this section:

- a. A brief and general description of the RTS, including a block diagram showing the location of all RTS components on the vehicle and the interfaces with other systems

- b. A cable diagram of the RTS

- c. A complete line schematic of the entire RTS from antenna to the transponder or GPS unit, including telemetry pick-off points and ground (umbilical) interfaces

- d. For GPS, it shall include the down link system.

4A.2.2.2.2 RTS Detailed Component and System Descriptions. The detailed system description section includes complete and detailed narrative description of all of the major components of the RTS. The following items are included in this section:

- a. Narrative Description.

1. A complete and detailed description of the

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RTS operation including all possible scenarios and discussion of how RTS components function at the system and piece part level

2. A complete and detailed description of each RTS component and how it functions, including specifications and schematics, mechanical and piece part specifications, and operating parameters

b. Detailed Schematics and Drawings.

1. Detailed schematics of the complete RTS showing component values such as resistance, capacitance, and wattage; tolerance; shields; grounds; connectors and pin numbers; and telemetry pick-off points

2. The schematics shall include all vehicle components and elements that interface with or share common use with the RTS.

3. All pin assignments shall be accounted for.

4. Drawings showing the location of all RTS system and subsystem components on the vehicle, including the following descriptions:

(a) Descriptions of element siting, mounting (attach points), and cable routing for physical isolation

(b) Descriptions of electrical connectors and connections and the electrical isolation of the RTS

4A.2.2.2.3 RTS Analysis Results. As applicable, a summary of the results of the following analyses shall be included and the analyses shall be submitted separately:

- a.* Failure Analysis
- b.* Qualification by Similarity Analysis
- c.* Reliability Analysis
- d.* Failure Modes, Effects, and Criticality Analysis
- e.* Battery Analysis
- f.* RF Link Analysis
- g.* Antenna Analysis
- h.* Antenna Heat Shield Fly-Off Analysis

4A.2.2.2.4 RTS Development, Qualification, and Acceptance Test Plans, Procedures, and Reports. The following data shall be included:

- a.* A list of test plans, procedures, and reports by title, number, and revision date
- b.* The maximum predicted flight loads for all anticipated environmental forces such as shock, vibration, and thermal for each RTS component, subsystem, and system
- c.* A summary of the analyses or measurements

used to derive the maximum predicted environments for each component

d. A matrix of the actual qualification and acceptance test levels used for each component, subsystem, and system in each test versus the predicted flight levels for each environment. The test tolerance allowed for each operational qualification test shall be included (for example, shock test at 6 dB over MPE with a ± 3 dB test tolerance)

e. A clear identification of those components qualified by similarity analysis or a combination of analysis and test

f. A summary of each applicable test report.

NOTE: The actual test report shall be submitted as a stand-alone document.

4A.2.2.2.5 Software and Firmware Independent Verifications and Validations. A summary of software and firmware independent verification and validation shall be included.

4A.2.2.2.6 RTS Modifications. The RTS modifications section shall include all proposed final modifications to an approved RTS, its associated equipment, component identification, test procedures, or any changes affecting the configuration and integrity of the RTS.

4A.2.2.2.7 RTS Ground Support and Monitoring Equipment. The ground support and monitoring equipment section shall include a complete description of the ground test equipment used to checkout the RTS including contractor peculiar tests. This section shall also include specifications and schematics for all test equipment.

- a.* RF Ground Support System
- b.* RF Repeater system
- c.* ER OSC and WR Safety console layout, display arrangement, and function of each monitor
- d.* ER OSC and WR Safety console terminations including the following:

1. Schematics of all RTS monitor circuits from the RTS component pick-off points to the console termination

2. Calibration data for all monitor circuit terminations provided to the console

e. Any other ground support and monitoring equipment as required by Range Safety.

4A.2.2.2.8 RTS Installation and Checkout. The installation and checkout section shall include the following information:

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a. A list of procedures for checkout, calibration, and installation of all components, systems, and subsystems of the RTS and its associated ground checkout equipment, including launch day count-down

b. A task summary of each procedure, including:

1. Each separate task
2. The responsible agency
3. The objective of the procedure
4. Initial and final configuration
5. Equipment and support required
6. Description of task
7. Figures, as required

c. A flowchart indicating expected time sequence and location of each RTS procedure and task

4A.2.2.2.9 RTS Unique Configuration. The unique configuration section shall include any information relevant to unique program requirements necessary to satisfy the Range.

4A.2.2.2.10 RTS Noncompliances. The non-compliance section shall include all required and existing deviations, waivers, MICs, technical agreements, and understandings concerning the RTS.

4A.2.2.2.11 RTS Changes to the RSSR. The change section shall include a summary of all changes to the last edition of the RSSR. All changes shall be highlighted using change bars or similar means of identification.

4A.2.2.2.12 RTS Compliance Checklist. The compliance checklist section shall include a checklist of all design, test, and data submittal requirements in Chapter 4. The following items are included in this section:

- a. Criteria/Requirement
- b. System
- c. Compliance
- d. Noncompliance
- e. Not applicable
- f. Resolution

g. References for compliance, noncompliance, not applicable **NOTE:** The rationale for noncompliance and not applicable shall be included.

h. Copies of all Range Safety approved non-compliances including deviations, waivers, and formal Meets Intent Certifications (MICs) shall be included.

4A.2.2.3 TDTs Appendix

The telemetry and parameter values section contains all FTS hardline and RF telemetry data. The following items shall be included in this section

4A.2.2.3.1 TDTs General System Description.

a. A brief and general description of the TDTs, including a block diagram showing the location of all TDTs components on the vehicle and the interfaces with other systems

b. A complete line schematic of the entire TDTs from antenna to the transmitting unit, including ground (umbilical) interfaces.

4A.2.2.3.2 TDTs Detailed Component and System Descriptions. The detailed system description section includes complete and detailed narrative description of all of the major components of the TDTs. The following items are included in this section:

a. Narrative Description.

1. A complete and detailed description of the TDTs operation including all possible scenarios and discussion of how TDTs components function at the system and piece part level

2. A complete and detailed description of each TDTs component and how it functions, including specifications and schematics, mechanical and piece part specifications, and operating parameters.

b. Detailed Schematics and Drawings.

1. Detailed schematics of the complete TDTs showing component values such as resistance, capacitance, and wattage; tolerance; shields; grounds; connectors and pin numbers.

2. The schematics shall include all vehicle components and elements that interface with or share common use with the TDTs.

3. All pin assignments shall be accounted for.

4. Drawings showing the location of all TDTs system and subsystem components on the

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vehicle, including the following descriptions:

(a) Descriptions of element siting, mounting (attach points), and cable routing for physical isolation

(b) Descriptions of electrical connectors and connections and the electrical isolation of the TDTS

4A.2.2.3.3 TDTS Analysis Results. As applicable, a summary of the results of the following analyses shall be included and the analyses shall be submitted separately:

- a. Failure Analysis
- b. Qualification by Similarity Analysis
- c. RF Link Analysis
- d. Antenna Heat Shield Fly-Off Analysis

4A.2.2.3.4 TDTS Development, Qualification, and Acceptance Test Plans, Procedures and Reports. The following data shall be included:

- a. A list of test plans, procedures, and reports by title, number, and revision date
- b. The maximum predicted flight loads for all anticipated environmental forces such as shock, vibration, and thermal for each TDTS component, subsystem, and system
- c. A summary of the analyses or measurements used to derive the maximum predicted environments for each component
- d. A matrix of the actual qualification and acceptance test levels used for each component, subsystem, and system in each test versus the predicted flight levels for each environment. The test tolerance allowed for each operational qualification test shall be included (for example, shock test at 6 dB over MPE with a ± 3 dB test tolerance)
- e. A clear identification of those components qualified by similarity analysis or a combination of analysis and test
- f. A summary of each applicable test report.

NOTE: The actual test report shall be submitted as a stand-alone document.

4A.2.2.3.5 TDTS Modifications. The TDTS modifications section shall include all proposed final modifications to an approved TDTS, its associated equipment, component identification, test procedures, or any changes affecting the configuration and integrity of the TDTS.

4A.2.2.3.6 TDTS Ground Support and Monitoring Equipment. The ground support and monitoring equipment section shall include a complete description of the ground test equipment used to checkout the TDTS including contractor peculiar tests. This section shall also include specifications and schematics for all test equipment.

- a. RF Ground Support System
- b. RF Repeater system
- c. Calibration data for all monitor circuit terminations provided to the console
- d. Any other ground support and monitoring equipment as required by Range Safety.

4A.2.2.3.7 TDTS Installation and Checkout. The installation and checkout section shall include the following information:

- a. A list of procedures for checkout, calibration, and installation of all components, systems, and subsystems of the TDTS and its associated ground checkout equipment, including launch day count-down
- b. A task summary of each procedure, including:
 1. Each separate task
 2. The responsible agency
 3. The objective of the procedure
 4. Initial and final configuration
 5. Equipment and support required
 6. Description of task
 7. Figures, as required
- c. A flowchart indicating expected time sequence and location of each TDTS procedure and task

4A.2.2.3.8 TDTS Unique Configuration. The unique configuration section shall include any information relevant to unique program requirements necessary to satisfy the Range.

4A.2.2.3.9 TDTS Noncompliances. The non-compliance section shall include all required and existing deviations, waivers, MICs, technical agreements, and understandings concerning the TDTS.

4A.2.2.3.10 TDTS Changes to the RSSR. The change section shall include a summary of all

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changes to the last edition of the RSSR. All changes shall be highlighted using change bars or similar means of identification.

4A.2.2.3.11 TDTS Compliance Checklist. The compliance checklist section shall include a checklist of all design, test, and data submittal requirements in Chapter 4. The following items are included in this section:

- a.* Criteria/Requirement
- b.* System
- c.* Compliance

d. Noncompliance

e. Not applicable

f. Resolution

g. References for compliance, noncompliance, not applicable. **NOTE:** The rationale for non-compliance and not applicable shall be included.

h. Copies of all Range Safety approved non-compliances including deviations, waivers, and formal Meets Intent Certifications (MICs) shall be included.

5 CHAPTER 5



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GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

30 CEG - 30th Civil Engineer Group

30 CEG/CEF - 30th Civil Engineer Group, Fire Protection

45 and 30 LG - 45th and 30th Logistics Group

45 and 30 MDG/SGPB - 45th and 30th Medical Group, Bioenvironmental Engineering

45 CES - 45th Civil Engineer Squadron

45 CES/CEF - 45th Civil Engineering Squadron, Fire Protection

45 and 30 SW - 45th and 30th Space Wings

45 and 30 SW/SEG - 45th and 30th Space Wing, Ground Safety

45 and 30 SW/SES - 45th and 30th Space Wing, Systems Safety

ACGIH - American Conference of Governmental Industrial Hygienists

A50 - aeroxine 50; a 50-50 blend of hydrazine and unsymmetrical dimethyl hydrazine

AFI - Air Force Instruction

AFM - Air Force Manual

AFOSH - Air Force Occupational Safety and Health

AFR - Air Force Regulation

AFSC - Air Force Systems Command

AFSPC - Air Force Space Command

AHU - air handling unit

AISC - American Institute of Steel Construction

ANSI - American National Standards Institute

ASCE - American Society of Civil Engineers

ASME - American Society of Mechanical Engineers

ASTM - American Society for Testing Materials

ATC - Applied Technology Council

AWS - American Welding Society

CCAS - Cape Canaveral Air Station

cDR - Conceptual Design Review

CDR - Critical Design Review, Command Destruct

Receiver

CFR - Code of Federal Regulations

conventional facility or structure - office buildings, libraries, auditoriums, warehouses, cafeterias, utility buildings, and other facilities whose structures are characterized by well established design precedents and loading conditions and whose function is non-hazardous

critical facility or structure - a hazardous facility or structure; a facility used to store or process explosives; a facility or structure used to process high value hardware; a facility or structure that contains or is used to handle or process systems determined by Range Safety to be critical; a facility or structure determined to be critical by Range Safety

critical hardware or system - any hazardous or safety critical equipment or system; non-hazardous DoD high value items such as a payload, launch vehicles, or any unique item identified by DoD as critical; high value non-hazardous hardware owned by Range Users other than DoD may be identified as critical or non-critical by the Range User

DDESB - Department of Defense Explosive Safety Board

DoD - Department of Defense

DOT - Department of Transportation

EM - engineering manual

EGSE - electrical ground support equipment

EMI - electromagnetic interference

EPC - emergency power cutoff

ER - Eastern Range

explosion proof apparatus - an enclosure that will withstand an internal explosion of gases or vapors and prevent those gases or vapors from igniting the flammable atmosphere surrounding the enclosure, and whose external temperature will not ignite the surrounding flammable atmosphere

explosives - all ammunition, demolition material, solid rocket motors, liquid propellants, pyrotechnics, and ordnance as defined in AFMAN 91-201 and DoD 6055.9-STD

explosives facility - any facility that contains ex-

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

plosives or is quantity distance sited or licensed to contain explosives

explosives quantity distance site plan - a formal plan required for explosive facilities and areas required per AFM 91-201 and DoD-STD 6055.9 detailing explosives quantity operating and storage limits and restrictions, and resultant distance clearance requirements

FDR - Final Design Review

FM - Factory Mutual Corporation; frequency modulation

FSDP - Facility Safety Data Package

ft - foot, feet

GN₂ - gaseous nitrogen

h - hour, hours

hazardous facility or structure - a facility or structure used to store, handle, or process hazardous materials or systems and/or perform hazardous operations

hazardous materials - liquids, gases, or solids that may be toxic, reactive, or flammable or that may cause oxygen deficiency; either by themselves or in combination with other materials.

hazardous operations - those operations classified as hazardous according to the following criteria: (1) consideration of the potential or kinetic energy involved, (2) changes such as pressure, temperature, and oxygen content in ambient environmental conditions, (3) presence of hazardous materials. Hazardous operations include, but are not limited to, the following types of operations: propellant transport, transfer, handling and sampling; ordinance transport, handling, checkout, installation, and connection; launch vehicle stages, payloads, and other critical loads hoists; pressure systems operating at pressures above 150 psig use and maintenance; radioactive and toxic material storage, transport, and handling; confined space entry and cleaning; flight termination checkout (See Chapter 4); radio frequency (RF) transmission; laser operations; cryogenic operations; energized circuit work. **NOTE:** Some low pressure systems operations such as those involving flight hardware, large volume systems, or those containing hazard-

ous commodities may be classified as hazardous by Range Safety.

hazard proof - a method of making electrical equipment safe for use in hazardous locations; these methods include explosion proofing, intrinsically safe, purged and pressurized, and non-incendive and must be rated for the degree of hazard present

HVDS - Hypergolic Vapor Detection System

hydraulic - operating by water or other liquids under pressure

in. - inch, inches

intrinsically safe - incapable of producing sufficient energy to ignite an explosive atmosphere and two fault tolerant against failure with single fault tolerance against its most hazardous failure at 1.5 times the maximum voltage or energy

IR - infrared

KSC - Kennedy Space Center

lb - pound, pounds

LEL - lower explosive limit

MIC - meets intent certification; a non-compliance designation used to indicate that an equivalent level of safety is maintained despite not meeting the exact requirements stated in this document

MIL-HDBK - military handbook

MIL-SPEC - military specification

MIL-STD - military standard

MSPSP - Missile System Prelaunch Safety Package; a data package demonstrating compliance with the system safety requirements of Chapter 3, serves as a baseline for safety related information on the system throughout its life cycle

MMH - monomethyl hydrazine

N₂H₄ - hydrazine

NASA - National Aeronautics and Space Administration

NEC - *National Electrical Code*

NFPA - National Fire Protection Association

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

non-incendive - will not ignite group of gases or vapors for which it is rated; similar to “intrinsically safe,” but does not include failure tolerance ratings; used in rating electrical products for Class, Division 2 locations only

OSHA - Occupational Safety and Health Act

O&SHA - Operating and Support Hazard Analysis

PDB - Project Definition Book

PDR - Preliminary Design Review

PPE - Personal Protective Equipment

RAMP - Requirements Analysis Management Plan

RIDs - Review Item Discrepancies

safety critical facility - a hazardous facility or a facility that is used to store, handle, or process systems determined to be safety critical by Range Safety

SCAPE - Self-Contained Atmospheric Protective Ensemble

SEAOC - Structural Engineers Association of California

THC - Toxic Hazard Corridor

Toxic Hazard Corridor - a sector in which toxic materials may reach predetermined concentration levels

UDMH - Unsymmetrical Dimethyl Hydrazine

UEL - upper explosive limit

UL - Underwriters Laboratories

USAF - United States Air Force

UT - ultrasonic testing; umbilical tower of a launch pad

UV - ultraviolet

WR - Western Range

REFERENCED DOCUMENTS

- 29 CFR 1910, *Occupational Safety and Health Standards*
- 29 CFR 1926, *Safety and Health Regulations for Construction*
- 29 CFR 1910.23, *Guarding Floor and Wall Openings and Holes*
- 29 CFR 1910.106, *Flammable and Combustible Liquids*
- 29 CFR 1926.104, *Safety Belts, Lifelines, and Lanyards*
- AFI 32-1065, *Grounding Systems*
- AFI 32-2001, *The Fire Protection Operations and Fire Prevention Program*
- AFM 88, *Air Force Civil Engineering Series Manuals*
- AFM 88-3, Chapter 1, "Structural Design Criteria Loads"
- AFM 88-3, Chapter 13, "Seismic Design For Building"
- AFM 88-3, Chapter 14, "Design Criteria for Facilities in Areas Subject to Typhoons and Hurricanes"
- AFM 88-9, Chapter 3, "Electrical Design, Lightning, and Static Electricity Protection"
- AFMAN 91-201, *Explosives Safety Standards*
- AFOSH 91 and 127, *Air Force Occupational Safety and Health (Safety Series)*
- AFOSH 91-25, *Confined Spaces*
- AFOSH 91-66, *General Industrial Operations*
- AFOSH 127-43, *Flammable and Combustible Liquids*
- AFR 88-22, *Structures to Resist the Effects of Accidental Explosions*
- AISC, *Manual of Steel Construction-Allowable Stress Design*
- AISC Manual S337, *Specification for Allowable Stress Design of Simple Shear Connections*
- AISC Manual S329, *High Strength Fasteners*
- ANSI/ASME A10.14, *Construction and Demolition Operation-Requirements for Safety Belts, Harnesses, Lanyards, and Lifelines for Construction and Demolition Use*
- ANSI/ASME A17.1, *Safety Code for Elevators and Escalators*
- ANSI/ASME A17.2, *Inspectors Manual for Elevators and Escalators*
- ANSI/ASME Z359.1, *Safety Requirements for Personnel Fall Arrest Systems, Subsystems, and Components*
- ANSI/EIA/TIA 222, *Structural Standards for Steel Antenna Towers and Antenna Supporting Structures*
- ANSI/RIA R15.06, *Design, Installation, Testing, and Operation Requirements for Industrial Robots and Robot Systems*
- ASCE 7-95, *Minimum Design Loads for Buildings and Other Structures*
- ASTM A36/A36M-96, *Standard Specification for Carbon Structural Steel*
- ASTM A53-96, *Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc-Coated, Weldless and Seamless*
- ASTM A307-94, *Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength*
- ASTM A325-96, *Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength*
- ASTM A325 M-93, *Standard Specification for High Strength Bolts for Structural Steel Joints (Metric)*
- ASTM A490-93, *Standard Specification for Heat Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength*
- ASTM A490M-93, *Standard Specification for High-Strength-Strength Steel Bolts, Classes 10.9 and 10.9.3 for Structural Steel Joints (Metric)*
- ASTM A500-93, *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel*

REFERENCED DOCUMENTS

Structural Tubing in Rounds and Shapes

ASTM A501-93, *Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing*

ASTM E1444, *Magnetic Particle Inspection*

ATC 3-06, *Tentative Provisions for the Development of Seismic Regulations for Buildings, National Bureau of Standards*

AWS D1.1, *Structural Welding Code Steel*

DoDI-4145.26, *DoD Contractors' Safety Requirements for Ammunition and Explosives*

DoD 4145.26-M, *DoD Contractors' Safety Manual for Ammunition and Explosives*

DoD 6055.9-STD, *Ammunition and Explosives Safety Standards*

EM 385-1-1, *US Army Corps of Engineers Safety and Health Requirements Manual*

KSC-STD-C-0001, *Recommendations for Protective Coating Procedures and Materials for Exterior Structural Steel in Hypergolic Storage Facilities*

KSC-STD-E-0012, *Standard for Bonding and Grounding*

MIL-B-5087, *Bonding, Electrical, and Lightning Protection for Aerospace Systems*

MIL-HDBK-419, *Grounding, Bonding, and Shielding for Electronic Equipment and Facilities*

MIL-HDBK-1008, *Fire Protection for Facilities Engineering, Design, and Construction*

MIL-HDBK-1190, *Facility Planning & Design Guide*

MIL-STD-188/124, *Grounding, Bonding, and Shielding for Electronic Equipment and Facilities*

MIL-STD-410E, *Non-Destructive Examination Personnel Qualification and Certification*

MIL-STD-810, *Environmental Test Methods and Engineering Guidelines*

MIL-STD-882, *System Safety Program Requirements*

MIL-STD-1472, *Human Engineering Design*

Criteria for Military Systems, Equipment, and Facilities

MIL-STD-1542, *Electromagnetic Compatibility and Grounding Requirements for Space System Facilities*

MIL-STD-2154, *Ultrasonic Inspection for Wrought Metals*

NEC Article 480, *Storage Batteries*

NEC Article 500, *Hazardous (Classified) Locations*

NEC Section 500-3, *Hazardous Atmospheric Groups*

NEC Article 504, *Intrinsically Safe Systems*

NFPA 15, *Water Spray Fixed Systems for Fire Protection*

NFPA 30 *Flammable and Combustible Liquids Code*

NFPA 70, *National Electric Code*

NFPA 77, *Static Electricity*

NFPA 101, *Life Safety Code*

NFPA 780, *Lightning Protection Systems*

NFPA 496, *Purges and Pressurized Enclosures for Electrical Equipment*

NFPA 497, *Recommended Standard Practice for Classification of Class 1 Hazardous Locations (Classified) for Electrical Installations in Chemical Process Areas*

SEAOC, *Recommended Lateral Force Requirements and Tentative Commentary*

SNT-TC-1A, *American Society for Non-Destructive Testing Standards*

Society for Non-Destructive Testing Standards

Standard Building Code

Uniform Building Code

UL 913, *Construction and Testing: Intrinsically Safe Apparatus and Associated Apparatus*

CHAPTER 5

FACILITIES AND STRUCTURES DOCUMENTATION, DESIGN, CONSTRUCTION, TEST, AND INSPECTION REQUIREMENTS

5.1 INTRODUCTION

5.1.1 Purpose of the Chapter

Chapter 5 specifies minimum design, test, inspection and data requirements for the construction and modification of conventional and critical facilities and structures at the Eastern Range (ER) and Western Range (WR). The following major topics are addressed:

- 5.2 Responsibilities and Authorities
- 5.3 Facilities and Structures Design and Construction Site Policies
- 5.4 Documentation Requirements
- 5.5 Conventional Facilities and Structures
- 5.6 Critical Facilities and Structures
- 5.7 Facility and Structure Emergency and Critical Systems Test Requirements
- 5.8 Critical Facilities and Structures Initial Inspection Requirements

5.1.2 Applicability

All ER and WR facilities and structures are subject to the requirements of this document regardless of real property accountability or ownership, including Department of Defense (DoD), National Aeronautics and Space Administration (NASA), and commercial users.

5.2 RESPONSIBILITIES AND AUTHORITIES

5.2.1 Systems Safety, 45th Space Wing and 30th Space Wing

Any design standard having a reference to the "authority having jurisdiction" shall be interpreted to mean the 45th and 30th Space Wing, Systems Safety (SES) with the exception of the National Fire Protection Association (NFPA) standards, but not NFPA 70, the *National Electrical Code* (NEC). **NOTE:** Unless otherwise noted, all references to *Range Safety* in this Chapter refer to 45 SW/SES or 30 SW/SES. Range Safety is responsible for the following:

- a. Reviewing and approving the design, construction, modification, or demolition of all facilities and structures on the Ranges
- b. Assisting Civil Engineering (45 CES and 30 CEG), in preparing explosive quantity distance site plans and for submitting them (with Civil Engineering assistance), to the Department of Defense Explosive Safety Board (DDESB) through engineering and safety channels for review and approval.
- c. In conjunction with Civil Engineering (45 CES and 30 CEG), reviewing and approving facility or structure modification or operational changes that

affect explosive site plans or hazard level of the facility

d. Approving the movement or relocation of a hazardous operation and/or system into a facility or structure even if the facility or structure has been used for similar operations in the past

e. In conjunction with Bioenvironmental Engineering (45 and 30 MDG/SGPB) and the Fire Marshal, (45 CES/CEF, 30 CEG/CEF) reviewing and approving the performance characteristics of hypergolic propellant vapor control foam and delivery system design

f. In conjunction with Bioenvironmental Engineering (45 and 30 MDG/SGPB), reviewing and approving the requirements for and design of air monitoring systems

g. Performing surveillance and support of hazardous and safety critical operations as applicable to this Chapter. **NOTE:** Certain areas covered by AFI 31-101, Chapter 10, "Standard for DoD Space Lift Operations Systems are exempted.

5.2.2 Range Users

Range Users are responsible for the following:

a. Ensuring that all facilities and structures under their jurisdiction are designed, constructed, modified, and demolished in accordance with the provisions of this Chapter

b. Ensuring construction site safety

c. Coordinating with Bioenvironmental Engineering (45 and 30 MDG/SGPB) in the design of scrubbers and incinerators, hypergolic propellant vapor control foam and delivery systems, and air monitoring systems

d. Coordinating with the Fire Marshal (45 CES/CEF and 30 CEG/CEF) in the design of fire protection systems and conduct of fire protection activities

e. Assisting in the preparation of explosive site plans

5.2.3 Supporting Agencies

5.2.3.1 Civil Engineer Squadron, 45th Space Wing, and Civil Engineer Group, 30th Space Wing

The Civil Engineer Squadron, 45th Space Wing (45 CES) and the Civil Engineer Group, 30th Space Wing (30 CEG) are responsible for the following: **NOTE:** Unless otherwise noted, these agencies will be referred to as *Civil Engineering*.

a. Preparing explosive site plans in coordination with the Range User and Range Safety, and assisting Range Safety to submit them to the DDESB through engineering and safety channels. **NOTE:** The DDESB is responsible for reviewing and approving explosive site plans.

b. Obtaining permits for scrubbers and incinerators

c. In conjunction with Range Safety, reviewing and approving facility and structure modification or operational changes that affect explosive site plans

5.2.3.2 Fire Marshal, 45th Space Wing and 30th Space Wing

Any design standard in the NFPA standards with the exception of NFPA 70, having a reference to the "authority having jurisdiction" shall be interpreted to mean the 45th or 30th Space Wing, Fire Marshal (45 CES/CEF and 30 CEG/CEF). **NOTE:** Unless otherwise noted, these agencies will be referred to as the *Fire Marshal*. The Fire Marshals are responsible for the following:

a. Providing necessary information to Civil Engineering and Range Safety in regard to Range facilities and structures fire protection requirements

b. Coordinating with Range Safety to ensure that facilities and structures on the Ranges meet national fire protection standards

c. Reviewing and approving fire protection plans in accordance with AFI 32-2001

d. Conducting fire protection activities in accordance with MIL-HDBK-1008

e. In conjunction with Range Safety and Bioenvironmental Engineering, reviewing and approving the performance characteristics of hypergolic propellant vapor control foam and delivery systems design

5.2.3.3 Bioenvironmental Engineering, 45th Space Wing and 30th Space Wing

Bioenvironmental Engineering, 45th Space Wing (45 MDG/SGPB) and 30th Space Wing (30 MDG/SGPB) are responsible for the following: **NOTE:** Unless otherwise noted, these agencies will be referred to as *Bioenvironmental Engineering*.

a. Reviewing and approving the design of scrubbers and incinerators

b. In conjunction with Range Safety and the Fire Marshal (45 CES/CEF and 30 CES/CEF), review-

ing and approving the performance characteristics of hypergolic propellant vapor control foam and delivery systems design

c. In conjunction with Range Safety, reviewing and approving the requirements for and design of air monitoring systems

5.2.3.4 Operations Safety

The Range Support Contractor at the ER and the 30th Space Wing Ground Safety Section (30 SW/SEG) at the WR shall be referred to as *Operations Safety*. Operations Safety is responsible for inspecting new and modified facilities and structures prior to initial startup operations in accordance with AFMAN 91-201 and DoD 6055.9-STD.

5.3 FACILITIES AND STRUCTURES DESIGN AND CONSTRUCTION SITE POLICIES

5.3.1 Design, Construction, and Modification Policy

All facilities and structures designed, constructed, and modified for use on the Ranges shall meet the standards and provisions established in Chapters 3 and 5 of this document and in other nationally recognized codes and standards, including applicable state regulations.

5.3.2 Location Planning Requirements

During the planning phase for construction or modification of facilities, the following requirements shall be taken into consideration:

a. The impact of the new facility operations to existing and planned near-by facilities, base cantonment areas, and off-base population centers as well as the impact of existing and planned near-by facilities on the new facility operations shall be addressed.

b. Facilities shall not be located inside an existing explosive safety clear zone unless the facility is related to the existing explosive-sited facility.

c. Overflight hazards shall be considered and critical facilities should not be located immediately downrange of existing launch sites.

d. Location of facilities shall address operational impact from hypergolic transfer and storage operation in near-by facilities.

e. Location of facilities that may contain hypergolic commodities shall address Toxic Hazard Corridors (THC) (see Chapter 6) and the potential impact on the general public and near-by facilities.

f. RF hazards shall be addressed.

5.3.3 Construction Site Safety Policy

With the exception of item *d* below, construction site safety shall be the sole responsibility of the Range User or contractor when the construction contract is issued by one of the following:

a. The United States Army Corps of Engineers

b. A Range User or contractor where the accountability of a 45/30 SW facility or work area is transferred to another Range User or contractor for construction and modification purposes

c. A United States Department of Transportation (DOT) commercial contractor or other non-United States Air Force (USAF) agencies, such as NASA, involved in construction activities on their own accountable facilities and launch complexes

d. All construction activities conducted within or in the vicinity of sites used to store or handle hazardous systems, high value equipment, or flight hardware shall be monitored by Range Safety with the authority to impose a hold (stop work) when unsafe conditions exist. However, the Range User or contractor shall continue to have ultimate responsibility for safety on the site.

5.3.3.1 Compliance with Occupational Safety and Health Administration Regulations

Construction site activities on the Ranges shall comply with Occupational Safety and Health Administration (OSHA) General Industry and Construction Standards (29 CFR 1910 and 1926). **NOTE:** Range Safety shall assume no liability for Range User or contractor compliance or noncompliance with OSHA requirements.

5.3.3.2 Compliance with the United States Army Corps of Engineers Safety and Health Requirements Manual and Other Criteria

Construction site activities on the Ranges should be performed in accordance with EM 385-1-1 and the criteria stated below. **NOTE:** Range Safety shall assume no liability for Range User or contractor compliance or noncompliance with this document or criteria.

a. The construction contractor project superintendent or a designated representative should be at the work site when work is being performed and should serve as the single point of contact on all questions concerning job site safety.

b. Safety violations should result in Contract Administrator actions, including stopping work.

c. Accidents and injuries should be reported to the Administrative Contracting Officer.

1. Serious mishaps should be reported as soon as possible.

2. The Administrative Contracting Officer should notify 45 or 30 SW/SEG, Ground Safety, of serious accidents and injuries.

5.4 DOCUMENTATION REQUIREMENTS

5.4.1 Conventional and Critical Facility Determination

All facilities, facility systems, and structures shall be evaluated by the Range User to determine if they are critical.

5.4.2 Documentation Review and Approval Process

a. Unless otherwise agreed to by Range Safety and the Range User or otherwise stated in this Chapter, the facility design engineering documents described in this section shall be submitted to Range Safety for review and approval 30 days prior to the following design review meetings: introductory; conceptual (30 percent); Preliminary (60 percent); Critical (90 percent); and Final (100 percent). **NOTE 1:** The introductory documentation shall include, but is not limited to, such preliminary facility design documents as Requirements Analysis Management Plans (RAMPs) and Project Definition Books (PDBs) **NOTE 2:** All facility design engineering drawing and specification packages shall have a space or block on the first drawing sheet reserved for the approval signature of the 45 SW/SES or 30 SW/SEG reviewing official. **NOTE 3:** All Review Item Discrepancies (RIDs) shall be addressed at each design review and resolved as soon as possible.

b. Documentation requiring the review and approval of Civil Engineering shall be submitted in accordance with schedules jointly agreed upon by the Range User and Civil Engineering.

c. Documentation requiring the review and approval of Bioenvironmental Engineering shall be

submitted in accordance with schedules jointly agreed upon by the Range User and Bioenvironmental Engineering.

d. Documentation requiring the review and approval of the Fire Marshal shall be submitted in accordance with MIL-HDBK-1008.

5.4.3 Conventional Facilities and Structures Documentation Requirements

5.4.3.1 Determining Criticality

Range Users shall submit documentation justifying the non-critical determination. This documentation shall be submitted at the introductory and conceptual (30 percent) design reviews.

5.4.3.2 Conventional Facility Design Drawings and Specifications

Facility design engineering drawings and technical specification packages for conventional facilities shall be submitted.

5.4.3.3 Conventional Facility Demolition Plan

If applicable, a demolition plan shall be submitted.

5.4.4 Critical Facilities and Structures Documentation Requirements

5.4.4.1 Critical Facility and Structure Design Criteria Document

a. Prior to facility and structure design, design criteria that clearly state Range User requirements and identify the essential features and functions required in the facility shall be submitted.

b. The design criteria document shall be revised periodically to reflect the current status of design requirements as they are developed.

5.4.4.2 Critical Facility and Structure Design Calculations

a. The design of all structural steel buildings and other structures shall be based on documented, detailed, design calculations.

b. Seismic design analysis is required for WR facilities, structures, and installed equipment.

c. Trailer anchoring analysis shall be submitted.

d. The above design calculations and analyses shall be submitted when completed.

5.4.4.3 Hazard Analyses

Hazard analyses of facilities, structures, and emergency and critical systems shall be conducted in accordance with Appendix 1B, System Safety Pro-

gram, as jointly tailored by Range Safety and the Range User.

5.4.4.4 Critical Facility and Structure Design Drawings and Specifications

Facility and design engineering drawings and technical specification packages for critical facilities shall be submitted.

5.4.4.5 Emergency and Critical Systems Design Drawings and Specifications

The following applicable emergency and critical systems design drawings and specifications shall be submitted for review and approval to Range Safety and other agencies as noted: **NOTE:** Design drawings and specifications for other emergency and critical systems not identified below may be required by Range Safety.

- a. Lightning protection
- b. Bonding and grounding
- c. Robots
- d. Emergency eyewash and showers (Bioenvironmental Engineering)
- e. Air monitoring systems (Bioenvironmental Engineering)
- f. Area warning systems
- g. Ventilation systems
- h. Drain and sump systems (Civil Engineering and Bioenvironmental Engineering)
- i. Scrubbers and incinerators (Civil Engineering and Bioenvironmental Engineering)
- j. Liquid level indicators
- k. Conductive floors
- l. Hazardous vapor detection systems (Bioenvironmental Engineering)
- m. Vapor control systems
- n. Room purge systems
- o. Emergency Power Cutoff Systems
- p. Emergency Monitor and Control Panel
- q. Personnel anchorage and anchorage connectors
- r. Elevators
- s. Fire Protection System (Fire Marshal)

5.4.4.6 Test Plans and Test Reports

5.4.4.6.1 Test Plans.

a. Test plans for the following applicable systems shall be submitted for review and approval to Range Safety and the other agencies noted 45 calendar days prior to the test: **NOTE:** Test plans for other systems may be required as identified by Range Safety.

1. Lightning protection in accordance with MIL-STD-1542
 2. Bonding and grounding in accordance with MIL-STD-1542
 3. Robots in accordance with ANSI/RIA R15.06
 4. Emergency eyewash and showers (Bioenvironmental Engineering)
 5. Air monitoring systems (Bioenvironmental Engineering)
 6. Area warning systems
 7. Ventilation systems
 8. Drain and sump systems (Civil Engineering and Bioenvironmental Engineering)
 9. Scrubbers/incinerators (Civil Engineering and Bioenvironmental Engineering)
 10. Liquid level indicators
 11. Conductive floors
 12. Vapor control systems
 13. Hazardous vapor detection systems (Bioenvironmental Engineering)
 14. Room purge systems
 15. Technical Power Cutoffs
 16. Emergency Power Cutoff Systems
 17. Emergency Monitor and Control Panels
 18. Elevators in accordance with ASME/ANSI A17.1 and A17.2
 19. Integrated end-to-end test of interrelated systems
 20. Personnel anchorage and anchorage connectors
- b. The test plan for the fire protection system shall be submitted for review and approval to the Fire Marshal 45 calendar days prior to the test.

5.4.4.6.2 Test Reports. Test reports shall be submitted to Range Safety and the other agencies noted above for review and approval at least 45 days prior to activation of the facility.

5.4.4.7 Critical Facility and Structure Demolition Plan

If applicable, a demolition plan shall be submitted.

5.4.4.8 Facility Safety Data Package

A Facility Safety Data Package (FSDP) providing detailed descriptions of the hazardous and critical systems in a facility or structure designated as critical shall be provided. Content requirements are found in Appendix 5A. As an alternate, a design

package that contains all the elements specified in Appendix 5A is acceptable.

5.5 CONVENTIONAL FACILITIES AND STRUCTURES

5.5.1 New, Rehabilitated, or Modified Conventional Facility and Structure Design Standards

At a minimum, the design of new, rehabilitated, or modified conventional facilities and structures on the Ranges shall comply with or be equivalent to the applicable standards of the current editions of the following documents:

- a. MIL-HDBK-1190
- b. MIL-HDBK-1008
- c. *Standard Building Code* (ER only)
- d. *Uniform Building Code*
- e. 29 CFR 1910
- f. 29 CFR 1926
- g. AFOSH 127 Series and 91 Series
- h. AFM 88 Series Manuals
- i. ANSI/ASCE-7

5.5.2 Conventional Facility and Structure Elevators

a. All elevators in conventional facilities and structures shall be designed, built, and installed in accordance with ASME/ANSI A17.1.

b. All elevators in conventional facilities and structures shall be inspected, tested, and maintained in accordance with ASME/ANSI A17.1. and ASME/ANSI A17.2.

5.5.3 Conventional Facility and Structure Life Safety Code Requirements

The provisions of NFPA 101, the *Life Safety Code*, shall be incorporated in the design of each conventional facility and structure at the Ranges.

5.5.3.1 Emergency Egress

All emergency egress doors shall be equipped with panic hardware and shall not be locked in a manner that would bar emergency egress.

5.5.3.2 Emergency Lighting

Emergency lighting shall be designed and installed in all locations such as windowless rooms and offices, stairways, and exit corridors from which personnel egress would be hazardous in the event of a power failure.

5.5.4 Conventional Facility and Structure Electrical Equipment

At a minimum, electrical equipment and its installation shall comply with the requirements of the most recent edition of the NEC (NFPA 70) or the regulations of OSHA, whichever are more restrictive.

5.5.5 Conventional Facility and Structure Personnel Anchorage and Anchorage Connectors

a. Consideration shall be given to the use of fixed platforms in lieu of extensive use of personnel tie-offs.

b. If the design process determines that personnel tie-offs are necessary, then fixed, permanently installed anchorage connectors shall be used.

c. Personnel anchorage and anchorage connectors shall be designed and tested in accordance with ANSI A10.14 and ANSI Z359.1.

d. Anchorage and anchorage connectors shall be designed to withstand a static load of 5000 lb per person.

e. Design analysis shall consider all possible vectors of forces induced by a fall.

f. Anchorage and anchorage connectors shall be load tested initially to 5000 lb static and shall not require re-testing except for causes such as corrosion, damage, replacement, modification, repair, or exposure to launch heating.

g. Anchorage and anchorage connectors shall be stenciled or tagged with the maximum number of persons and/or total weight allowed to be attached to the anchor at a given time using 5000 lb per person. **NOTE:** Such markings may be stenciled on the surrounding structure.

h. Anchorage and anchorage connectors shall be stenciled or tagged with test weight and date. **NOTE:** Such markings may be stenciled on the surrounding structure.

i. Anchorage and anchorage connectors shall be located as close as possible to the work point as practical.

j. Anchorage and anchorage connectors shall be located as high as practical to limit the distance of potential fall.

k. Anchorage and anchorage connectors shall be located so that an individual can attach to the connectors at waist height or above.

l. Anchorage and anchorage connectors shall be located so that they do not endanger fluid or gas lines, electrical cabling, critical hardware, or flight components when the lifeline or lanyard is attached, in use, or under load. **NOTE:** To preclude the above conditions, shielding or guarding of the components or system in question may be required.

m. Safety swivel hoist rings shall be the preferred anchorage connector rather than eye bolts.

5.5.6 WR Conventional Facility and Structure Seismic Design

AFM 88-3, Chapter 13, places the WR in Seismic Zone 4. **NOTE:** Local geologic structure determines zone designation 1 through 4, considering the potential severity, frequency, and damage from a seismic event. This designation means that the WR is located in the most severe seismic region. The probability of being exposed to a great earthquake is large enough to require taking specific mitigating measures in design.

a. Seismic design of all new or modified facilities, structures, installed equipment shall be in accordance with AFM 88-3, Chapter 13 and Sections A and B. Where specific design guidance is not provided in these manuals, industry standards such as those of the Seismology Committee Structural Engineers Association of California (SEAOC), UBC, and Applied Technology Council (ATC 3-06) shall be used.

b. Seismic design shall consider both the vertical and horizontal component of seismic loading.

c. Facilities, structures, installed equipment, and trailers that must remain operational after a seismic event shall be designed in accordance with an importance factor of I of 1.5 in accordance with AFM 88-3, Chapter 13.

d. Equipment installed in facilities needed for post-earthquake recovery shall be designed to remain operational after a seismic event.

e. Installed equipment that has the potential, directly or by propagation, to cause the following events shall be restrained to restrict movement and withstand a seismic event, but need not remain operational after a seismic event:

1. Severe personnel injury
2. Catastrophic events
3. Significant impact on space vehicle and/or missile processing and launch capability. **NOTE:**

This criteria does not apply to commercial programs.

5.5.7 Trailer Design

a. Trailers such as those used for offices, instrumentation, shop, or storage, remaining in position for longer than 24 hours shall be anchored and stabilized.

b. Trailers shall be secured against wind loads per the design criteria of AFM 88-3, Chapter 1 and ANSI/ASCE-7.

5.6 CRITICAL FACILITIES AND STRUCTURES

5.6.1 New, Rehabilitated, or Modified Critical Facilities and Structures General Design Requirements

5.6.1.1 Critical Facility and Structure Design Standards

At a minimum, the design of new, rehabilitated, or modified critical facilities and structures on the Ranges shall comply with or be equivalent to the applicable provisions of the current editions of the following documents:

- a. MIL-HDBK-1190
- b. MIL-HDBK-1008
- c. *Standard Building Code* (ER only)
- d. *Uniform Building Code*
- e. 29 CFR 1910
- f. 29 CFR 1926
- g. AFOSH 127 Series and 91 Series
- h. AFM 88 Series Manuals
- i. AFMAN 91-201 and DoD 6055.9-STD
- j. AFM 88-22
- k. MIL-STD-1472
- l. ANSI/ASCE-7

5.6.1.2 Critical Facility and Structure Elevators

a. All elevators in critical facilities on the Ranges shall be designed, built, and installed in accordance with ASME/ANSI A17.1.

b. All elevators in critical facilities on the Ranges shall be inspected, tested, and maintained in accordance with ASME/ANSI A17.1. and ASME/ANSI A17.2.

c. All passenger elevators in critical facilities shall be built to the code requirements for general purpose elevators approved for freight elevators in accordance with ASME/ANSI A17.1, Rule 207.1

d. All freight elevators in critical facilities shall be built to the code requirements for general purpose freight elevators approved for passengers in accordance with ASME/ANSI A17.1, Rule 207.4.

e. All elevators in critical facilities shall be equipped with a public address (PA) speaker where a PA system is available.

5.6.1.3 Critical Facility and Structure *Life Safety Code* Requirements

The provisions of NFPA 101, the *Life Safety Code*, shall be incorporated in the design of all critical facilities and structures at the Ranges.

5.6.1.3.1 Emergency Egress.

a. All side hinged doors that could be used as a means of emergency egress from a high hazard facility or structure shall be considered emergency exits and shall swing in the direction of exit travel.

b. All emergency egress doors shall be equipped with panic hardware and shall not be locked in a manner that would bar emergency egress.

5.6.1.3.2 Emergency Lighting. Emergency lighting shall be designed and installed in all locations such as windowless rooms and offices, stairways, and exit corridors from which person-nel egress would be made hazardous in event of a power failure.

5.6.1.4 Critical Facility and Structure Structural Steel

5.6.1.4.1 Critical Facility Structural Steel General Design Requirements.

a. Critical structural steel facilities and structures shall be designed in accordance with the American Institute of Steel Construction (AISC) "Manual of Steel Construction-Allowable Stress Design."

b. Connections between structural members shall be designed to use welded or bolted joints in accordance with AISC M016 and S337.

5.6.1.4.2 Bolts and Fasteners.

a. Permanent bolted structural joints shall use high strength fasteners in accordance with AISC S329. *EXCEPTION: ASTM A307 bolts may be substituted for ASTM A325 and ASTM A490 fasteners in those applications where stresses are very low.*

b. Joints using ASTM A307 and ASTM 325 bolts in exterior applications shall use galvanized

fasteners. Joints using ASTM A490 heat treated high strength bolts shall use plain fasteners that are coated for corrosion protection.

c. ASTM A325 and ASTM A490 fasteners shall not be reused.

5.6.1.4.3 Welding.

a. Welded connections shall use pre-qualified welded joints in accordance with AISC M016, AISC S337, and AWS D1.1.

b. Welders, welding operators, and tackers shall be qualified in accordance with AWS D1.1.

c. All welds shall be inspected in accordance with the following criteria:

1. 100 percent of all welds shall be visually inspected in accordance with AWS D1.1.

2. A random selection of 10 percent of all fillet welds shall be inspected using magnetic particle testing techniques in accordance with ASTM-E1444 or the equivalent.

3. A random selection of 10 percent of all full penetration welds shall be ultrasonically (UT) tested in accordance with MIL-STD-1699 or the equivalent.

(a) If rejectable discontinuities are found, then a second random 10 percent UT of these welds shall be accomplished.

(b) If, on the second random 10 percent, UT rejectable discontinuities are uncovered, the remainder of the full penetration welds shall receive the UT to determine the extent of the weld defects.

4. Nondestructive test personnel shall be qualified to SNT-TC-1A, Level 1 (under supervision of a Level 2) or above.

5.6.1.4.4 Recommended Structural Steel Materials.

a. ASTM A36 for plates and shapes

b. ASTM A53 for pipe

c. ASTM A500 or ASTM A501 for structural tubing

d. Materials that are susceptible to stress corrosion cracking shall be avoided.

5.6.1.5 Critical Facility and Structure Design Load Criteria

a. Design load assumptions for dead, live, and operational wind loads shall be in accordance with AFM 88-3, Chapter 1.

b. Facilities and structures built in hurricane areas shall be designed in accordance with AFM 88-3, Chapter 14 and/or American Society of Civil

Engineers (ASCE) 7-95 or the most current edition.

c. Unique loads such as equipment loads, impact loads, launch environment loads (rocket engine exhaust impingement, blast pressure, acoustics, or vibrations) shall be clearly defined and analyzed.

d. Minimum live loads for stairs, floor opening covers, wall openings, handrails, fixed ladders, foot walks, and ramps shall be designed in accordance with applicable sections of 29 CFR 1910 and ASCE 7-95 or the most current edition.

e. As required, structural members shall be sized to accept additional moments for the installation of OSHA required personnel anchor points as described in 29 CFR 1926.502.

5.6.1.6 Critical Facility and Structure Bonding and Grounding

a. At a minimum, bonding and grounding requirements for all critical facilities and structures shall comply with the requirements of ANSI/NFPA 70. **NOTE:** The different types of facilities and structures at the Ranges require varying degrees of bonding and grounding beyond those specified by NFPA 70.

b. All facilities used to store, handle, or process ordnance items or propellants shall be bonded and grounded in accordance with AFMAN 91-201 and DoD 6055.9-STD.

c. Documents that may be used to design grounding and bonding systems for the protection of personnel and equipment from abnormal voltages are as follows:

1. MIL-STD-1542
2. MIL-B-5087
3. KSC-STD-E0012
4. MIL-STD-188/124
5. AFMAN 91-201 and DoD 6055.9-STD,

Chapter 6

6. MIL-HDBK-419
7. AFM 88-9, Chapter 3
8. ANSI/NFPA 77

5.6.1.7 Critical Facility and Structure Lightning Protection

a. At a minimum, lightning protection requirements for critical facilities and structures shall comply with ANSI/NFPA 780.

b. Facilities and structures that require greater protection against direct or indirect lightning strikes such as launch pads or explosives storage areas, shall also comply with the following:

1. AFM 88-9, Chapter 3, "Electrical Design, Lightning and Static Electricity Protection"
2. AFI 32-1065

3. AFMAN 91-201 and DoD 6055.9-STD

4. MIL-STD-1542

5.6.1.8 Critical Facility and Structure Electrical Equipment

a. At a minimum, electrical equipment and its installation in critical facilities and structures shall comply with the requirements of the most recent edition of the NEC (NFPA 70) or the regulations of the OSHA, whichever are more restrictive.

b. Prior to being put into service, any electrical equipment that is not specifically labeled for the purpose or conditions of operation intended by a recognized testing agency or that is not manufactured or installed to meet the electrical classification of the area in which the equipment is to be operated shall be approved by Range Safety.

5.6.1.8.1 Definition of Hazardous (Classified) Locations. Hazardous (classified) locations are defined in Article 500 of the NEC; however, some explosives and propellants are not covered. For Range installations, the following paragraphs define the minimum requirements to be applied in the definitions of locations in which explosives, pyrotechnics, or propellants are or are expected to be present. These requirements shall be followed unless less stringent classifications are justified and approved as part of the design data submittal process. Range Safety and the Fire Marshal shall approve all potential critical facility hazardous location designations. (See Appendix 5B for a flowpath for classifying hazardous areas.)

a. Class 1, Division 1

1. Locations in which flammable liquids, vapors, or gases may be present in air during normal operations

2. Locations in which ignitable concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage

3. Locations in which the breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases or vapors and might also cause simultaneous failure of electrical equipment

4. As a baseline, these include the following locations:

(*a*) Within 25 ft of any vent opening unless the discharge is normally incinerated or scrubbed to nonflammable conditions (less than 25 percent of Lower Explosive Limit (LEL)). This distance may be increased if the vent flow rate creates a flamma-

bility concern at a distance greater than 25 ft.

(*b*) Below grade locations in a Class 1, Division 2 area.

b. Class 1, Division 2

1. Locations in which volatile flammable liquids or flammable gases are handled, processed or used, but in which the liquids, vapors, or gases will normally be confined in closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or system or in case of abnormal operation of equipment

2. Locations in which ignitable concentrations of gases or vapors are normally prevented by positive mechanical ventilation and which might become hazardous through failure or abnormal operation of ventilation equipment

3. Locations adjacent to a Class 1, Division 1 location and to which ignitable concentrations of gases or vapors might occasionally be communicated unless communication is prevented by adequate positive pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided. **NOTE 1:** This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used but, in the judgment of Range Safety and the Fire Marshal, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of an accident, the adequacy of ventilating equipment, the total area involved, and the record of the Range User with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location. **NOTE 2:** Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions. **NOTE 3:** As determined by Range Safety and the Fire Marshal, locations may actively change classification depending upon the flammable fluid system activity and configuration. For these types of locations, fixed or permanently installed electrical equipment shall be designed for the worst case hazardous environment. **NOTE 4:** Portable electrical equipment shall be designed for the worst case hazardous environment in which it will be used. Portable equipment that is not designed for use in a particular hazardous environment is not allowed in

that environment or shall be locked out from use in that environment.

4. As a baseline, Class 1, Division 2 locations include the following equipment or areas:

(a) Storage vessels (including carts and drums): 25 ft horizontally and below to grade and 4 ft vertically above the vessel (25 ft in any direction for hydrogen)

(b) Transfer lines: 25 ft horizontally and below to grade and 4 ft above the line (25 ft in any direction for hydrogen)

(c) Launch vehicle (liquid fueled vehicle, stage, or payload): 100 ft radius horizontally from and 25 ft vertically above (100 ft for hydrogen) the highest leak or vent source and below the vehicle to grade

(d) Enclosed locations such as rooms, work bays, and launch complex clean rooms that are used to store and handle flammable and combustible propellants when the concentration of vapors inside the room resulting from a release of all fluids stored and handled equals or exceeds the LEL. **NOTE:** The quantity of fluids used in the analysis shall be the maximum amount allowed in the explosives site plan.

c. *Hazardous Commodity Groups.* Hazardous commodities are grouped by similar characteristics. **NOTE:** These fuels shall be considered ignitable regardless of the ambient temperature. The following fuels shall be categorized as follows:

1. Group B: Liquid or gaseous hydrogen
2. Group C: Hypergolic fuels such as N_2H_4 , MMH, UDMH, A50
3. Group D: Hydrocarbon fuels (RP and JP)
4. Group D: Oxidizers. Oxidizers shall be considered Group D hazardous substances in addition to the fluids listed in Section 500-3 of the NEC.

d. *Exposed Solid Propellants.* The atmosphere within 10 ft of exposed solid propellant shall be classified as a Class 1, Division 2, Group D location. Solid rocket motors are considered exposed in the following situations:

1. The motor nozzle is not attached and the aft end of the motor does not have a cover.
2. The motor nozzle is attached but does not have a nozzle plug.
3. The unassembled motor segments do not have front and rear covers.
4. The igniter is removed from the motor and cover is not provided.

5.6.1.8.2 Electrical Systems and Equipment Hazard Proofing. Electrical systems and equip-

ment used in hazardous locations shall be designed and listed for the locations in accordance with the following requirements:

a. Explosion proof apparatus shall meet the requirements of the NEC for Class I, Division 1 or 2, and be listed and labeled by a nationally recognized testing laboratory such as Underwriter's Laboratories (UL), Factory Mutual Corporation (FM).

b. Non-incendive apparatus shall meet the requirements of NEC Article 501, ANSI/ISA-S12.2, and are restricted to installation in Class I, Division 2 locations only. They shall be listed and labeled by a nationally recognized testing laboratory such as UL or FM.

c. Intrinsically safe equipment intended for any NEC Hazardous (Classified) location shall meet the requirements of NEC Article 504 and UL 913 and be listed and labeled by a nationally recognized testing laboratory such as FM or UL.

d. The use of purged and pressurized electrical enclosures designed in accordance with NFPA 496 for the purpose of eliminating or reducing the hazardous location classification as defined in Article 500 of the NEC is acceptable with the following additional requirements:

1. The purged and pressurized enclosure shall be maintained at a nominal 1/2 in. of water unless a lower pressure is approved by Range Safety. In no case shall the pressure in enclosures be less than 1/10 in. of water.

2. Rooms into which unprotected personnel may enter shall be purged with air only.

3. Purged rooms and enclosures shall be provided with an audible alarm set to trigger when the pressure drops below 1/4 in. water.

e. Equipment inspected and tested to other government standards such as MIL-STD-810 may be used if approved by Range Safety in coordination with Civil Engineering.

f. *Exterior Interconnecting Cable*

1. Exterior interconnecting cable installed in the "open" is acceptable for interconnecting electrical equipment in a hazardous location. **NOTE:** *Open* refers to open trays or raceways that cannot trap gases when installing exterior type cable to interconnect electrical equipment in a hazardous location.

2. Cable installation shall comply with the requirements of Article 504 of the NEC.

5.6.1.8.3 Backup Power Sources. Backup

power sources shall be provided for critical load requirements when the loss of the normal power source would cause injury and/or death to personnel or loss of flight hardware.

5.6.1.9 Critical Facility and Structure Fencing

a. Fencing encompassing critical facilities shall have emergency egress gates.

b. A sufficient number of gates shall be provided and located to preclude the necessity for personnel to egress toward or past any potential hazard.

c. If fencing can become electrically charged by lightning, falling electrical power lines, or component failure of adjacent electrical equipment, such as substation transformers or switchgear, fences shall be grounded and gates bonded.

5.6.1.10 Critical Facility and Structure Personnel Anchorage and Anchorage Connections

a. Consideration shall be given to the use of fixed platforms in lieu of extensive use of personnel tie-offs.

b. If the design process determines that personnel tie-offs are necessary, then fixed permanently installed anchorage connectors shall be used.

c. Personnel anchorage and anchorage connectors shall be designed and tested in accordance with ANSI A10.14 and ANSI Z359.1.

d. Anchorage and anchorage connectors shall be designed to withstand a static load of 5000 lb per person.

e. Design analysis shall consider all possible vectors of forces induced by a fall.

f. Anchorage and anchorage connectors shall be load tested initially to 5000 lb static and shall not require retesting except for causes such as corrosion, damage, replacement, modification, repair, or exposure to launch heating.

g. Anchorage and anchorage connectors shall be stenciled or tagged with the maximum number of persons and/or total weight allowed to be attached to the anchor at a given time using 5000 lb per person. **NOTE:** Such markings may be stenciled on the surrounding structure.

h. Anchorage and anchorage connectors shall be stenciled or tagged with test weight and date. **NOTE:** Such markings may be stenciled on the surrounding structure.

i. Anchorage and anchorage connectors shall be located as close as possible to the work point as practical.

j. Anchorage and anchorage connectors shall be located as high as practical to limit the distance of potential fall.

k. Anchorage and anchorage connectors shall be located so that an individual can attach to the connector at waist height or above.

l. Anchorage and anchorage connectors shall be located so that they do not endanger fluid or gas lines, electrical cabling, critical hardware, or flight components when the lifeline or lanyard is attached, in use, or under load. **NOTE:** To preclude the above conditions, shielding or guarding of the components or system in question may be required.

m. Safety swivel hoist rings shall be the preferred anchorage connector rather than eye bolts.

5.6.1.11 WR Critical Facility and Structure Seismic Design Requirements

AFM 88-3, Chapter 13, places the WR in Seismic Zone 4. **NOTE:** Local geologic structure determines zone designation 1 through 4, considering the potential severity, frequency, and damage from a seismic event. This designation means that the WR is located in the most severe seismic region. The probability of being exposed to a great earthquake is large enough to require taking specific mitigating measures in design.

a. Seismic design of all new or modified facilities, structures, installed equipment shall be in accordance with AFM 88-3, Chapter 13 and Sections A and B. Where specific design guidance is not provided in these manuals, industry standards such as SEAOC, UBC, and ATC 3-06 shall be used.

b. Seismic design shall consider both the vertical and horizontal component of seismic loading.

c. Facilities, structures, installed equipment, and trailers that must remain operational after a seismic event shall be designed in accordance with an importance factor of 1 or 1.5 in accordance with AFM 88-3, Chapter 13.

d. Equipment installed in facilities needed for post-earthquake recovery shall be designed to remain operational after a seismic event.

e. Installed equipment that has the potential, directly or by propagation, to cause the following events shall be restrained to restrict movement and withstand a seismic event, but need not remain operational after a seismic event:

1. Severe personnel injury
2. Catastrophic events
3. Significant impact on space vehicle and/or

missile processing and launch capability. **NOTE:** This criteria does not apply to commercial programs.

4. Damage to high value flight hardware.

NOTE: This criteria does not apply to commercial programs.

5.6.2 Special Critical Facility Systems and Structures

The following requirements are for unique critical facility systems and structures. These requirements supplement the general requirements in the **New, Rehabilitated, or Modified Critical Facilities and Structures General Design Requirements** section of this Chapter.

5.6.2.1 Critical Facility and Structure Air Monitoring Systems

5.6.2.1.1 Critical Facility and Structure Air Monitoring System General Design Requirements.

a. Locations in which there is a potential hazard of oxygen deficiency, toxicity, or flammability that could result in personnel injury or death shall be provided with air monitoring systems. Portable monitoring units may be utilized prior to access in lieu of permanent systems with Bioenvironmental Engineering and Range Safety approval. **NOTE:** The following are examples of locations requiring air monitoring if personnel entry is required: (1) enclosed areas, rooms, and vehicle compartments where pressurized inert gas systems are located and/or routed that could deplete or displace oxygen; (2) enclosed areas, rooms, and vehicle compartments where propellant systems are located and/or routed; (3) storage tank entry points; (4) drain pits; and (5) tunnels.

b. Range Users, Bioenvironmental Engineering, and Range Safety shall evaluate and identify locations that require air monitoring systems.

c. AFOSH 91-25 and OSHA requirements shall be complied with.

5.6.2.1.2 Air Monitoring Systems Locations Having Regular Access.

a. Continuous monitoring equipment with local and remote alarms and primary power and backup battery power shall be installed in the hazardous area.

b. The alarm shall be audible above ambient noise levels and shall not be capable of being locally silenced.

c. The remote alarm signal shall be transmitted to the blockhouse, operations control center, or Range Fire Station where 24 hr continuous monitoring is provided.

d. Alarms at local and remote locations shall have visual and audible signals.

5.6.2.1.3 Air Monitoring System Locations Having Infrequent or Temporary Access.

a. Local warning indicators including signs and portable flashers shall be provided.

b. Portable monitors with battery power that provide continuous monitoring with a local alarm may be used.

5.6.2.1.4 Oxygen Deficiency Monitoring Systems. For oxygen deficiency monitoring systems, alarms shall be activated in accordance with minimum OSHA requirements.

5.6.2.1.5 Toxicity Monitoring Systems. For toxicity monitoring systems, alarms shall be activated at no greater than the threshold limit value of the particular vapor(s) being monitored as established by the American Conference of Governmental Industrial Hygienists (ACGIH) and as accepted by the Air Force Surgeon General.

5.6.2.1.6 Flammability Monitoring Systems. For flammability monitoring systems, alarms shall be activated at 25 percent of the LEL.

5.6.2.1.7 Air Monitoring Equipment Calibration. All air monitoring equipment shall be calibrated annually unless otherwise directed by Range Safety and Bioenvironmental Engineering.

5.6.2.2 Guyed Towers

Guyed towers shall be designed in accordance with ANSI/EIA/TIA 222.

5.6.2.3 Robot Systems

Industrial robots and robot systems shall be designed, installed, tested, and operated in accordance with ANSI/RIA R15.06.

5.6.2.4 Mobile Service Towers

For mobile service towers, the overturning moment due to wind load shall not exceed two-thirds of the dead load stabilizing moment of the tower unless the structure is anchored to resist the excess moment. **NOTE:** When the total friction force is insufficient to prevent sliding, anchorage shall be provided to resist the excess sliding force.

5.6.2.5 Hazardous Commodity Lockers

Lockers or cabinets positioned for the purpose of storing flammable, toxic reactive, or caustic materials shall be designed in accordance with OSHA 1910.106, NFPA 30, and AFOSH 127-43.

5.6.2.6 Battery Storage and Processing Areas

a. Battery shops shall be designed in accordance with AFOSH 91-66 and Article 480 of the NEC.

b. Dedicated storage and processing areas for batteries that have the potential for venting hazardous fluids shall be designed with the following:

1. Emergency eyewash and shower systems
2. A dedicated water system, hose and spray attachment, and floor drain and containment system for electrolyte spill
3. A ventilation hood located directly above the battery charging area and vented to a safe location outside the facility
4. Sufficient ventilation in the battery maintenance area to prevent accumulations of explosive vapor concentrations from exceeding 25 percent of the LEL
5. Floors constructed of a material compatible with the battery electrolyte and kept clean and dry
6. Battery racks constructed of a material resistant to corrosion due to contact with electrolyte
7. Separate areas for storage and servicing of batteries that have incompatible electrolytic solutions such as acid and alkaline

5.6.3 Explosives Storage, Handling, and Processing Facilities

The following requirements are for facilities used to store, handle, or process ordnance and/or propellants. These requirements supplement the requirements in the **New, Rehabilitated, or Modified Critical Facilities and Structures General Design Requirements** section of this Chapter.

5.6.3.1 Explosives Site Plans

a. All facilities, including launch complexes, used to store, handle, or process ordnance items or propellants shall be properly sited and approved in accordance with DoD quantity distance criteria and explosives safety standards as specified in DoD 6055.9-STD and implemented in AFMAN 91-201.

b. Preparation of site plans and construction of facilities affected by explosive criteria are the responsibility of Civil Engineering in coordination with the Range User and Range Safety. Civil Engi-

neering shall assist Range Safety to submit site plans to the DDESB through engineering safety channels for review and approval.

c. A minimum of six months is required between the time the site plan is forwarded through channels to the DDESB and final approval. Final approval from the DDESB shall be obtained prior to the start of construction.

d. Any facility that contains explosives is considered an explosives facility; however, certain classes or divisions of explosives in small quantities may require only a Range Safety approved license. (See AFMAN 91-201 and DoD 6055.9-STD.) **NOTE:** Class/Division 1.1 explosives will not be approved by license.

e. If Range Safety determines that a facility modification or operational change affects the explosive site plan, the Range User shall provide the documentation required by AFMAN 91-201 and DoD 6055.9-STD to Range Safety and Civil Engineering for review and approval. An update to the explosives site plan may be required. **NOTE:** If an update is required, a minimum of six months is required between the time the site plan is forwarded through channels to the DDESB and final approval. Final approval from the DDESB must be obtained prior to start of construction.

f. Movement or relocation of a hazardous operation and/or system into a facility shall be approved by Range Safety. **NOTE:** Even if the facility has been used for similar operations in the past, Range Safety review and approval is required.

g. Temporary buildings or trailers shall not be placed inside an explosive safety clear zone without Range Safety approval.

5.6.3.2 Explosives Storage, Handling, and Processing Facilities General Design Requirements

a. Explosives storage, handling, and processing facilities shall be designed and constructed in accordance with AFMAN 91-201 and DoD 6055.9-STD.

b. When it is necessary to design explosives facilities in such a manner as to ensure against propagation of explosions between adjacent rooms or nearby facilities, analysis and design of walls, doors, roofs, and other similar items shall conform to AFM 88-22.

5.6.3.3 Explosives Facilities Area Warning Systems

5.6.3.3.1 Explosives Facilities Area Warning System General Requirements. **NOTE:** Dedicated explosives storage facilities not associated with operating areas may not require warning systems meeting all of the following requirements. Facilities used to store, handle, or process hazardous materials other than explosives may require area warning systems meeting all or some of the requirements. Determination shall be made by Range Safety on a case-by-case basis.

a. Each explosives facility shall have an area warning system to alert personnel near, entering, or in the area as to the hazard status of that area.

b. The warning system shall consist of warning lights and audible signals augmented by public address (PA) announcements.

c. Each facility shall have an instruction sign at the entry point explaining the area warning system.

d. The visual and audible warning systems shall be visible and audible throughout the facility in 360° in direction and for a distance of at least 2500 ft.

e. Area warning systems shall be used at work areas within overall controlled areas such as fuel or oxidizer storage areas, mobile service towers, and test cells to display locally controlled hazard status. Single flashing amber lights, activated during hazardous operations, may be used in these work areas.

5.6.3.3.2 Explosives Facility Area Warning Systems Specific Requirements.

a. All area warning system electrical circuits (warning lights, audible alarms) shall be designed with an independent backup power system that is activated by an automatic transfer switch.

b. Permanently installed area warning lights shall be designed to provide for flashing green, flashing amber, and flashing red lights to show the hazard status of the affected area.

c. Audible warning signals shall be provided in the form of an audible horn or tone device and PA system. These signals shall be audible throughout the controlled areas and immediate vicinity.

1. Controlled area warning horns shall be pressure or electrically operated.

2. Warning horn and/or tone oscillator controls shall be easily accessible for emergency use.

3. Audible alarms shall be capable of both local and remote activation.

4. Audible alarms shall sound both locally and at the monitoring station.

5.6.3.4 Hypergolic Propellant Main and Ready Storage Facilities

5.6.3.4.1 Hypergolic Propellant Storage Facility Containment System.

a. Each storage tank shall be located in its own reinforced concrete containment bay or compartment.

b. Each containment bay shall be capable of holding at least four times the tank capacity.

c. The containment walls shall be designed to withstand the hydraulic pressure created when the bay is filled to the top with liquid. These walls shall be at least 12 in. thick and constructed in accordance with AFM 88-22 unless engineering studies determine that less protection is acceptable for present and known future requirements.

d. Storage facilities that contain multiple tanks and their containment bays shall be designed so that the exterior walls of the structure are 12 in. higher than the interior bay walls. **NOTE:** This design will eliminate interior wall weirs and provide controlled overflow into adjacent bays.

e. The floor area for each containment bay shall be kept to a minimum to reduce the potential spill area and resulting evaporation rate to prevent exposing the general public and near-by facilities.

f. Propellant transfer areas shall be capable of containing four times the capacity of the largest mobile tanker to be used at the facility.

5.6.3.4.2 Hypergolic Propellant Storage Facility Ventilation.

a. Open shed construction shall be used for fuels to provide adequate shade and weather protection with maximum ventilation unless specific conditioning requirements require closed or confined storage.

b. Closed or confined areas shall have good ventilation. If natural ventilation is inadequate, a mechanical exhaust ventilation system shall be provided.

c. Forced draft ventilating systems shall be so arranged that a fire in the storage facility will automatically cause shut down.

d. Remote manual controls shall be provided

for ventilation systems.

5.6.3.4.3 Hypergolic Propellant Storage Facility Compatibility.

a. Facilities and structures that may contain hypergols shall be designed to provide isolation of the fuels and oxidizers.

b. Propellant transfer systems shall be designed to ensure that no single failure can cause mixing of the propellants.

c. Propellant transfer system design shall ensure that all non-compatible fuels and oxidizers are separated so that inadvertent operation of either the oxidizer or fuel subsystems cannot cause mixing of the propellants.

d. All incompatible propellant system connections shall be keyed or sized so that it is physically impossible to interconnect or cross connect them.

e. All hypergolic storage facilities and structures shall be designed to protect against hypergols contacting incompatible, static producing, or absorbent materials. **NOTE:** Areas of concern include floors, the first 4 ft of walls, doors, trenches, plumbing, caulking, sealants, and other items.

f. If the compatibility of a particular material is unknown, tests shall be performed by the Range User to develop compatibility data for review and approval by Range Safety. **NOTE:** The NASA Materials Test Laboratory is available to perform these tests.

g. All exterior structural steel used in a hypergolic storage facility shall be coated with a hypergolic compatible protective coating. Recommended coating procedures and materials are contained in KSC-STD-C-0001.

h. Copper, bronze, or other alloys that might form copper oxides should not be used in hydrazine areas. If these alloys are used, they shall be positively protected by distance, sealing in a compatible material, or use of a splash guard.

5.6.3.4.4 Hypergolic Propellant Storage Facility Gravity Drain Sump Systems.

a. All hypergolic propellant storage facilities and structures shall be provided with a gravity drain sump system.

b. The gravity drain and sump system shall provide drain and containment capability for both containment bay floors and propellant transfer aprons.

c. Sump tanks shall be located below grade with a capacity to hold four times the volume of the

largest mobile tanker to be used at the transfer station.

d. The drainage system from the containment bay floors and the transfer apron to the containment sump shall be underground and gravity fed.

e. Containment bay floors and transfer aprons shall be sloped to low point drain fittings.

f. Welded drain fixtures, piping, and sump tanks shall be fabricated from 304L stainless steel.

g. Sump tanks shall have an offload system capable of transferring the sump contents to each of the following locations: a dedicated emergency storage tank, a mobile waste tanker, and to grade.

h. The facility shall have the capability to sample the contents of each sump.

i. All drain valves shall be manually controlled.

j. All drain valves located below grade shall be provided with valve extensions.

k. Gaseous nitrogen (GN₂) purge interfaces shall be located at the drain system high points to facilitate draining to the system low point.

5.6.3.4.5 Hypergolic Propellant Transfer Areas. All hypergolic propellant storage facility transfer areas shall have concrete aprons, safety showers, wash down hoses, eyewashes, and wind-socks.

5.6.3.4.6 Hypergolic Propellant Storage Facility Emergency Storage Tanks.

a. A dedicated emergency storage tank shall be provided in hypergolic propellant storage facilities.

b. The capacity of the dedicated emergency storage tank shall be equal to the largest storage tank, plus 10 percent.

c. A transfer system to move products from any storage tank to the dedicated emergency storage tank shall be provided.

5.6.3.4.7 Hypergolic Facilities Scrubbers and Incinerators.

a. All routine venting shall go through a scrubber and/or incinerator.

b. The scrubber and/or incinerator design shall be reviewed and approved by Bioenvironmental Engineering.

c. Scrubbers and/or incinerators shall be permitted for use through Civil Engineering.

5.6.3.4.8 Hypergolic Propellant Storage Facility Fire Protection Systems. For storage of hypergolic fuels such as N₂H₄, UDMH, MMH, A50, the

following requirements supplement the general fire protection requirements contained in MIL-HDBK-1008, AFMAN 91-201, DoD 6055.9-STD, and AFI 32-2001:

a. Fire Detection

1. Optical fire detectors shall be used to detect fires. Ultraviolet (UV), infrared (IR) or UV/IR combination may be used to sense hydrazine fires.

2. The detectors shall be set and/or filtered to the specific radiation wavelength of the fire to be detected: N₂H₄, MMH, UDMH, or A50.

3. The detectors shall be capable of performing self-checks. **NOTE:** At a minimum, these self-checks shall determine the internal status of the detector as well as the cleanliness of the detector window.

4. The detectors shall include manual remote and automatic self-testing capability.

5. All possible sources for false alarms shall be identified for the storage facility.

(a) The selection of detectors and the design of the detection system shall reduce the probability of these sources causing false alarms.

(b) Sources of false alarms that may require evaluation include lightning, arc welding, wind, rain, humidity, solar radiation, sunshine, x-radiation, and black body radiation.

(c) Time delay, voting, cross-zoning, and other methods may be used to reduce false alarms.

b. Extinguishment Systems.

1. The containment bays and transfer areas shall be protected by an automatic and manually activated water spray system in accordance with the requirements of NFPA 15.

2. The water spray system shall be of the deluge valve and open spray nozzle type.

3. The spray systems shall deliver a coarse spray of water not less than 0.5 gal/min/ft² of the exposed vessel surface area.

4. The spray system shall deliver a coarse spray of water not less than 0.5 gal/min/ft² of the transfer apron area.

5. The deluge system shall be capable of preventing propagation of a fire from the affected bay to adjacent bays.

6. A 0.5 sec response time of the deluge system is required. **NOTE:** The response time is the time from the sensing of a detectable event to the beginning of the flow of water from the heads of the deluge system.

7. Automatic fire suppression systems may be disengaged in the presence of high value national assets when the risk to personnel is minimal or mitigated, with the Fire Marshal and Range Safety approval.

5.6.3.4.9 Hypergolic Propellant Storage Facility Leak Detection Systems. One of the following leak detection systems shall be provided at the storage facility to detect hypergol leaks:

a. Liquid Level Sensing and Indicator System

1. Each storage vessel shall be equipped with a mechanical liquid level sensing and indicator system having remote readouts and alarm capabilities.

2. A programmable controller shall be provided to interpret 1/16 in. liquid level deviations and send an alarm to the Range Fire Station.

3. Readout of level and alarm shall be installed on site.

b. Hypergolic Vapor Detection System

1. A hypergolic vapor detection system (HVDS) shall be provided to detect hypergolic leaks from storage vessels.

2. Continuous monitoring equipment with local and remote alarms and primary power and backup battery power shall be installed in the hypergolic storage facility.

3. The alarm shall be audible above ambient noise levels and shall not be capable of being locally silenced.

4. The remote alarm signal shall be transmitted to the blockhouse, operations control center, or the Range Fire Station where 24-hr continuous monitoring is provided.

5. Alarms at local and remote locations shall have visual and audible signals.

6. The set point shall be determined on a case-by-case basis with a maximum set point of 25 percent of the LEL.

5.6.3.4.10 Hypergolic Storage Facility Vapor Control Systems. A facility vapor control system is recommended and, if installed, shall meet the following requirements:

a. A fixed foam vapor suppression system is provided to control the amount of vapor released from a large hypergol leak or spill.

b. The system shall be manually controlled only.

c. The system shall be installed in each containment bay and transfer area.

d. The performance characteristics of the foam and delivery system design shall be reviewed and approved by Range Safety, the Fire Marshal, and Bioenvironmental Engineering.

5.6.3.4.11 Hypergolic Storage Facility Personal Protective Equipment Support.

a. Provisions should be made to supply breathing air for Self-Contained Atmospheric Protective Ensemble (SCAPE) suits used during hypergolic transfer operations.

b. Change areas for “suiting up” and staging equipment and support personnel shall be provided. Communications support between these areas shall be provided.

c. Facilities shall be available for decontamination of equipment and personnel wearing personal protective equipment after operations.

5.6.3.4.12 Hypergolic Storage Facility Control Room. There are no firm requirements for a control room, but a remote room from which to conduct operations in “shirt sleeves” is highly desirable. Explosion-proof cameras are often used to monitor the loading area.

a. If used, a control room should have communications with transfer and support areas, camera monitoring capability, and communication with base support agencies, such as the fire department, hospital, weather, and command post.

b. If used, this room shall be shown to be protected from hypergolic vapor leakage into the room through wall openings, door seals, cracks, or other openings including ventilation systems intake.

5.6.3.5 Enclosed Hypergolic Propellant Processing Facilities

The following design requirements are for enclosed areas used to transfer hypergolic propellants to and from upper stages and payloads during launch processing. The areas include off-pad facilities and environmental enclosures on launch complexes except as noted.

5.6.3.5.1 Enclosed Hypergolic Propellant Facility Conductive Floors.

a. Enclosed facilities used for processing easily detonated or ignited explosives sensitive to static electricity shall have conductive, non-sparking floors.

b. Conductive floors shall be designed in accordance with DoD 4145.26-M. *EXCEPTION: The resistance from the facility ground to any point on*

the floor shall be in accordance with AFMAN 91-201 and DoD 6055.9-STD.

c. Conductive floors shall be tested in accordance with DoD 4145.26-M.

5.6.3.5.2 Enclosed Hypergolic Propellant Processing Facility Containment Systems.

a. A containment system shall be provided for all areas where hypergolic transfer operations occur.

b. The containment system shall have the capability to hold four times the volume of the largest hypergolic container used in the transfer area.

c. The containment system area shall be kept to a minimum to reduce the potential spill area and resulting evaporation.

5.6.3.5.3 Enclosed Hypergolic Propellant Processing Facility Purge Systems.

a. Enclosed areas used to process hypergols shall have a manually activated purge system.

NOTE 1: The performance and efficiency criteria for the purge system shall be reviewed and approved by Range Safety during the conceptual phase of design. **NOTE 2:** The purge system is normally activated after an accident (spill) has occurred, the situation is under control, and the emergency response team has decided to purge the toxic vapor to the atmosphere.

b. Activating the purge system shall energize the emergency exhaust fan for the selected area and set the corresponding air handling unit (AHU) in emergency mode.

1. The AHU shall go to maximum outside air intake.

2. The AHU shall close off its return air damper.

3. The AHU shall open its exhaust damper and exhaust fan.

c. Manual purge station boxes shall be located on the exterior of the enclosed area immediately adjacent to the exit door.

1. Manual purge station boxes shall be single action type switches with normally open contacts.

2. The manual purge station boxes shall be covered to prevent inadvertent activation.

d. Enclosed hypergol operating areas shall be designed to operate at a lower pressure relative to adjoining rooms during propellant transfer.

5.6.3.5.4 Enclosed Hypergolic Propellant Processing Facility Compatibility.

a. Facilities that may contain hypergols shall

be designed to provide isolation of the fuels and oxidizers.

b. Propellant transfer systems shall be designed to ensure that no single failure can cause mixing of the propellants.

c. The propellant transfer system design shall ensure that all non-compatible fuels and oxidizers are separated so that inadvertent operation of either the oxidizer or fuel subsystems cannot cause mixing of the propellants.

d. All incompatible propellant systems connections shall be keyed or sized so that it is physically impossible to interconnect or cross connect them.

e. All hypergolic processing areas shall be designed to protect against hypergols contacting incompatible, static producing, or absorbent materials. **NOTE:** Areas of concern include floors, the first 4 ft of walls, doors, trenches, plumbing, caulking, sealants, and other areas.

f. If the compatibility of a particular material is unknown, tests shall be performed by the Range User to develop compatibility data for review and approval by Range Safety. **NOTE:** The NASA Materials Test Laboratory is available to perform these tests.

g. Exhaust duct material shall be compatible with the vapors to be exhausted in the maximum predicted concentration.

h. Copper, bronze, or other alloys that might form copper oxides should not be used in hydrazine areas. If these alloys are used, they shall be positively protected by distance, sealing in a compatible container, or use of a splash guard.

5.6.3.5.5 Enclosed Hypergolic Propellant Processing Facility Gravity Drain Sump Systems.

a. All hypergolic propellant processing areas shall be provided with a gravity drain sump system.

b. The gravity drain sump system shall provide drain and containment capability for transfer areas and temporary storage areas.

c. Sump tanks shall be located below grade with a capacity to hold four times the volume of the largest hypergol container to be used in the transfer area.

d. Welded piping and sump tanks shall be fabricated from 304L stainless steel unless otherwise approved by Range Safety.

e. Sump tanks shall have offload capability.

f. The facility shall have the capability to sample the contents of each sump.

g. All drain valves shall be manually controlled.

h. All drain valves located below grade shall be provided with valve extensions.

i. GN₂ purge interfaces shall be located at the drain system high points to facilitate draining to the system low point.

j. Environmental enclosures on launch complexes shall be designed to provide the capability to "mop and sop" hypergolic spills at the transfer areas. **NOTE:** The "mop and sop" system shall be designed to transfer spilled propellant from catch basins, drip pans, and other areas to the interface with the facility gravity drain and sump system.

k. For off-pad facilities and structures, the drainage system from the transfer and storage areas to the containment sump shall be underground and gravity fed.

l. For off-pad facilities and structures, transfer and storage area floors shall be sloped to low point drain fittings.

5.6.3.5.6 Enclosed Hypergolic Propellant Processing Transfer Areas. All transfer areas shall have safety showers, wash down hose, and eye-washes.

5.6.3.5.7 Enclosed Hypergolic Propellant Processing Facility Scrubbers and Incinerators.

a. All routine venting shall go through a scrubber and/or incinerator.

b. The scrubber and/or incinerator design shall be reviewed and approved by Bioenvironmental Engineering.

c. Scrubbers and/or incinerators shall be permitted for use by Civil Engineering.

5.6.3.5.8 Enclosed Hypergolic Propellant Processing Fire Protection. The following requirements for enclosed hypergolic fuels such as N₂H₄, UDMH, MMH, and A50 processing areas supplement the general fire protection requirements contained in MIL-HDBK-1008, AFMAN 91-201, DoD 6055.9-STD, and AFI 32-2001:

a. Fire Detection

1. Optical fire detectors shall be used to detect fires. UV, IR, or a UV/IR combination may be used to sense hydrazine fires.

2. The detectors shall be set and/or filtered to the specific radiation wave length of the fire to be detected: N₂H₄, MMH, UDMH, or A50.

3. The detectors shall be capable of performing self-checks.

(a) At a minimum, these self-checks shall

determine the internal status (functional/non-functional) of the detector as well as the cleanliness of the detector window.

(b) The detectors shall include manual remote and automatic self-testing capability.

4. All possible sources for false alarms shall be identified for the processing area.

(a) The selection of detectors and the design of the detection system shall reduce the probability of these sources causing false alarms.

(b) Time delay, voting, cross-zoning and other methods may be used to reduce false alarms.

b. Extinguishment Systems.

1. Processing areas shall be protected by a water spray system in accordance with NFPA 15.

2. The water spray system shall be of the deluge valve and open spray nozzle type.

3. The fire protection system shall be designed to provide personnel protection from the most severe hazard anticipated during processing operations.

4. The deluge system shall be capable of preventing propagation of a fire from the affected bay to the adjacent bays.

5. A 0.5 sec response time of the deluge system is required. **NOTE:** The response time is the time from the sensing of a detectable event to the beginning of the flow of water from the heads of the deluge system.

6. Automatic fire suppression systems may be disengaged in the presence of high value national assets when the risk to personnel is minimal or mitigated, with the Fire Marshal and Range Safety approval.

5.6.3.5.9 Enclosed Hypergolic Propellant Processing Facility Vapor Detection Systems.

a. An HVDS shall be provided to detect hypergolic leaks in processing areas.

b. Continuous monitoring equipment with local and remote alarms and primary power and backup battery power shall be installed in the hypergolic propellant processing facility.

c. The alarm shall be audible above ambient noise levels and shall not be capable of being locally silenced.

d. The remote alarm signal shall be transmitted to the blockhouse, operations control center, or the Range Fire Station where 24-hr continuous monitoring is provided.

e. Alarms at local and remote locations shall

have visual and audible signals.

f. The set point shall be determined on a case-by-case basis with a maximum set point of 25 percent of the LEL.

5.6.3.5.10 Emergency Power Cutoff Systems.

a. Each enclosed hypergolic propellant processing area shall be equipped with an Emergency Power Cutoff (EPC) system that permits manual shutdown of all nonessential electrical equipment in the event of a leak or other emergency.

b. The EPC system shall meet the following design requirements:

1. A manual EPC switch shall be located at each exit from a processing area.

2. Actuation of any of the manual EPC switches shall result in the following:

(a) Shutdown of the AHU for that area

(b) Shutdown of all electrical equipment except for one outlet receptacle (this outlet must be designed for use in a Class 1, Division 1 location) and those systems required for emergency response.

NOTE: The following emergency response systems shall not be shut down: emergency lights, crane, communication system, air monitoring system, purge system, and fire protection system.

3. A general alarm shall sound throughout the facility.

4. An alarm signal shall be sent to the facility emergency monitor and control panel.

5. An alarm signal shall be sent to the Range Fire Station.

6. The manual EPC switch shall be a surface mounted "slap" switch located immediately adjacent to each exit.

(a) EPC switches shall be mounted 4.5 feet above the floor.

(b) EPC switches shall be covered to prevent inadvertent actuation.

7. A single, twist lock outlet receptacle shall be marked to indicate that it is not controlled by the EPC system.

8. All other outlet receptacles shall be marked to indicate that they are controlled by the EPC system.

5.6.3.5.11 Enclosed Hypergolic Propellant Processing Facility Emergency Monitor and Control Panels.

a. An emergency control panel shall be provided in the facility at a convenient location.

b. The control panel shall provide the following functions:

1. EPC system monitor
2. Purge system monitor
3. HVDS monitor
4. Fire alarm monitor slaved from the master fire alarm control panel
5. EPC system test control
6. Area warning lights control
7. Push button silencing of all audible alarms except fire alarms

5.6.3.5.12 Enclosed Hypergolic Propellant Processing Facility Windscreens. Windscreens shall be provided adjacent to all enclosed hypergolic propellant processing facilities.

5.6.3.5.13 Enclosed Hypergolic Propellant Processing Facility Personal Protective Equipment Support.

a. Provisions should be made to supply breathing air for SCAPE suits used during hypergolic transfer operations.

b. Change areas for “suiting up” and staging equipment and support personnel shall be provided. Communication support between these areas shall be provided.

c. Facilities shall be available for decontamination of equipment and personnel wearing personal protective equipment after operations.

5.6.3.5.14 Enclosed Hypergolic Propellant Processing Facility Control Room. There are no firm requirements for a control room, but a remote room from which to conduct operations in “shirt sleeves” is highly desirable. Explosion-proof cameras are often used to monitor the loading area.

a. If used, a control room should have communications with transfer and support areas, camera monitoring capability, and communication with base support agencies, such as the fire department, hospital, weather, and command post.

b. If used, this room shall be shown to be protected from hypergolic vapor leakage into the room through wall openings, door seals, cracks, or other openings including ventilation systems intake.

5.7 FACILITY AND STRUCTURE EMERGENCY AND CRITICAL SYSTEMS TEST REQUIREMENTS

a. Prior to facility activation, the functional capability of all emergency and critical systems in the facility shall be demonstrated.

b. At a minimum, the following applicable emergency and critical systems shall be tested in accordance with approved test plans to verify compliance with the design requirements for the system contained in Sections 5.5 and 5.6 of this Chapter:

1. Fire protection system in accordance with NFPA
2. Elevators in accordance with ASME/ANSI A17.1 and A17.2.
3. Lightning protection system in accordance with MIL-STD-1542
4. Bonding and grounding systems in accordance with MIL-STD-1542
5. Robot systems in accordance with ANSI/RIA R15.06
6. Emergency eyewash and showers
7. Air monitoring system
8. Area warning system
9. Ventilation system
10. Drain and sump system
11. Scrubber/incinerator
12. Liquid level indicator system for storage tanks
13. Conductive floors
14. HVDS
15. Vapor control system

-
16. Room purge system
 17. Emergency Power Cutoff system
 19. Emergency Monitor and Control Panel
 20. Personnel anchorage and anchorage connectors
- c. As applicable, Range Users shall demonstrate in one integrated end-to-end test the proper interaction of all systems that are interrelated.

5.8 CRITICAL FACILITY AND STRUCTURE INITIAL INSPECTION REQUIREMENTS

- a. Prior to initial startup operations, Operations Safety shall inspect new and modified facilities and structures in accordance with AFMAN 91-201, DoD 6055.9-STD, and Range Safety Facility Activation Compliance Checklists.
- b. Inspection reports shall be forwarded to Range Safety within 15 calendar days after the conduct of the inspection.

APPENDIX 5A FACILITY SAFETY DATA PACKAGE

5A.1 INTRODUCTION

5A.1.1 Purpose

The Facility Safety Data Package (FSDP) provides a detailed description of the hazardous and critical systems of a facility assessed as critical. It is the medium from which final approval to activate the facility is obtained from Range Safety.

5A.1.2 Content

a. This Appendix contains the content preparation instructions for the data generated by the requirements delineated in this Chapter.

b. Critical systems, as identified in Chapter 3 of this document, that will be part of a facility design and not addressed in any program Missile System Prelaunch Safety Plan (MSPSP), shall be addressed as part of the FSDP. Data requirements from Appendix 3A shall be included in the FSDP, as applicable.

5A.1.3 Applicability

Except as noted, the FSDP is applicable to all facilities that are assessed as critical. The FSDP shall be submitted by the Range User responsible for overseeing the construction for these facilities or the construction contractor.

5A.1.4 Submittal Process

The FSDP submittal periods are as follows:

a. Drafts shall be provided at least 45 days prior to each of the introductory, conceptual, preliminary, critical and final (0, 30, 60, 90 and 100 percent) design reviews.

b. The final submission shall be at least 45 days prior to intended facility activation.

5A.1.5 Final Approval

The FSDP shall be approved prior to the activation of the facility.

5A.2 PREPARATION INSTRUCTIONS

5A.2.1 Content

The FSDP contains technical information on the facility. Where applicable, previously approved documentation shall be referenced throughout the package.

5A.2.2 Data Requirements

a. The data requirement sections of this Chapter and Chapter 3 and Appendix 3A as applicable, contain the information required in this Appendix.

b. The FSDP describes all hazardous and critical systems, subsystems, and their interfaces.

c. The FSDP provides verification of compliance with the design requirements of this Chapter and Chapter 3 as applicable, and the critical design criteria agreed to in the project book and design criteria document.

d. Summaries of the analyses, test plans, and test results shall be provided in the FSDP as appendixes. The actual analysis, test plans, and test results shall be provided as separate documentation for review and approval.

5A.2.3 Format

Contractor format is acceptable provided the information below is provided.

5A.2.3.1 Table of Contents and Glossary

The FSDP shall contain a table of contents and a glossary.

5A.2.3.2 Introduction

The introduction section shall address the scope and purpose of the FSDP.

5A.2.3.3 General Description

The general description section shall present an overview of the facility and the major hazardous and critical systems as a prologue to the individual system descriptions. The following items are included in this section:

a. Layout of facility

b. Location of the facility at CCAS or VAFB and explosives quantity distance siting information if the facility requires explosive siting

c. Location of major systems in the facility and outside the facility that provide direct support

d. Synopsis of each hazardous and critical system

5A.2.3.4 Critical Facility and Structure Design Criteria Document

The final facility and structure design criteria shall be provided as an appendix to the FSDP.

APPENDIX 5A

FACILITY SAFETY DATA PACKAGE

5A.2.3.5 Critical Facility and Structure Design Calculations

The final design calculations for safety critical issues such as wind loading and the safety critical portions of facilities such as blast walls, doors, and windows shall be referenced, with a summary of results provided in the body of the FSDP. **NOTE:** When completed, the calculations shall be forwarded as a separate document for Range Safety review and approval.

5A.2.3.6 WR Seismic Analysis

For conventional and critical WR facilities, structures, and installed equipment, seismic design analysis shall be referenced with a summary of results provided in the body of the FSDP. **NOTE:** When completed, the calculations shall be forwarded as a separate document for Range Safety review and approval.

5A.2.3.7 Trailer Anchoring Analysis

The trailer anchoring analysis shall be either referenced in, with a summary of results, or appended to the FSDP.

5A.2.3.8 Hazard Analyses

Hazard analyses of facilities, structures, and emergency and critical systems shall be provided in accordance with Appendix 1B, System Safety Program, as jointly tailored by Range Safety and the Range User. At a minimum, a summary of each hazard analysis shall be provided in the FSDP.

5A.2.3.9 Demolition Plans

If applicable, demolition plans for conventional and critical facilities shall be referenced in or appended to the FSDP.

5A.2.3.10 Critical Facility and Structure Design Drawings and Specifications

Facility and design engineering drawings and technical specification packages shall be referenced with the latest revision dates.

5A.2.3.11 Individual System Descriptions

a. The individual system description section contains a description of each hazardous and critical system by giving an overview of each system and then describing each item in terms of the fol-

lowing criteria:

1. Nomenclature
2. Function
3. Location
4. Operations
5. Design parameters
6. Acceptance testing
7. Operating parameters
8. Hazard analyses

b. Supporting data shall be included or summarized and referenced, as appropriate, with availability upon request.

c. Tables, matrices, and sketches are required for component data.

5A.2.3.12 Emergency and Critical System Design Drawings and Specifications

Each of the following emergency and critical system design drawings and specifications shall be referenced in the FSDP. **NOTE:** Design drawings and specifications for other systems identified by Range Safety shall also be referenced.

- a.* Lightning protection
- b.* Bonding and grounding
- c.* Robots
- d.* Emergency eyewash and showers
- e.* Air monitoring systems
- f.* Area warning systems
- g.* Ventilation systems
- h.* Drain and sump systems
- i.* Scrubbers and incinerators
- j.* Liquid level indicators
- k.* Conductive floors
- l.* Hazardous vapor detection systems
- m.* Vapor control systems
- n.* Room purge systems
- o.* Technical Power Cutoffs
- p.* Emergency Power Cutoff Systems
- q.* Emergency Monitor and Control Panel
- r.* Personnel anchorage and anchorage connectors
- s.* Elevators
- t.* Fire protection system

5A.2.3.13 Chapter 3 Data

Critical systems identified in Chapter 3 of this document that will be a part of a facility design and will not be addressed as part of any program MSPSP shall be addressed in the FSDP. As appli-

APPENDIX 5A

FACILITY SAFETY DATA PACKAGE

cable, data requirements from Appendix 3A shall be included in the FSDP. Critical systems include the following:

- a.* Material handling equipment
- b.* Systems with acoustic hazards
- c.* Ionizing radiation sources
- d.* Non-ionizing radiation sources
- e.* Hazardous materials
- f.* Pressure systems
- g.* Ordnance systems
- h.* Electrical systems
- i.* Vehicles
- j.* Operations safety console
- k.* Hazardous and safety critical computing systems and software

5A.2.3.14 Test Plans and Test Results

Safety critical test plans and test reports shall be summarized in the FSDP. The actual plans and results shall be referenced in or provided as an appendix to the FSDP.

- a.* Lightning protection in accordance with MIL-STD-1542
- b.* Bonding and grounding in accordance with MIL-STD-1542
- c.* Robots in accordance with ANSI/RIA R15.06
- d.* Emergency eyewash and showers
- e.* Air monitoring systems
- f.* Area warning systems
- g.* Ventilation systems
- h.* Drain and sump systems
- i.* Scrubbers/incinerators
- j.* Liquid level indicators
- k.* Conductive floors
- l.* Vapor control systems
- m.* Hazardous vapor detection systems
- n.* Room purge systems
- o.* Technical Power Cutoffs
- p.* Emergency Power Cutoff Systems
- q.* Emergency Monitor and Control Panels
- r.* Elevators in accordance with ASME/ANSI A17.1 and A17.2

- s.* Integrated end-to-end test of interrelated systems

- t.* Personnel anchorage and anchorage connectors

5A.2.3.15 Post-Activation Requirements

Post-activation requirements for use of a facility shall be addressed. This section includes the following topics:

- a.* Operational restrictions such as personnel loading, clear areas, and mandatory sequences of use
- b.* Critical maintenance requirements such as recalibration of relief valves, servicing of hypergolic system, HVDS calibration, ordnance ground checks, and conductive floor checks

5A.3 COMPLIANCE CHECKLIST

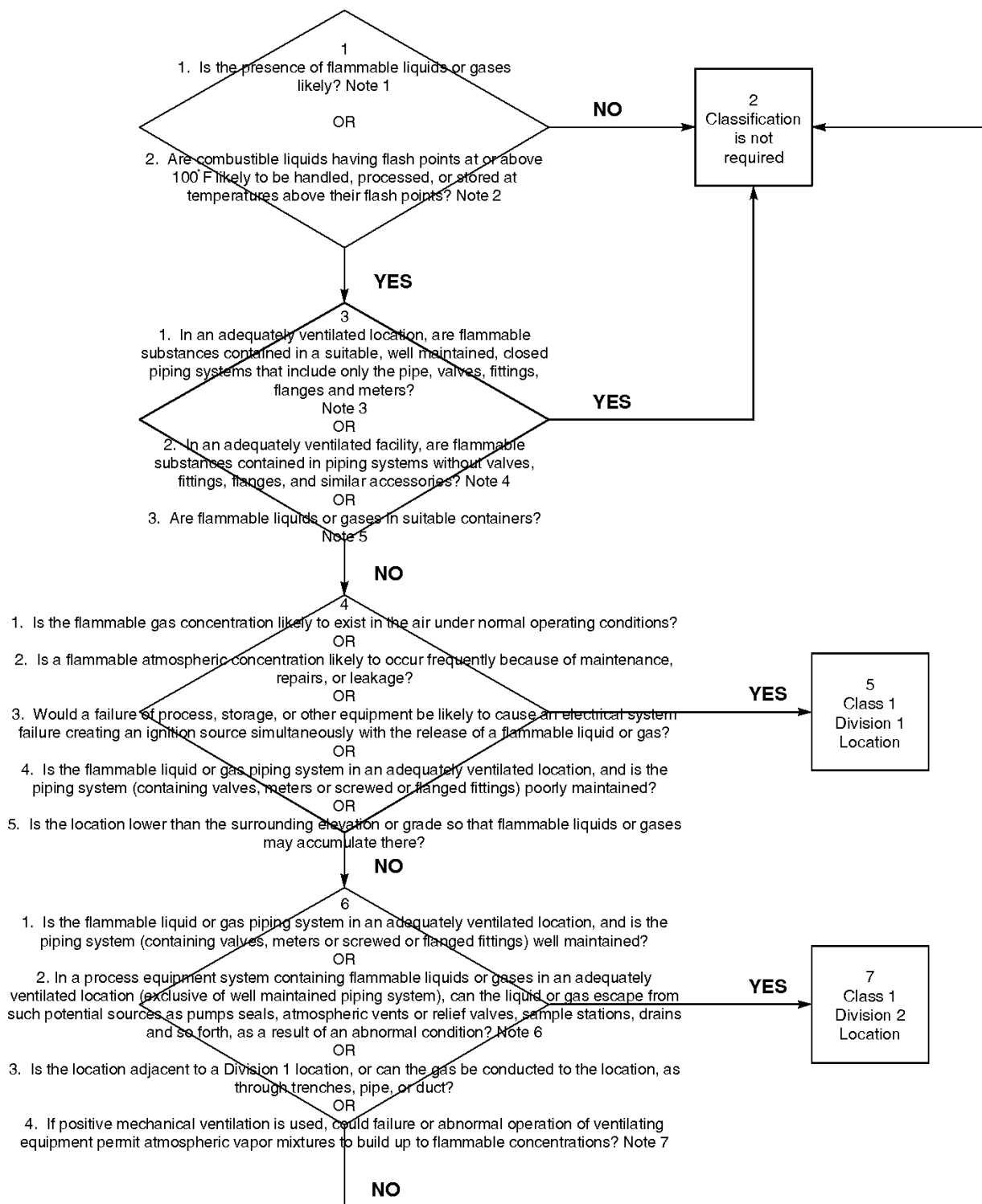
The compliance checklist section contains a checklist of all design, test, and data submittal requirements in this Chapter and Chapter 3, as applicable and the critical facility, structure, and emergency and critical system design criteria. The following items are included in this section:

- a.* Criteria/requirement
- b.* System
- c.* Compliance
- d.* Noncompliance
- e.* Not applicable (with rationale)
- f.* Resolution
- g.* Reference (verifying compliance)
- h.* Approved Noncompliances. Copies of all Range Safety approved noncompliances including deviations, waivers, and formal meets intent certifications (MICs) shall be included.

5A.4 MODIFICATIONS TO THE FSDP

The change section contains a summary of all changes to the last edition of the FSDP. All changes shall be highlighted using change bars or similar means of identification.

APPENDIX 5B HAZARDOUS AREA CLASSIFICATION



APPENDIX 5B HAZARDOUS AREA CLASSIFICATION

NOTES

- 1: The following are considered flammable liquids/gasses:
 - a. Unsymmetrical dimethyl hydrazine (UDMH) - Flashpoint 34⁰F
 - b. Monomethyl hydrazine (MMH) - Flashpoint 62⁰F
- 2: Hydrazine (N₂H₄) - is considered a combustible liquid.
 - a. The surface temperature of potential spill areas must also be considered.
 - b. Temperature in the area must be single fault tolerant to remain below 100⁰F.
 - c. Below grade locations may still accumulate enough N₂H₄ to become flammable at lower temperatures.
- 3: Adequate ventilation is defined by NFPA 30, *Flammable and Combustible Liquids Code*, as that which is sufficient to prevent the accumulation of significant quantities of vapor-air mixtures in concentrations over 25 percent of the lower flammability limit.
 - a. An adequately ventilated location is one of the following:
 1. An outside location
 2. A building, room, or space that is substantially open and free of obstruction to the natural passage of air, either vertically or horizontally. Such locations may be roofed over with no walls, may be roofed over and closed on one side or may be provided with suitably designed wind breaks.
 3. An enclosed or partly enclosed space provided with mechanical ventilation equivalent to natural ventilation. The mechanical ventilation system must have adequate safeguards against failure.
 - b. Lower flammability limits of specific commodities are as follows:
 1. N₂H₄ - 4.7 percent
 2. MMH - 2.5 percent
 3. UDME - 2.0 percent
 - c. Payload propellant systems cannot normally be considered closed piping systems that include only the pipe, valves, fittings, flanges, and meters; they normally also include a pressure vessel.
- 4: Payload propellant systems cannot normally be considered piping without valves, fitting, flanges, and similar accessories.
- 5: Payload propellant systems cannot be considered suitable containers unless they meet DOT or ASME requirements or meet EWR 127-1, section 3.12 and are also protected from outside damage.
- 6: A payload propellant system would normally be considered a process equipment system. In a dynamic mode, the answer to this question will almost always be *yes*; in a static mode, the answer may be *yes* or *no* depending on past history and adequacy of protection from outside damage.
- 7: An analysis must be provided. Consideration must be given to the size of the containment area, credible potential size of the spill, adequacy of the ventilation equipment and its potential failure modes, and the specific gravity of the commodity in question.

6CHAPTER 6

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GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

30 AMDS/SGPB - 30th Medical Group, Bioenvironmental Engineering, including the Radiation Protection Officer

30 CEG - 30th Civil Engineering Group

30 CEG/CEF - 30th Civil Engineering Group, Fire Protection

30 SW/SE - 30th Space Wing, Office of the Chief of Safety; *see also Office of the Chief of Safety*

30 SW/SEGP - 30th Space Wing, Operations Safety

30 SW/SEGW - 30th Space Wing, Explosives Safety, Nuclear Assurity

30 SW/SEW -

30 TRANS/LGTT - 30th Transportation Squadron/LGTT

45 CES - 45th Civil Engineer Squadron

45 CES/CEF - 45th Civil Engineer Squadron, Fire Protection

45 WS - 45th Weather Squadron

45 and 30 RANS/DOS - 45th and 30th Range Squadrons, Range Scheduling

45 and 30 SW/SES - 45th and 30th Space Wing, Systems Safety

45 and 30 WS/RWO - Range Weather Operations

AF - Air Force

AFB - Air Force Base

AFI - Air Force Instruction

AFM - Air Force Manual

AFOSH - Air Force Occupational Safety and Health

AFR - Air Force Regulation

AFSPC - Air Force Space Command

AGE - aerospace ground equipment

ANSI - American National Standards Institute

API - American Petroleum Institute

ASME - American Society of Mechanical Engineers

AWS - American Welding Society

bldg - building

CAL-OSHA - California Occupational Safety and Health Act

Category A EEDs/ordnance - electroexplosive devices or ordnance that by the expenditure of their own energy or because they initiate a chain of events, may cause injury or death to people or damage to property

Category B EEDs/ordnance - electroexplosive devices or ordnance that will not, in themselves, or by initiating a chain of events cause injury to people or damage to property

CCAS - Cape Canaveral Air Station

cDR - conceptual design review

CDR - critical design review; Command Destruct Receiver

CEMP - Combined Emergency Management Plan

Certified Inspector - a person qualified and certified in Non-Destructive Examination inspection techniques according to the American Society for Nondestructive Testing recommended practices (SNT-TC-1A)

CFR - Code of Federal Regulations

CMAA - Crane Manufacturers Association of America

control authority - a single commercial user on-site director or manager, full time government tenant director or commander, or USAF Squadron or Detachment Commander responsible for the implementation of launch complex safety requirements

COPV - composite overwrapped pressure vessel

CPIA - Chemical Propulsion Information Agency

crew rest - that period of time immediately prior to the beginning of duty as assigned; for mission-essential personnel, it is mandatory that the rest period include the time necessary for meals, transportation, and 8 h of uninterrupted rest prior to reporting for duty. In preparation for launch operations, rest periods start no earlier than 2 h after the assigned personnel are released from an earlier launch or range operation. Only the Chief of Safety or Range Commander has the authority to

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waive the safety rest period requirements for Mission Ready (Category A) personnel. *See also rest period.*

critical facility or structure - a hazardous facility or structure; a facility or structure used to store or process explosives; a facility or structure used to process high value hardware; a facility that contains or is used to handle or process systems determined by Range Safety to be safety critical; a facility or structure determined to be critical by Range Safety

critical hardware - any hazardous or safety critical equipment or system; non-hazardous Department of Defense (DoD) high value items, such as payloads, launch vehicles, or any unique item identified by DoD as critical; high value non-hazardous hardware owned by Range Users other than DoD may be identified as critical or non-critical by the Range User

DAIP - Danger Area Information Plan; an Eastern Range document prepared by Operations Safety specifying roadblocks and the fallback area associated with hazardous areas for each launch complex during launch operations.

dB - decibel

DDESB - Department of Defense Explosives Safety Board

decibel - a unit of relative power; the decibel ratio between power levels, P1 and P2, is defined by the relation $dB = 10 \log_{10} (P1/P2)$

deviation - a term used when a design noncompliance is known to exist prior to hardware production or an operational noncompliance is known to exist prior to beginning operations at CCAS or Vandenberg Air Force Base

DOC - Command Control Directorate

DoD - Department of Defense

DOT - Department of Transportation

duty time - the time personnel are at work from the time they arrive at their duty location until the end of the duty tour; duty time begins on first arriving at the base or office for transportation to later launch support positions

EBW - high voltage exploding bridgewire, an initiator in which the bridgewire is designed to be

exploded (disintegrated) by a high energy electrical discharge that causes the explosive charge to be initiated

EEAP - Emergency Evacuation Assembly Point

EED - low voltage electroexplosive device

EH - Environmental Health; on the Western Range, the Range User is responsible for performing the EH tasks described in this document for contractor operations; on the Eastern Range, the responsible agency is 45 MG/SGPB and a range contractor

EOD - Explosive Ordnance Disposal Team

EPA - Environmental Protection Agency

ER - Eastern Range

ERP - effective radiated power; Emergency Response Plan

ESMC - Eastern Space and Missile Center

ESP - Explosives Safety Plan; a type of Operations Safety Plan

essential personnel - those personnel who do not meet the requirements of mission-essential personnel, but may be permitted within safety control areas to prevent a mission impact; all requests to enter require Range Safety approval on a case-by-case basis

explosion proof apparatus - an enclosure that will withstand an internal explosion of gases or vapors and prevent those gases or vapors from igniting the flammable atmosphere surrounding the enclosure, and whose external temperature will not ignite the surrounding flammable atmosphere

explosive quantity distance site plan - a formal plan required for explosive facilities and areas in accordance with AFM 91-201 and DoD 6055.9-STD, detailing explosives quantity operating and storage limits and restrictions and the resultant distance requirements

Facility Operator - government organization or contractor responsible for maintaining and/or controlling use of a facility

FCA - flight caution area; the controlled ground area outside of the Flight Hazard Area where injury or property damage could occur because of a launch vehicle flight failure. The FCA is restricted

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

to only mission-essential personnel during launch operations

FHA - flight hazard area; the controlled surface area and airspace about the launch pad and light azimuth where individual risk from a malfunction during the early phase of flight exceeds 1×10^{-5} . Because the risk of serious injury or death from blast overpressure or debris is so significant, only mission-essential personnel in approved blast-hardened structures are permitted in this area during launch.

FDEP – Florida Department of Environmental Protection

FEOP - Facility Emergency Operating Plan

FEP - Facility Emergency Procedures

FM - frequency modulation; Factory Mutual Corporation

FOP - Facility Operating Plan

FSA - Fuel Storage Area

FSP - Facility Safety Plan

ft - foot, feet

FTS - Flight Termination System

GHz - gigahertz

GOP - Ground Operations Plan

GR/EP - graphite epoxy

GSE - Ground Support Equipment

h - hour, hours

hangfire - a condition that exists when the ignition signal is known to have been sent and reached an initiator but ignition of the propulsion system is not achieved

hazard, hazardous - equipment or systems with an existing or potential condition that can result in a mishap

Hazardous Launch Areas - safety clearance zones during launch operations with defined mishap probabilities, including the Flight Caution Area, Flight Hazard Area, and Launch Danger Zone

hazard proof - a method of making electrical equipment safe for use in hazardous locations;

methods include explosion proofing, intrinsically safe, purged and pressurized, and non-incendive and must be rated for the degree of hazard present

hazardous facility or structure - a facility or structure used to store, handle, or process hazardous materials or systems and perform hazardous operations

hazardous materials - liquids, gases, or solids that may be toxic, reactive, or flammable or that may cause oxygen deficiency either by themselves or in combination with other materials

hazardous operations - those operations classified as hazardous according to the following criteria: (1) consideration of the potential or kinetic energy involved, (2) changes such as pressure, temperature, and oxygen content in ambient environmental conditions, (3) presence of hazardous materials. Hazardous operations (including storage, transport, and handling) include, but are not limited to, the following: material (launch vehicle, payload, and other critical loads) handling operations; operations with acoustic hazards; operations with ionizing and non-ionizing sources and systems; operations with hazardous materials; pressure system (greater than 150) psig operations; propellant system operations; ordnance operations; and electrical system operations. **NOTE:** Some low pressure systems operations such as those involving flight hardware, large volume systems, or those containing hazardous commodities may be classified as hazardous by Range Safety.

Hazardous Clear Areas - Safety Clearance Zones for ground processing that are defined in the Operations Safety Plans for each operating facility; include BDA, Control Area Clears, and Toxic Hazard Corridor/Zone

hazardous procedure - a designation for a particular type of Range User procedure; a document containing specific steps in sequential order used to safely process hazardous materials or conduct hazardous operations. Hazardous procedures have specific content requirements delineated in Appendix 6B and require Range Safety approval.

HMS - Hazard Monitor System

HOS – Hazardous Operations Support; a Western Range contractor responsible for specific security operations

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

hydraulic - operated by water or other liquid under pressure; includes all hazardous fluids as well as typical hydraulic fluids that are normally petroleum-based

IATA - International Air Transport Association

IEEE - Institute of Electrical and Electronic Engineers

initiator - low voltage electroexplosive devices and high voltage exploding bridgewire devices

intrinsically safe - incapable of producing sufficient energy to ignite an explosive atmosphere and two-fault tolerant against failure with single fault tolerance against its most hazardous failure at 1.5 times the maximum voltage or energy

ISI - In-Service Inspection Plan

KSC - Kennedy Space Center

launch complex safety - safety requirements involving risk that is limited to personnel and/or property under the control of a single commercial user, full time government tenant organization, or USAF squadron or detachment commander (control authority). Launch complex safety is limited to risks confined to a physical space for which the single control authority is responsible.

launch area safety - safety requirements involving risk that is limited to personnel and/or property on CCAS with possible extension to KSC and Vandenberg Air Force Base. Launch area safety involves multiple commercial user, government tenants, or USAF Squadron Commanders

launch vehicle - a vehicle that carries and/or delivers a payload to a desired location; this is the generic term that applies to all vehicles that may be launched from the Ranges; includes, but is not limited to airplanes, all types of space launch vehicles, manned launch vehicles, missiles and rockets and their stages, probes, aerostats and balloons, drones, remotely piloted vehicles, projectiles, torpedoes, and air-dropped bodies

LBB - leak before burst

LBS - launch base support

LBTP - Launch Base Test Plan

LEL - lower explosive limit

LDCG - Launch Disaster Control Group; a team

responsible for responding to launch emergencies

LIO - laser initiated ordnance

LV - launch vehicle

mA - milliamperes

major leak or spill - a leak or spill that could affect regions beyond the immediate work area, constitute a hazard to personnel, or involve damage to facilities or equipment. A major leak or spill is more than one gallon.

MARSS - Meteorological and Range Safety System

MAWP - maximum allowable working pressure; the maximum pressure at which a component or system can continuously operate based on allowable stress values and functional capabilities

MEOP - maximum expected operating pressure; the highest pressure that a pressure vessel, pressurized structure, or pressure component is expected to experience during its service life and retain its functionality, in association with its applicable operating environments; synonymous with maximum operating pressure (MOP) or maximum design pressure (MDP); includes the effect of temperature, pressure transients and oscillations, vehicle quasi-steady, and dynamic accelerations and relief valve operating variability; *see also MOP*

MFCO - Mission Flight Control Officer

MHE - material handling equipment used to handle, lift, support, or manipulate critical or noncritical hardware. MHE includes, but is not limited to, cranes, hoists, sling assemblies, hydrasets and load cells, handling structures, and personnel work platforms

MHI - Materials Handling Institute

MHSE - Material Handling Safety Equipment

MIC - meets intent certification; a certification used to indicate an equivalent level of safety is maintained despite not meeting the exact requirements stated in the document

MIL-STD - Military Standard

minor leak or spill - a leak or spill that does not affect regions beyond the immediate work area, constitute a hazard to personnel, or involve dam-

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age to facilities or equipment. A minor leak or spill is less than one gallon.

misfire - a condition that exists when it is known that the ignition signal has been sent but did not reach an initiator and ignition of the propulsion system was not achieved

mishap - an unplanned event or series of events resulting in death, injury, occupational illness, or damage to or loss of equipment or property or damage to the environment

mission-essential personnel - the minimum number of persons necessary to successfully and safely complete a hazardous or launch operation and whose absence would jeopardize the completion of the operation; this designation also includes people required to perform emergency actions according to authorized directives, persons specifically authorized by the Wing Commanders to perform scheduled activities, and those personnel in training. The Range Users and Wing Commanders determine, with Range Safety concurrence, the number of mission-essential personnel allowed within Safety Clearance Zones or Hazardous Launch Areas; *see also Safety Clearance Zones and Hazardous Launch Area*

Mission-Ready (Category A) Personnel - people who make irrevocable operational decisions and exercise direct control over the countdown and launch of a launch vehicle. The success of the launch vehicles mission is directly affected by the actions of mission ready personnel. Mission ready personnel include the following: Mission Flight Control Officer; Range Operations Commander; Range Control Officer; Launch Controller, Launch Control Officer, Test Director or Test Controller, as applicable; Booster Countdown Controller, Launch Vehicle Test Controller, Assistant Launch Controller, Assistant Launch Control Officers, or Launch Director, as applicable; Payload Launch Controller, Satellite Countdown Controller, or Test Controller, as applicable; Explosive Ordnance Disposal Personnel, Aeronautical Control Officer, Booster Operations Controller, and Spacecraft Operations Controller

Mission Support (Category B) Personnel - all other support personnel engaged in direct support of mission ready personnel

MMH - monomethylhydrazine

MOP - maximum operating pressure; the maximum pressure a system will be subjected to during planned static and dynamic conditions; *see also MEOP*

MOSR - Missile Operations and Support Requirements

MSDS - Material Safety Data Sheet

MSPSP - Missile System Pre-launch Safety Package; a data package that demonstrates compliance with the system safety requirements of Chapter 3 and serves as a baseline for safety related information on the system throughout its life cycle

N²H⁴ - hydrazine

NASA - National Aeronautics and Space Administration

NCO - Non-Commissioned Officer

NDE - non-destructive examination; any testing, inspection, or evaluation that does not cause harm to or impair the usefulness of an object satisfies the meaning of the word *non-destructive*. In common usage, *non-destructive testing* (NDT) often refers just to test methods and test equipment with only a general reference to materials and/or parts. *Non-Destructive Inspection* (NDI) relates to specific written requirements, procedures, personnel, standards, and controls for the testing of a particular material of a specific part. *Non-Destructive Evaluation* is concerned with the decision making process, the determination of the meaning of the results, of the final acceptance or rejection of the material of part, and may be qualitative or quantitative.

NEC - National Electrical Code

NFPA - National Fire Protection Association

NIOSH - National Institute of Occupational Safety and Health

non-critical hardware - equipment and systems employed for standard industry use; equipment or systems that are determined not to be hazardous, of high value, or safety critical

non-hazardous procedure - a designation for a particular type of Range User procedure; a document containing general or specific steps in sequential order to ensure proper execution of a non-hazardous, non-safety critical process. Non-

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

hazardous procedures do not have specific content requirements and do not require Range Safety approval.

non-incendive - will not ignite group of gases or vapors for which it is rated. Similar to *intrinsically safe*, but does not include failure tolerance ratings; used in rating electrical products for Class I, Division 2 locations only

NOTU - Naval Ordnance Test Unit

NRC - Nuclear Regulatory Commission

O&SHA - Operating and Support Hazard Analysis

Operations Safety - a Range Contractor at the Eastern Range and 30 SW/SEGP, a government agency at the Western Range

OPLAN - Operations Plan

ordnance operation - any operation consisting of shipping, receiving, transportation, handling, test, checkout, installation and mating, electrical connection, render safe, removal and demating, disposal, and launch of ordnance

OSC - Operations Safety Console

OSHA - Occupational Safety and Health Act

OSP - Operations Safety Plan; detailed safety procedures used for missile operations; these plans are written by the Range Contractor and Operations Safety; includes Explosives Safety Plans, Facility Safety Plans, and Safety Operational Plans

OST - a Western Range Operations Safety Technician

PA - public address

payload - the objects(s) within a payload fairing carried or delivered by a launch vehicle to a desired location. This is a generic term that applies to all payload that may be delivered from the ER or WR and includes, but is not limited to, satellites, other spacecraft, experimental packages, bomb loads, warheads, reentry vehicles, dummy loads, cargo, and any motors attached to them in the payload fairing

PDR - Preliminary Design Review

personnel work platforms - platforms used to provide personnel access to flight hardware at off-

pad processing facilities as well as at the launch pad; they may be removable, extendible, or hinged.

pneumatic - operated by air or other gases under pressure

POL - paints, oil, and lubricants

PPE - personal protective equipment

ppm - parts per million

propellant servicing - any dynamic operation involving propellants such as transfer, sampling, pressurization, decontamination, connecting and disconnecting lines, and venting

propellant storage tank - any container of propellants greater than one gallon. Application of the requirements of this document to storage tanks will normally vary with the size of the tank and associated hazards. Containers less than one gallon will also be subject to operational controls, as appropriate, as would any container of flammable liquid

psig - pounds per square inch gauge

PTR - public transportation route

public safety - safety involving risks to the general public or foreign countries and/or their property

QD - quantity distance; *see also quick disconnect*

radioactive material - materials that generate, or are capable of generating, ionizing radiation including naturally occurring radioactive materials, by-product materials, fission products, materials containing induced or deposited radioactivity, and nuclear reactors

Ranges - in this document, *Ranges* refers to the Eastern Range at CCAS, KSC, and PAFB, and the Western Range at VAFB

Range Users - clients of Cape Canaveral Air Station and Vandenberg Air Force Base; includes Department of Defense government agencies, civilian commercial companies, and foreign government agencies that use the Eastern and Western Range facilities and test equipment to conduct prelaunch, launch and impact operations or require on-orbit support

rated load - the maximum static load or force that

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

can be imposed on the part or structure at any time during its intended operation and expected environment

Recertification File - a file that contains documentation showing that a specific piece of MHE/MHSE meets the periodic analysis and test requirements of Chapters 3 and 6

referee fluid - a compatible fluid, other than that used during normal operation of a system, that is substituted for test purposes because it is safer due to characteristics such as being less toxic, explosive, or easier to detect

RF Silence - turning off or powering down of RF emitters within a particular area; local RF silence is normally the launch vehicle and mobile transmitters in the area

render safe - an action to bring to a safe condition

rest period - that period of time immediately prior to the beginning of the duty period; for mission-essential personnel, it is mandatory that the rest period include the time necessary for meals, transportation, and 8 h of uninterrupted rest prior to reporting for duty. Rest periods in preparation for launch operations will start no earlier than 2 h after the assigned personnel are released from an earlier launch or range operations. Only the Chief of Safety or Wing Commander has the authority to waive the safety rest period requirements for Mission Ready (Category A) personnel; *see also crew rest*.

RF - radio frequency

RF silence - turning off or powering down of RF emitters within a particular area. Local RF silence is normally the launch vehicle and mobile transmitters in the area

RPO - Radiation Protection Officer; the responsible agent to ensure enforcement of 45 SWI 40-201 and AFI 91-110 30 SW1

RT - radiographic testing

S&A device - safe and arm device; devices that provide for mechanical interruption (safe) or alignment (arm) of the explosive train and electrical interruption (safe) or continuity (arm) of the firing circuit

Safety Clearance Zones - restricted areas design-

ated for day-to-day prelaunch processing and launch operations to protect the public, launch area, and launch complex personnel. These zones are established for each launch vehicle and/or payload at specific processing facilities, including launch complexes; includes Hazardous Clear Areas and Hazardous Launch Areas

safety critical - an operation, process, facility, system, or component that controls or monitors equipment, operations, systems, or components to ensure personnel, launch area, and public safety (for example, Flight Termination System integrity); these operations, processes, facilities, systems, or components may or may not be hazardous in and of themselves

safety critical procedure - a designation for a particular type of Range User procedure; a document containing steps in sequential order used to reliably process safety critical systems or conduct safety critical operations. Non-hazardous safety critical procedures have no specific content requirements but do require Range Safety review and approval.

safety factor - for pressure systems, the ratio of design burst pressure over the maximum allowable working pressure or as design pressure; for mechanical systems, it can also be expressed as the ratio of tensile or yield strength over the maximum allowable stress of the material.

safing procedures - the process of taking a system that is in a hazardous configuration and performing those tasks necessary to bring it to a condition which is safe for further activities; safing procedures are part of the backout procedures for a system

SCAPE - Self-Contained Atmospheric Protective Ensemble

SFP - single failure point; in general, a component that, if failed, could lead to the overall failure of the system; for mechanical systems, a component, such as a lug, link, shackle, pin, bolt, or rivet, or a weld that, if failed, could cause a system inability to support a load using load path analysis

shall - mandatory action

SLC - Space Launch Complex

SOP - Safety Operating Plan; a type of Operations

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

Safety Plan (See Appendixes 6C, 6D, and 6E.); standard operating procedure

SPIF - Spacecraft Processing Integration Facility at the ER

standing by - being at the scene and not on call

static firing - testing of a propulsion system by securing it to a rigid structure and preventing powered flight

structural sling - a rigid or semi-rigid fixture that is used between the load and hoisting device hook; such as spreader bars, equalizer bars, and lifting beams

SW - space wing

TD - technical document

THZ - toxic hazard zone

TLV - threshold limit value; time weighted average concentrations that must not be exceeded during any 8-h work shift of a 40-h work week

Toxic Hazard Zone - a generic term that describes an area in which predicted concentration of propellant or toxic byproduct vapors or aerosols may exceed acceptable tier levels; predictions are based on an analysis of potential source strength, applicable exposure limit, and prevailing meteorological conditions; THZs are plotted for potential, planned, and unplanned propellant releases, and launch operations.

TMO - Transportation Management Office

TNT -Trinitrotoluene

T.O. - Technical Order

to safe - to bring to a safe condition

UDMH - unsymmetrical dimethylhydrazine

UL - Underwriters' Laboratories

UN - United Nations

USAF - United States Air Force

UT - Ultrasonic Testing; Umbilical Tower of a launch pad

visible damage - for composite pressure vessels; anomalies that are visible to the naked eye under not less than 15 foot candles at a distance no greater than 24 inches and not less than a 30 degree angle. Lighting up to 50 foot candles may be used for the detection of small anomalies

VAFB - Vandenberg Air Force Base; located in California

VIP - very important person

waiver - a designation used when, through an error in the manufacturing process or for other reasons, a hardware noncompliance is discovered after hardware production or an operational noncompliance is discovered after operations have begun at Eastern Range and Western Range

WR - Western Range

REFERENCED DOCUMENTS

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- 29 CFR 1910.27, *Fixed Ladders*
- 29 CFR 1910.95, *Occupational Noise Exposure*
- 29 CFR 1910.146, *Permit-Required Confined Spaces*
- 29 CFR 1910.252, *Welding, Cutting, and Brazing General Requirements*
- 29 CFR 1926.104, *Safety Belts, Lifelines, and Lanyards*
- 29 CFR 1926.105, *Safety Nets*
- 29 CFR 1926.550(g), *Crane or Derrick Suspended Personnel Platforms*
- 29 CFR 1910.1200, *Hazard Communication*
- 30 SPS/SPOS OI 31-1010, Volume 2, Chapter 5
- 30 SW 15-101, *Weather Support*
- 30 SW 105-1, *Weather Support Procedures*
- 30 SW 127-3, *Mishap Notification, Investigation Response, and Reporting Procedure*
- 30 SW OPLAN 32-1, *Vandenberg Air Force Base Disaster Preparation Operations Plans*
- 30 SW OPLAN 355-1, *Disaster Preparedness*
- 30 SW Plan 91-119, *Process Safety Management Implementation Plan*
- 30 SWI 40-101, *Managing Radioactive Materials on VAFB*
- 30 SWI 91-106, *Toxic Hazard Assessments*
- 40 CFR, *Protection of the Environment*
- 45 WS *Meteorological Handbook*
- 45 SPW/JOP 15E-3-50, *Transportation of Over-sized Loads*
- 45 SW *Launch Toxic Hazard Control Plan*
- 45 SW OPLAN 32-1, Volume II, *Disaster Preparedness Operations Plan*
- 45 SW OPLAN 32-3, Volume I, *Hazardous Materials Response Plan*
- 45 and 30 SW OPLAN 19-14, *Petroleum Products and Hazardous Waste Management Plan*
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- 45 and 30 SWR 160-1, *Radiation Protection Program*
- AFI 10-229, *Responding to Severe Weather Events*
- AFI 21-114, *Managing Intercontinental Ballistic Missiles Maintenance*
- AFI 32-1064, *Electrical Safe Practices*
- AFI 32-1065, *Grounding Systems*
- AFI 32-2001, *The Fire Protection Operations and Fire Protection Program*
- AFI 32-4001, *Disaster Preparedness Planning and Operations*
- AFI 32-4002, *Hazardous Material Emergency Planning and Response Compliance*
- AFI 48-119, *Medical Service Environmental Quality Programs*
- AFI 91-110, *Nuclear Safety Review & Launch Approval for Space or Missile Use of Radioactive Material & Nuclear Systems*
- AFI 91-202, *US Air Force Mishap Prevention Program*
- AFI 91-204, *Safety Investigations and Reports*
- AFI 91-301, *Air Force Occupational and Environmental Safety, Fire Prevention, and Health (AFOSH) Program*
- AFJMAN 24-204, *Preparing Hazardous Materials for Military Air Shipments*
- AFM 85-16, *Maintenance of Petroleum Systems*
- NOTE:** *AFM and AFMAN are used interchangeably to denote Air Force Manual*
- AFM 91-201, *Explosive Safety Standards*
- AFM 91-201, *Explosive Safety Standards*
- AFM 161-30, *Volume II Liquid Propellants*
- AFOSH 48-1, *Respiratory Protection Program*
- AFOSH 48-8, *Controlling Exposures to Hazardous Materials*
- AFOSH 48-19, *Hazardous Noise Program*
- AFOSH 91-25, *Confined Spaces*
- AFOSH 91-31, *Personal Protective Equipment*
- AFOSH 91-46, *Materials Handling and Storage*

REFERENCED DOCUMENTS

AFOSH 91-119, *Process Safety Management of Highly Hazardous Chemicals*

AFOSH 127-22, *Walking Surfaces, Guarding Floor/Wall Openings and Holes, Fixed Industrial Stairs, and Portable and Fixed Ladders*

AFOSH 127-32, *Emergency Shower and Eyewash Units*

AFOSH 127-43, *Flammable and Combustible Liquids*

AFOSH 127-45, *Hazardous Energy Control and Mishap Prevention Signs and Tags*

AFOSH 161-9, *Exposure to Radio Frequency Radiation*

AFOSH 161-2, *Industrial Ventilation*

AFOSH 161-20, *Hearing Conservation Program*

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ANSI Z49.1, *Safety in Welding and Cutting*

ANSI Z89.1, *Protective Headwear for Industrial Workers*

ANSI Z117.1, *Safety Requirements for Confined Spaces*

ANSI Z244.1, *Safety Requirements for the Lock-out/Tagout of Energy Sources*

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ANSI/ASME B30, *Series Cranes, Hoists, and Lifting Devices*

API 500A RP 500, *Recommended Practices for Classification of Locations for Electrical Installations at Petroleum Facilities, First Edition*

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American Welding Standards

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CMAA 74, *Specifications for Top Running and Under Running Single Girder Electric Overhead Traveling Cranes Utilizing Under Running Trolley Hoist*

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Interim Safety Requirements for Design, Test, and Ground Processing of Flight Graphite Epoxy Composite Overwrapped Pressure Vessels at the Kennedy Space Center, Cape Canaveral Air Force Station, and Vandenberg Air Force Base

MHI, *Materials Handling Institute Standards*

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MIL-STD-278, *Welding and Casting Standard*

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MIL-STD-883, *Test Methods and Procedures for Microelectronics*

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MIL-STD-1576, *Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems*

MIL-STD-2154, *Ultrasonic Inspection, Requirement for*

MIL-STD-2175, *Castings, Classification and Inspection of*

MIL-STD-6866, *Liquid Penetrant Inspection*

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MSFC-STD-1249, *Standard NDE Guidelines and Requirements for Fracture Control Programs*

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NAVFAC P-306, *Testing and Licensing of Weight Handling and Construction Equipment Operators*

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NAVSHIP 250-692-2, *Radiographic Standards for Steel Castings, Aluminum and Magnesium Alloy*

NFPA 70, *National Electrical Code*

NFPA 70E, *Electrical Safety Requirements for Employee Workplaces*

NFPA 497A, *Recommended Standard Practice for Classification of Class 1 Hazardous Locations (Classified) for Electrical Installations in Chemical Process Areas*

NFPA 780, *Lightning Protection Systems*

T.O. 00-25-232, *Control and Use of Insulating Matting for High Voltage Application*

T.O. 00-25-235, *Safety Procedures and Equipment for Confined Space Entry (including Missile Propellant Tanks)*

T.O. 00-25-245, *Operations Instructions, Testing and Inspection Procedures for Personnel Safety and Rescue Equipment*

T.O. 31Z-10-4, *Electromagnetic Radiation Hazards*

VAFB Supplement 1 to AFM 91-201

6.1 INTRODUCTION

6.1.1 Purpose of the Chapter

Chapter 6 contains safety requirements for ground personnel and equipment, systems, and material operations on the Ranges. The following major topics are addressed:

- 6.2 Responsibilities and Authorities
- 6.3 Ground Operations Policies
- 6.4 Documentation Requirements
- 6.5 Ground Operations General Requirements
- 6.6 Material Handling Equipment Operations
- 6.7 Acoustic Hazard Operations
- 6.8 Non-Ionizing Radiation Operations
- 6.9 Radioactive (Ionizing Radiation) Sources Operations
- 6.10 Hazardous Materials Operations
- 6.11 Ground Support Pressure Systems Operations
- 6.12 Flight Hardware Pressure Systems Operations
- 6.13 Ordnance Operations
- 6.14 Electrical Systems Operations
- 6.15 Motor Vehicle Operations
- 6.16 Convoy Operations
- 6.17 Launch Operations

6.1.2 Applicability

All agencies operating on the Ranges are subject to the requirements of this document to ensure that operations are conducted safely.

6.2 RESPONSIBILITIES AND AUTHORITIES

6.2.1 Systems Safety, 45th Space Wing and 30th Space Wing

Systems Safety, 45th Space Wing (45 SW/SES) and 30th Space Wing (30 SW/SES) are responsible for the following: **NOTE:** Unless otherwise noted, all references to *Range Safety* in this Chapter refer to Systems Safety.

- a. Reviewing and approving all procedures relating to the performance of any hazardous operation and safety critical operation
- b. Reviewing and approving all Operations Safety Plans (OSPs), Ground Operations Plans (GOPs), and Danger Area Information Plans (DAIPs)
- c. Reviewing and approving Facility Emergency Plans (FEPs), and Facility Emergency Operating Plans (FEOPs)
- d. Ensuring that hazardous facilities and safety

critical and hazardous operations are periodically inspected as required

- e. Monitoring hazardous and safety critical operations as required

- f. Defining the threat envelopes of all hazardous operations that may affect public safety or launch base safety and establishing safety clearance zones

- g. Ensuring that all personnel performing hazardous and safety control operations are provided adequate training to ensure proper conduct of their jobs and tasks, by reviewing Range User training plans

- h. In coordination with 45 Medical Group (45 MDG) and 30 Medical Group (30 AMDS), ensuring that adequate personal protective equipment is provided to personnel as defined by this document and approved OSPs

6.2.2 Operations Safety, 45th Space Wing and Ground Safety, 30th Space Wing

Operations Safety, a government contractor for the 45th Space Wing, and Ground Safety, 30th Space Wing (30 SW/SEGP) are responsible for the following. **NOTE:** Unless otherwise noted, these two groups shall be referred to as *Operations Safety* in this Chapter.

6.2.2.1 General Responsibilities

- a. Observing, evaluating, and enforcing compliance of Range Safety requirements by all personnel within launch complexes, assembly and checkout areas, propellant and ordnance storage areas, and other areas as deemed appropriate by Operations Safety or Range Safety. **NOTE:** Operations Safety personnel shall not be denied access to any area where hazardous operations are conducted.

- b. Reviewing and providing comments on hazardous procedures to Range Safety

- c. Reviewing and commenting on system design data and operating procedures as necessary and at the ER, as directed by Range Safety

- d. Implementing specified safety precautions and imposing a safety hold when necessary during ground operations as required by the appropriate procedure or OSP

- e. Assisting in the resolution of safety problems in all areas where Operations Safety has jurisdiction as necessary and at the ER, as directed by Range Safety

- f. Maintaining close coordination with Range Safety concerning policy and procedures

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g. Attending meetings and conferences on subjects and at locations including, but not limited to, Safety Working Group Meetings, Facility Working Group Meetings, and Technical Interchange Meetings as necessary and at the ER, as directed by Range Safety

h. Coordinating with the RPO to ensure enforcement of the Radiation Control Program on launch complexes and areas where launch vehicles and payloads and their related hazards are located

i. Maintaining close coordination with Bioenvironmental Engineering and Environmental Health (both Health Physics and Industrial Hygiene) on environmental health hazards

j. In all incidents involving an environmental health hazard, immediately notifying Cape Support on the ER and Range Scheduling on the WR, Environmental Health, and Range Safety

k. When present, ensuring that complexes and facilities are cleared of personnel and operations have been halted when a lightning hazard is imminent in accordance with the OSP or other safety plans

l. Responding to any mishap and/or incident in accordance with 45 OPLAN 32-1 and 30 SW OPLAN 355-1

m. Assisting Range Users in all safety related issues

6.2.2.2 Document Preparation and Maintenance

a. Preparing OSPs, DAIPs, and other safety plans as needed and directed by Range Safety
NOTE: OSP preparation is accomplished by the Range User at the WR

b. Preparing detailed checklists in accordance with this document, safety plans, and operating procedures for use by the OSM during surveillance of hazardous and safety critical tests and operations

c. Promptly revising checklists whenever new operational procedures or changes in system or support configuration occur

d. At the ER, maintaining an accurate log of events during launch countdown and other operations as designated by Range Safety for three launches or three years, whichever is greater for each program

e. At the ER, forwarding a written report to Range Safety of any violation of this document within five calendar days of the violation if re-

quested by Range Safety

f. At the ER, forwarding a written report to Range Safety of any launch vehicle or payload mishap, hazard, handling malfunction, or other incident creating or contributing to an unsafe condition for personnel or critical hardware within five calendar days of the incident

g. At the ER, maintaining explosive area and facility inspection reports for a period of five years

h. At the ER, providing copies of explosive area and facilities inspection reports to determine compliance with AFM 91-201 and DoD-STD 6055.9 to Range Safety

6.2.2.3 Hazardous and Safety Critical Operations Support

a. Ensuring compliance with established directives and procedures during hazardous and safety critical operations

b. Assessing procedure deviations and coordinating with Range Safety as necessary

c. Ensuring the number of personnel is kept to a minimum in the designated safety clearance zone in accordance with Range Safety approved procedures. **NOTE:** Operations Safety shall be considered part of the maximum manning level unless Range Safety determines that adequate support can be provided from a remote location.

d. Ensuring a clearly understood comprehensive briefing has been conducted prior to the start of a hazardous operation

e. Ensuring that appropriate support personnel such as Fire, Medical, Environmental Health, and other agencies are standing by at the complex, facility, or area during hazardous operations as specified in the applicable OSPs

f. Ensuring that safety road blocks and roving patrols are established to clear the FCA, FHA, and other hazardous launch areas at times required by applicable OSPs

g. In conjunction with the Range User, controlling personnel access into safety clearance zones during hazardous operations

h. As applicable, providing advice to the operation control authority regarding the continuation or stoppage of operations when an imminently hazardous condition or a safety compromise exists

i. Allowing operations to resume only after the imminent danger has been eliminated and safety requirements have been met

j. Providing inspection reports of new or modi-

fied facilities to Range Safety within 15 calendar days of the inspection. **NOTE:** This function is performed by the Range User at the WR.

k. At the ER, operating the Hazard Monitor System (HMS) console for all Spacecraft Processing Integration Facility (SPIF) hazardous operations

6.2.2.4 Launch Support

a. Providing technical support for the Launch Disaster Control Group (LDCG) as required in the Safety Operating Plan and the specific procedure in use

b. Operating the Operations Safety Console (OSC), for launches

c. Monitoring hazardous and safety critical launch operations

6.2.2.5 Notifications

a. At the ER, immediately notifying Range Safety of any launch vehicle or payload mishap, hazard, handling malfunction, or other incident creating or contributing to an unsafe condition for personnel or critical hardware

b. At the ER, verbally notifying Range Safety of any violation of this document as soon as possible followed by a written report within five calendar days if requested by Range Safety

c. At the WR, immediately notifying the 30th Command Post at 866-9961

6.2.2.6 FTS Installation, Checkout, and Status

a. At the ER, monitoring and verifying the installation, checkout, and status of the FTS in accordance with Range Safety instructions at locations designated by Range Safety. **NOTE:** At the WR, these duties are performed by the FSPO.

b. At the ER, providing representation on board submarines for specified launch operations and for in-tube conversions to monitor and ensure proper FTS installation, checkout, and readiness

6.2.2.7 Inspections

a. At the ER, periodically, but not less than annually, inspecting all explosive areas and facilities to determine compliance with the requirements of this document, AFM 91-201, and DoD 6055.9-STD. **NOTE:** At the WR, 30 SW/SEW performs these duties.

b. Inspecting critical facilities prior to the start of a hazardous operation or as determined necessary by Operations Safety and/or Range Safety

c. At the ER, inspecting new or modified critical facilities prior to initial start up operation and forwarding inspection reports to Range Safety within 15 calendar days

d. Periodically auditing the execution of procedures for handling ordnance, propellant material, and high pressure gases at CCAS and VAFB, not less than quarterly, and for downrange stations, not less than annually

6.2.2.8 Additional 30 SW/SEGP Responsibilities and Authorities

The 30 SW/SEGP OSM is responsible for the following:

a. Managing a specific launch vehicle/payload system with decision making authority. The OSM has GO/NO-GO authority relating to all safety issues that arise during selected processing and launching activities.

b. Training new Operations Safety Technicians (OSTs) and cross-training other OSMs

c. Interfacing with local, county, state and federal safety agencies regarding OSHA and environmental issues

6.2.2.9 30 SW/SEGP Operations Safety Technicians

Under the direction of the OSM, the OST is responsible for performing the following:

a. Providing safety surveillance during hazardous and safety critical and selected routine launch operations

b. Observing and providing guidance to Range Users to ensure compliance and implementation of safety requirements

c. Performing inspections and surveys to analyze risks, identify cause factors and suggest risk assessment codes

d. Performing mishap investigations and monitoring corrective actions

e. Organizing and supervising missile support teams

f. Representing Range Safety at the daily launch vehicle and/or payload processing meetings

g. Providing in-house training, evaluation, and certification

h. Managing, scheduling, and performing source mission support requirements

6.2.3 Range Users

Range Users are responsible for the following:

6.2.3.1 Range User Control Authority Respon-

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sibilities

The option for operational safety control authority within the launch complex shall be available beginning in fiscal 1996. When certified in accordance with the Launch Complex Safety Training and Certification Requirements, the Control Authority is responsible for the following. (See Appendix 1G for the Launch Complex Safety Training and Certification Requirements.) **NOTE 1:** If this option is used, Range Safety shall audit the program on an unannounced and periodic basis. **NOTE 2:** Range Safety shall perform these duties if a control authority is not qualified. **NOTE 3:** Range Safety can assume these responsibilities for qualified control authorities, if requested. **NOTE 4:** At the WR, Operations safety will audit the program, perform duties, and assume responsibilities, if requested.

a. Reviewing and approving all procedures relating to the performance of any hazardous operation and safety critical operation that are limited to launch complex safety. **NOTE:** This does not include maintenance and testing required by this Chapter and Chapter 3. These procedures still shall be reviewed by Range Safety.

b. Reviewing and approving FEPs and FEOPs that are limited to launch complex safety and all OSPs

c. Ensuring hazardous facilities and safety critical and hazardous operations limited to launch complex safety are periodically inspected, as required

d. Monitoring hazardous and safety critical operations that are limited to launch complex safety, as required

e. Defining the threat envelopes of all hazardous operations limited to launch complex safety and establishing safety clearance zones to protect launch complex personnel and resources

f. Ensuring that all personnel performing hazardous operations that are limited to launch complex safety are provided adequate training to ensure proper conduct of their jobs and tasks by reviewing Range User training plans

g. Ensuring that adequate personal protective equipment is provided to launch complex personnel as defined by this document and approved OSPs

6.2.3.2 Conduct of Operations

a. Planning and conducting hazardous and safety critical operations in accordance with Range Safety approved procedures

b. Planning and conducting operations in accordance with the current edition of the applicable OSP for the launch complex, facility, or area in use and for ordnance and propellant operations and areas

c. Planning and conducting other operations in accordance with the current edition of other safety plans, as applicable

6.2.3.3 Notification of Hazardous and Safety Critical Operations to Range Agencies

a. Notifying Cape Support (853-5211) for the ER and (276-8823) for the WR at least 24 hours prior to the start of any hazardous or FTS-related operation. **NOTE:** The following information shall be provided: date, time, nature of the operation, location, and procedure or task number

b. Notifying Range Safety and Operations Safety of all hazardous and safety critical operations and tests including FTS-related operations

c. Notifying Range Safety and Operations Safety at least 30 calendar days prior to the scheduled erection of a launch vehicle and/or payload

6.2.3.4 Document Preparation and Maintenance

a. Developing and implementing a Ground Operations Plan in accordance with Appendix 6A to cover operations conducted on the Ranges

b. Developing and implementing procedures and general instructions to cover all operations conducted on the Ranges

c. Developing, obtaining Range Safety approval, and implementing procedures related to hazardous and safety critical operations. **NOTE 1:** The designation of a procedure as *Hazardous* or *Non-Hazardous* is evaluated on a case-by-case basis and does not necessarily result in mandatory Operations Safety coverage of the operation. **NOTE 2:** The requirements for hazardous procedures may be found in Appendix 6B.

d. Obtaining Range Safety approval of new procedures or revisions to previously approved procedures when there is an impact to the safe conduct of the procedure

e. Developing and implementing a program to

control hazardous energy sources by locking and tagging in accordance with lockout-tagout approved procedures

f. Developing, obtaining Range Safety approval, and implementing a propellant off-load plan and procedure

g. Developing, obtaining Range Safety approval, and implementing an Emergency Response Plan (ERP) for graphite/epoxy composite over-wrapped and kelvar wrapped pressure vessels

h. Developing, implementing, and maintaining records for an In-Service Inspection (ISI) Plan in accordance with the requirements of this Chapter and Chapter 3

i. Developing, implementing, and maintaining records for a Non-Destructive Examination (NDE) Plan in accordance with the requirements of this Chapter and Chapter 3

j. Developing, implementing, and maintaining records for a recertification program for ground pressure vessels in accordance with ESMC TR-88-01

k. Developing and maintaining hazardous facility inspection records and submitting reports to Range Safety, as required

l. Developing and implementing a Ground System Test Plan for ordnance facilities and areas as required

m. Obtaining 45 CES or 30 CEG approval for procedures in accordance with AFI 32-2001, DoD, federal, state, and local EPA requirements

n. Obtaining 45 MDG or 30 AMDS approval for procedures in accordance with 45 SWI 40-201 or AFI 91-110 30 SW1

o. Preparing and maintaining OSPs as needed and directed by Range Safety. **NOTE:** This function is accomplished by ER Operation Safety at the ER

p. Developing, obtaining Range Safety approval, and implementing a Dual Crane Lift Plan

q. Developing, obtaining Range Safety approval, and implementing a Training Plan for all Range User personnel performing hazardous and safety critical procedures and operations

r. Developing pathfinder requirements in coordination with Range Safety

s. At the WR, developing, obtaining 30 SW Range Safety approval and implementing an 30 SW First Use Tag Program for lifting hardware at the WR.

6.2.3.5 Operational Duties

a. Ensuring required support and emergency elements approved by Operations Safety have continuous access to any area where hazardous conditions could occur

b. Obtaining Operations Safety concurrence to proceed before starting any hazardous and safety critical operations and before any operation that has been interrupted resumes. **NOTE:** Interruptions include such events as a safety hold, shift change, evacuation, or breaks.

c. Before the conduct of hazardous or safety critical operations, performing the following actions:

1. Pre-operation and shift change briefings

2. Pre-operation and shift change inspections to verify proper system, facility, and area configuration; personnel and equipment support; and use of a Range Safety approved procedure

d. Maintaining an accurate written or computerized log of events during launch countdown for three years or three launches, whichever is greater

e. Observing, evaluating, and enforcing compliance with Range Safety requirements by all personnel within launch complexes, assembly, and checkout areas, propellant and ordnance storage areas, and other areas as deemed appropriate by Range Safety.

f. Reviewing and providing comments on hazardous and safety critical procedures to Range Safety.

6.2.4 Supporting Agencies

6.2.4.1 Medical Group, 45th Space Wing and 30th Space Wing

The 45th and 30th Medical Groups, Bioenvironmental Engineering (45 ADOS/SGGB and 30 AMDS/SGBP) and the 45th and 30th Medical Group, Radiation Protection (45 ADOS/SGGB and 30 AMDS/SGPH) are responsible for coordinating with other groups such as Range Safety and Operations Safety to ensure that operations are in compliance with 45 SWI 40-201, AFI 91-110 30 SW1, the AFOSH 161 series, AFI 91-301, and 40 CFR. **NOTE:** Unless otherwise noted, these agencies shall be referred to as *Bioenvironmental Engineering* and *RPO* in this Chapter.

6.2.4.2 Civil Engineering Squadron, 45th Space Wing and Civil Engineering Group, 30th Space Wing

The Civil Engineering Squadron, 45th Space Wing

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(45 SW/CES) and Civil Engineering Group, 30th Space Wing (30 SW/CEG) are responsible for coordinating with other groups such as Range Safety and Operations Safety to ensure that operations are in compliance with AFI 32-2001 and DoD, federal, state, and local environmental regulations at their respective ranges. **NOTE:** Unless otherwise noted, these agencies shall be referred to as *Civil Engineering* in this Chapter.

6.2.4.3 Cape Support (ER) and Range Scheduling (WR)

Prior to prelaunch and launch operations, CCAS Cape Support (ER) or Range Scheduling (WR) is responsible for notifying and requesting support as required from Operations Safety, Fire, Medical, Security (at the WR, security is handled by the Hazardous Operations Support [HOS] contractor), Environmental Health, and other agencies.

6.2.4.4 Facility Operators

Facility Operators are responsible for the following:

- a. Developing and submitting FEOPs and FEPs for review and approval by Range Safety
- b. Performing monthly inspections, developing and maintaining Hazardous Facility Inspection records, and developing and maintaining Explosives Facility and/or Area Ground System Test Plans, as required and at the ER, submitting reports to Range Safety
- c. Conspicuously posting explosive limits, personnel limits, and fire symbols when ordnance and propellants are moved into or out of a facility

6.3 GROUND OPERATIONS POLICIES

6.3.1 Personnel Safety

It is the policy of the Ranges that all personnel shall be protected during the performance of operations.

6.3.2 Stopping Unsafe Operations

a. The following personnel have authority to immediately stop operations or practices that, if allowed to continue, could reasonably be expected to result in death or serious physical harm to personnel, major system damage, or the inability to accomplish its mission:

1. A Safety representative
2. Any operational supervisor

3. Personnel in the chain of command who exercise supervisory authority

b. These personnel are authorized to stop operations or practices when imminent danger cannot be eliminated through regular channels. **NOTE:** All personnel observing an unsafe operation or practice should tell one of these individuals of the problem observed.

6.3.2.1 Notification of Action

Any action taken by any of the individuals as authorized above to stop an unsafe operation where imminent danger is involved shall be followed by direct verbal, telephone, or radio communication and notification to Range Safety at the ER and Operations Safety at the WR, the Squadron Commander, the Group Commander, or their designated representative.

6.3.2.2 Notification of Work Stoppage

The Air Force Contracting Officer or Administrator for an Air Force Construction Contract shall be immediately notified of any work stoppage.

6.4 DOCUMENTATION REQUIREMENTS

6.4.1 Ground Operations Plans

GOPs shall be developed in accordance with the requirements in Appendix 6A and submitted to Range Safety for review and approval.

a. The GOP provides a detailed description of hazardous and safety critical operations for processing aerospace systems and their associated ground support equipment (GSE). **NOTE:** Along with the MSPSP, the GOP is the medium from which missile system prelaunch safety approval is obtained.

b. Preliminary drafts shall be provided 45 days prior to the Conceptual Design Review (cDR), Preliminary Design Review (PDR), and Critical Design Review (CDR) but no later than one year prior to the projected date the hardware will arrive at the Ranges.

c. The final GOP shall be submitted 45 calendar days prior to hardware delivery to the Ranges.

d. The GOP shall be approved prior to the start of any hazardous operations.

6.4.2 Test and Inspection Plans

6.4.2.1 Non-Destructive Examination Plans

a. Non-destructive examination (NDE) plans shall be developed if material handling equipment (MHE) has single failure point (SFP) components or SFP welds. **NOTE 1:** NDE applies to all hooks and all MHE used to lift and support critical hardware. **NOTE 2:** NDE plans shall be submitted as part of the MSPSP as required in Chapter 3 of this document.

b. The NDE plan shall include the following:

1. NDE technique and acceptance criteria to be used on each SFP component or SFP weld after initial and periodic proof load tests

2. Detailed engineering rationale for each technique and acceptance criteria

3. A determination of whether the MHE is a dedicated piece of equipment used for only one function or whether it is multipurpose

4. The environment and/or conditions under which MHE will be used and stored

5. The existence of any SFP component and weld materials susceptible to stress corrosion

6. Corrosion protection and maintenance plans

c. The plan shall be submitted to Range Safety for review and approval as soon as developed and no later than the MHE PDR.

6.4.2.2 Ground Support Pressure Vessel In-Service Operating, Maintenance, and Inspection Plans and Logs

NOTE: ISI plans shall be submitted as part of the MSPSP as required in Chapter 3 of this document.

6.4.2.2.1 Ground Support Pressure Vessel In-Service Operating, Maintenance, and Inspection Plans.

a. Ground support pressure vessel in-service operating, maintenance, and inspection plans (ISI) shall be developed during the design phase by the Range User responsible for the design of fixed, mobile, and portable hazardous pressure systems

b. The ISI Plan includes the following information:

1. An analysis of credible failure mechanisms that may cause service related failures of the system during pressure vessel service life. **NOTE:** Failure mechanisms to be evaluated include corrosion, stress, fatigue, creep, design fab-

rication, installation, operation, and maintenance deficiencies.

2. Identification of the methods such as “eliminated,” “controlled by design,” “controlled by procedure,” “and controlled by corrosion protection” used to eliminate and/or control the failure mechanisms

3. Certification and recertification criteria

c. Records shall be maintained for all certification and recertification data. Requirements are included in the **Ground Based Pressure Vessels and Liquid Holding Tank Recertification Requirements** section of this Chapter.

6.4.2.2.2 Ground Support Propellant Systems Logs. Logs shall be maintained on propellant systems to keep track of use, maintenance, modification, testing, and inspection.

6.4.2.3 Material Handling Equipment Test Records and Overhead Crane Logs

6.4.2.3.1 MHE Test Records.

a. Test records verifying that MHE meets the applicable periodic testing requirements shall be maintained. **NOTE:** The data required for incorporation in the test records can be found in the **Recurring Data Requirement** section for each type of MHE addressed in this Chapter.

b. Discrepancies and their resolution shall be noted.

c. The test records shall be made available to Range Safety upon request.

6.4.2.3.2 Crane Logs.

a. Critical crane logs shall be maintained for the life of the crane.

b. All operations and maintenance, including running time, shall be recorded.

c. The critical crane logs shall be made available to Range Safety upon request.

6.4.2.4 Hazardous Facility Inspection Records and Reports

a. Hazardous facility inspection records shall be maintained by Facility Operators and/or Range Users in accordance with AFM 91-201, AFI 91-202, DoD 6055.9-STD, and this Chapter.

b. At a minimum, hazardous facility inspection records shall include discrepancies and discrepancy resolution.

c. Written reports describing actions taken to correct discrepancies shall be submitted to Range Safety within 15 calendar days or less if requested

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by Range Safety.

6.4.2.5 Explosives Facility and/or Area Ground System Test Plan

A floor plan layout for all explosives facilities and/or areas showing all grounding system test points shall be developed and maintained by the Facility Operator and/or the Range User.

6.4.3 Safety and Emergency Plans

6.4.3.1 Operations Safety Plans and Danger Area Information Plans

a. At the ER, OSPs (Appendixes 6C through 6E) shall be developed by ER Operations Safety and submitted to Range Safety for review and approval 30 calendar days prior to initial use.

b. At the WR, Range Users shall develop their OSPs and submit them to Operations Safety for review and approval before use.

c. At the ER, DAIPs shall be developed by Operations Safety and submitted to Range Safety for review and approval 30 calendar days prior to initial use.

d. At the WR, Launch Safety Plans shall be developed by Operations Safety and submitted to 30 SW/SE for approval 14 calendar days prior to initial use.

6.4.3.1.1 OSPs. OSPs must meet the following requirements:

a. OSPs shall be developed for all hazardous operating areas including launch complexes and associated areas and facilities.

b. OSPs shall be developed for unique, but frequently repeated operations that require special or detailed safety considerations not addressed in this document.

c. OSPs shall be comprehensive documents intended to clarify and provide detailed safety requirements that are particular to the operating area or operation in question.

d. At a minimum, OSPs shall contain, address, and provide reference to the following:

1. A scaled map of the operating area that identifies hazardous and safety critical systems, locations, or features including, but not limited to, propellant holding areas, explosive storage areas, high pressure vessels, emergency evacuation routes and assembly points, safety control areas, warning lights, and first aid rooms

2. A matrix list of all hazardous or safety

critical systems (fixed and portable) that are or will be in the operating area with designation as affecting public, launch base or launch complex safety, personal protective equipment required, and any special safety requirements

3. A matrix list of all hazardous or safety critical operations or tasks performed in the operating area in order of performance with designation as affecting public, launch base or launch complex safety; safety clearance zones required; personnel loading requirements; personal protective equipment required; any special safety requirements; and identification of those operations or tasks that may be run concurrently

4. A complete explanation of all aural-visual warning systems in the operating area including the required personnel response

5. The safety badging (permit) system at the operating area with details such as requirements for obtaining the safety badge, access control, and safety badge types for different personnel categories. **NOTE:** Range Safety and Operations Safety (ER) and Operations Safety (WR) retain the option to train Safety personnel on each launch vehicle payload, system, and launch complex

6. Range Users shall provide Range Safety and Operations Safety (ER) and Operations Safety (WR) updated listings of permit numbers, names, and assigned agencies 48 hr prior to all launches

7. Visitor safety briefings, including content and responsibility

8. Detailed personnel requirements, including, but not limited to, smoking areas especially in propellant and explosive locations; eating and drinking areas; conduct; handling of work clothes due to exposure to hazardous, toxic, or flammable materials; work hour restrictions; and tool tethering requirements

9. Fall Protection Surveys and Plans

10. Personal protective equipment (PPE) details including specific requirements regarding types and usage, especially concerning Self-Contained Atmospheric Protective Ensemble (SCAPE) and splash suits, leg and wrist stats, and hard hats

11. Training and Certification Plans

12. Detailed procedures for reaction to lightning and high wind warnings

13. Detailed procedures for general emergencies such as fire, explosion and propellant spills

14. Detailed procedures for natural disasters

such as hurricanes, tornadoes or earthquakes.

15. Mishap reporting and emergency response phone numbers, including immediate notification to the OSM or OST of any personnel injury or resource damage

16. FEOPs

17. EEPs

18. Lock-out-Tag-out Plans and Procedures

19. Confined Space Operations Surveys, Plans, and Procedures

20. Hot Work Plans and Procedures

21. Self-Inspection Program and Inspection Schedules

6.4.3.2 Facility Emergency Operating Plans

FEOPs shall be developed by Facility Operators and submitted to Range Safety for review and approval 45 calendar days prior to facility use.

6.4.3.3 Emergency Evacuation Plans

a. Emergency Evacuation Plans (EEPs) detailing safety and emergency actions shall be developed by Facility Operators and posted in every building, facility, and area.

b. Emergency Evacuation Plans shall include the following information:

1. Identification of exit/egress routes

2. Identification of primary and alternate Emergency Evacuation Assembly Points (EEAPs).

NOTE: EEAPs shall be designated by signs.

3. Responsibilities of supervisors and personnel for duties assigned in an emergency

4. Actions to be taken to safe an operation

5. Methods of communication including aural warning systems and PA announcements

6. Location of fire alarm boxes and other emergency activation devices

7. Required emergency equipment and personal protective equipment

8. Required personnel training

9. Reporting requirements such as, but not limited to, Squadron Commander or Command Post

6.4.3.4 Emergency Response Plans for Graphite Epoxy Composite Overwrapped Pressure Vessels

a. ERPs for graphite epoxy composite level in vessels shall be developed by Range Users and submitted to Range Safety for review and approval.

b. ERPs shall include the following information:

1. Contingency safing procedures

2. Backout plans for leaks, impacts to the pressure vessels and exposure to incompatible chemical agents

6.4.4 Procedures

6.4.4.1 General Requirements for Procedures

a. Procedures and general operating instructions for all operations conducted on the Ranges shall be developed.

b. All procedures shall be written in a logical format with clear instructions as to the tasks to be performed and the hazards and precautions involved.

c. Brief summaries of all procedures shall be submitted as part of the GOP review and approval process. At that time, the operating procedure summaries shall be designated as *Hazardous*, *Non-Hazardous*, or *Safety Critical*. **NOTE 1:** These designations shall be justified in the operating procedure summaries. **NOTE 2:** Range Safety may designate additional processes and operations as *Hazardous* or *Safety Critical*.

d. Revisions to any procedures shall be submitted to Range Safety for review and approval when there is a potential impact on the safe conduct of an operation.

6.4.4.2 Hazardous and Safety Critical Procedures

a. Procedures for hazardous and safety critical operations shall be developed in accordance with the requirements in Appendix 6B. Emergency actions shall be included in the procedures. **NOTE:** Approval of hazardous and safety critical procedures shall not be given until the MSPSP and GOP have been reviewed and approved.

b. One copy of procedures and revisions involving hazardous and safety critical operations shall be submitted to Range Safety and one copy to Operations Safety for review and approval. **NOTE:** See Appendix 6B for transmittal letter requirements.

c. For new programs, final Operations Safety and Range Safety comments, reviews, and approval shall be provided to the Range User 45 calendar days after receipt of the procedure.

d. For existing programs, final Operations Safety and Range Safety comments, reviews, and approval shall be provided to the Range User no later than 30 calendar days after receipt of the procedures.

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e. Final approved, published procedures incorporating Range Safety comments shall be submitted to Range Safety at least 7 calendar days prior to the conduct of the operation.

f. Disapproval of a formally submitted procedure may result in an additional 30 calendar day (45 calendar days for new programs) review time submittal and possible delay of operations.

NOTE: Range Users new to the Ranges are encouraged to provide a draft of a typical procedure for early review.

6.4.5 Safety Analysis for Proposed Work Under a Load

A safety analysis shall be performed when part or all of a person's body is placed under a load to perform necessary work. The safety analysis shall be part of the GOP and address the following topics:

- a. A detailed description of the task to be performed
- b. The rationale for performing the task
- c. The number and types of personnel to be exposed
- d. The duration and extent of exposure
- e. An explanation of why the operation cannot be conducted without personnel below the load
- f. Details of any precautions to be taken to protect personnel if the load falls

6.4.6 Range User Training Plan

A training plan listing all training courses used for personnel involved with hazardous or safety critical operations and procedures shall be submitted to Range Safety as part of the GOP.

6.4.7 Mishap Reporting

6.4.7.1 Mishaps Involving Air Force Personnel and Property

Reporting criteria for mishaps involving Air Force personnel and property are established in AFI 91-204. Mishaps involving radioactive materials shall be reported in accordance with AFI 91-110.

6.4.7.2 Accident Notification Plan

An accident notification plan shall be developed by the Range User and coordinated with Range Safety (ER)/Operations Safety (WR) to ensure proper and timely notification of mishaps. The plan shall be included in the GOP.

6.5 GROUND OPERATIONS GENERAL REQUIREMENTS

DOT, EPA, OSHA and industry standards are specified as compliance documents throughout this Chapter. When there is a conflict between Federal regulations, industry standards or other requirements in this section, the more stringent requirement shall be used unless otherwise agreed to by Range Safety.

6.5.1 Ground Operations Personnel Requirements

Range Users shall submit training plans to Range Safety for review and approval. A list of all training courses is the minimum requirement.

6.5.1.1 Ground Operations Safety Orientation and Training

- a. All Range Users shall ensure that their personnel receive formal safety orientation and training prior to receiving a controlled area badge.
- b. Periodic refresher training shall be required.

6.5.1.2 Job Safety, Fire Prevention, and Occupational Health Training

- a. All assigned personnel shall receive job safety, fire prevention, and occupational health training.
- b. This training shall include, but not be limited to, the following topics:
 1. Hazards of the job tasks they will perform, including but not limited to the following:
 - (a) Crane operations
 - (b) Ordnance handling and transportation
 - (c) Forklift operations
 2. Hazards of the work area
 3. Range requirements, safety standards, and other guidance that applies to the job and workplace
 4. PPE requirements and use
 5. Location and use of emergency and fire protection equipment
 6. How to report emergencies and fires to the proper authorities
 7. Emergency procedures applicable to the job and work place
 8. Actions to be taken in the event of specific warnings, PA announcements, or alarms
 9. How to identify and report hazards
 10. How to report work-related injuries and

illnesses

11. First aid, and, as applicable, cardiopulmonary resuscitation procedures

6.5.1.3 Personnel Conduct

6.5.1.3.1 Food, Beverage, and Cigarette Consumption. Eating, drinking, or smoking is authorized only in designated areas.

6.5.1.3.2 Alcoholic Beverages and Narcotics.

a. Using alcoholic beverages and narcotics while on duty is prohibited. An employee who reports for work while under the influence of alcoholic beverages or narcotics shall be removed from the premises by Security.

b. Personnel taking prescription or non-prescription medications that could affect performance shall notify their supervisor.

6.5.1.3.3 Mischief. Indulgence in practical jokes, horseplay, scuffling, and wrestling is prohibited.

6.5.1.4 Work Time Restrictions

a. Supervisors at all levels should ensure their personnel will not be assigned to, and not participate in, critical operations if it is evident that their physiological or psychological well-being is, or is likely to be, adversely affected by immunizations, fatigue, blood donations, use of drugs, illness, consumption of alcohol, or other stress conditions.

b. Each duty period for Mission Ready (Category A) and Mission Support (Category B) personnel, including participation in a launch or launch attempt activity, shall be preceded by an available rest period.

c. Planned duty for personnel in either mission ready or mission support should normally be eight hours, starting when the individual reports for duty. Those personnel identified to support operational tests shall not be scheduled for duty during the planned rest period.

6.5.1.4.1 Hazardous Operations and Prelaunch Attempts. The following criteria shall be used for determining hours worked versus rest time for all personnel who work with hazardous systems, materials, or components, or who accomplish prelaunch functions that require a high degree of concentration:

a. Maximum 12-h shift, unless approved by Range Safety or USAF Squadron Commander, with at least 8-h rest after 12 h of work

b. A maximum of 60 h per week

c. A maximum of 14 consecutive days

6.5.1.4.2 Consecutive Launch Attempts.

When 12-h shifts are required and launches are rescheduled on a 24-h basis, consideration shall be given for a 48-h launch delay after three consecutive back-to-back launch attempts. In the event mission impacts or operational requirements necessitate 12-h shifts, mission ready personnel shall not be scheduled for more than five consecutive shifts without a 48-h break and mission support personnel with not be scheduled for more than six consecutive shifts without a 24-h break.

6.5.1.4.3 30 SW Additional Work Restrictions.

a. In the event of a missile accident, emergency, or operational necessity, the duty time limits defined in this document may be exceeded with the expressed knowledge of the 30 SW Commander or Vice Commander, Commanders of tenant organizations, or the 30 SW Chief of Safety for personnel under their respective control.

b. When mission requirements dictate, the duty period may be extended to 12 h by the first level supervisor. Rest periods and break periods shall be provided according to appropriate regulations and negotiated agreements.

c. If, after a complete evaluation of the potential hazards involved, mission requirements dictate a duty period in excess of 12 h, the following criteria shall apply:

1. For Mission Ready (Category A) personnel, the duty periods may be increased to 14 h or rest periods may be waived with the expressed knowledge of the 30 SW Commander or Vice Commander, Western Range Commander, Operations Groups Commander, or the Chief of Safety.

2. For Mission Support (Category B) personnel, the duty period may be increased to 14 h with the expressed knowledge of the applicable division chief or equivalent level supervisor.

6.5.2 Personal Protective Equipment

a. Personal protective equipment (PPE) that provides sufficient protection against the hazards of specific operations and, at a minimum, meets the requirements established by OSHA, AFOSH, ANSI, and NIOSH, shall be provided.

b. All PPE shall be compatible with the toxic materials involved.

c. PPE selection shall be approved by Range Safety and the Bioenvironmental Engineering at the ER and Range Safety and the Bioenvironmen-

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tal Engineering at the WR. Contractors must ensure their employees are protected as required by OSHA regulations and CAL-OSHA, where applicable.

6.5.2.1 Use and Care of PPE

a. PPE shall be used, maintained, inspected, and stored properly to prevent degradation of its protective capability.

b. A means of cleaning and disinfecting PPE shared among employees shall be provided.

6.5.2.2 Hard Hats

a. Where the hazard of falling objects exists, hard hats meeting the requirements of ANSI Z89.1 shall be worn.

b. Hard hats shall be worn by all personnel within areas where head injury may occur unless specifically exempted by Range Safety.

c. Hard hat areas shall be clearly designated by yellow lines, barriers, signs, or other means.

6.5.2.3 Respiratory Protection Restrictions

a. Personnel requiring the use of respirators shall have the appropriate physical, training, and fit test prior to work in those areas where respiratory protection is required.

b. The wear of respirators is approved by Bio-environmental Engineering and Environmental Health for USAF employees. Other Agencies and contractors must have their own respiratory protection program that complies with OSHA regulations and CAL-OSHA, where applicable.

6.5.2.4 Clothing Requirements in Industrial and Missile Operating Areas

a. Complete upper and lower body attire shall be worn in industrial and missile operating areas.
NOTE: Lower arms, hands, and head do not have to be covered unless otherwise stated.

b. Open-toed and high-heeled shoes are prohibited.

c. Canvas shoes are not permitted where liquid propellants or cryogenics are handled.

d. Dresses shall not be worn on towers.

e. The appropriate attire for hazardous and safety critical operations shall be identified in the operating procedure.

f. Coveralls or other work clothes designated to be worn in toxic propellant areas shall not be worn in eating areas or other facilities off site.

g. Work clothes shall be stored in change rooms in designated lockers.

h. Work clothes requiring cleaning shall be bagged and identified.

i. Work clothes exposed to an oxygen rich atmosphere shall be thoroughly aired before smoking is allowed.

6.5.3 Fall Protection

6.5.3.1 Fall Protection General Requirements

Specific criteria for the equipment listed in this section can be found in ANSI Z359.1, A10.14, AFOSH 127-22 and 31, 29 CFR 1910.23 and 27, 29 CFR 1926.105, and MIL-STD-1212A.

6.5.3.2 Fall Hazards

a. All open-sided floors or fall hazards over 4 ft or any height where falls into hazards such as moving machinery, impaling, or drowning hazards exist shall be guarded by standard guard rails with mid-rails and toe boards.

b. Fall protective PPE shall be used when installing guardrails, safety nets, and other fall protection.

6.5.3.3 Hazard Guards

If standard guard rails are not installed, PPE, in the order of preference listed below, shall be used to protect personnel if they are within 6 ft of the hazard:

- a.* Full body harness (ANSI Class III)
- b.* Chest harness (ANSI Class II)
- c.* Safety nets (OSHA 1926.105)

6.5.3.4 PPE Lanyards

PPE shall be attached to anchorages by a lanyard that limits the length of a fall to no more than 6 ft. The order of preference is as follows:

- a.* Self-retracting lanyard (inertia reel)
- b.* Shock absorbing lanyard
- c.* Nylon rope lanyard
- d.* Wire rope lanyard (for welders)

6.5.3.5 Lanyard Anchorages

a. Lanyard anchorage points shall be based on criteria established in ANSI A10.14 as identified in Chapter 5, **Critical Facility and Structure, Personnel Anchorage and Anchorage Connections** and ANSI Z359.1.

b. Handrails shall not be used for anchorages or

lanyard tie-off points.

c. Life line (dog-run) style anchorages for lanyards require specific approval by Range Safety for each application. Appropriate justification with analysis must be submitted for Range Safety approval. Dog-runs are not an acceptable alternative to installed platforms or walkways.

6.5.3.6 Installation of Permanent Anchorage Connectors

a. Visual inspection of installed permanently fixed anchorage connections and dog-runs shall be accomplished annually by the Range User. Documentation shall be available for review by Range Safety.

b. Suspect connections or anchorages shall receive NDE as determined by Range Safety and shall be repaired or replaced as required.

6.5.3.7 Fall Protection Snap Hooks

Fall protection snap hooks used in fall protection systems shall be sized to ensure proper connection.

6.5.3.8 Fall Protection Equipment Inspections

a. Each article of PPE shall be visually inspected by the user prior to use.

b. All PPE shall be thoroughly inspected at least twice a year by a qualified person of the organization that owns the PPE.

c. Each piece of PPE shall have a visible tag or other indication of inspection permanently attached with the following information:

1. The date inspected
2. The next inspection due date
3. The stamp or signature of the quality inspector

6.5.3.9 Ladder Fall Protection

a. Ladder fall protection shall be installed on all fixed ladders with a fall hazard of 20 ft or more.

b. Ladder safety devices with full body harnesses shall be the preferred method of fall protection.

6.5.4 Smoking Areas

6.5.4.1 Designated Non-Smoking Areas

Smoking is prohibited at all times and flame-producing devices shall be prohibited within the following areas:

- a. Within 100 ft of any propellant storage tank
- b. On gantries or service towers
- c. Within 100 ft of the test stand while propellants are being transferred or during the time propellants are aboard the launch vehicle and/or payload

d. In the vicinity of the launch vehicle and/or payload during and after ordnance installation

e. In missile impact areas where radioactive contamination, ordnance, or fuels are present

f. In any area displaying NO SMOKING signs

g. In all propellant operating and storage areas except in specifically designated smoking areas

6.5.4.2 Designated Smoking Areas

Selection of designated smoking areas, their ash receptacles, and ventilation systems is subject to the review and approval of the Fire Department.

6.5.4.3 Marking Smoking and Non-Smoking Areas

No smoking and smoking areas in the complex shall be clearly designated by lines painted on the concrete or asphalt surfaces and appropriately marked by signs.

6.5.4.4 NO SMOKING Signs

NO SMOKING signs shall be posted as directed by the Fire Department.

6.5.5 Operating Restrictions Due to Lightning

Conditions under which launch complexes, launch vehicle and payload assembly areas, and other hazardous areas shall be cleared due to a threat of lightning shall be specified in the OSP.

6.5.5.1 ER Lightning Hazard Advisories and Hazard Warnings

a. Operations that will be allowed during lightning advisories and warnings shall be coordinated, reviewed, and approved by 45 SW/SES and documented in the specific OSP.

b. Phase I Lightning Advisory - For the 5 nautical miles lightning advisory (Forecast for lightning within 5 nautical miles of centroid of a specific lightning alert area, [Space Launch Complex (SLC) and/or facility], expected within some time, usually 30 minutes), the following actions shall be taken:

1. SCAPE operations, propellant tanking and detanking, hoisting hazardous materials or 1.1 to 1.3 class ordnance, and other hazardous operations that take 30 min or longer to secure shall not be started.

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2. If an operation is in progress, personnel shall begin safing the system so as to have the area secured and evacuated, if required, prior to the forecasted 5 nautical miles lightning warning start time.

c. Phase II Lightning Warning - For the lightning warning, lightning is imminent or occurring within the 5 nautical mile boundary of a centroid of a specific lightning alert area (SLC and/or facility), the following actions shall be taken:

1. All operations shall cease unless they are performed remotely and have been approved by either Range Safety or are authorized in the specific OSP

2. If the Phase I lightning advisory has not been previously announced or the 5 nautical mile lightning warning start time is earlier than forecast, the operation shall be terminated at the safest safe step, the area secured and evacuated in accordance with the specific OSP.

d. Due to the differences between launch vehicle configurations and SLCs, evacuation requirements shall be specified in each specific OSP. In general, the complex shall be cleared prior to the 5 nautical mile lightning warning start time whenever a launch vehicle with payload, propellants, solid rocket motors, or Class 1.1 to 1.3 ordnance is present or EEDs are electrically connected.

e. Additional information regarding lightning hazard advisories and warnings may be found in the 45 WS Meteorological Handbook.

6.5.5.2 WR Lightning/Thunderstorm Watches and Warnings

a. The 30th Weather Squadron issues two messages related to lightning/thunderstorms: A watch and a warning.

1. A Lightning/Thunderstorm Watch is a forecast issued when the potential for lightning/thunderstorms is expected to occur within 10 nautical miles of any location on VAFB. The desired lead time for this watch is 2 hours. The watch is forecast for a period of time (valid time) that lightning/thunderstorms are expected to be within 10 nautical miles.

2. A Lightning/Thunderstorm Warning is issued when lightning is observed within 10 nautical miles of VAFB.

b. Meteorological and weather warning notifi-

cation procedures are provided in 30 SWI 15-101.

c. Upon issuance of the Lightning/Thunderstorm Watch, all operations involving propellant or ordnance activities shall be completed before the start of the Lightning/Thunderstorm Watch “valid time.” All propellant or ordnance activities not completed before the watch “valid time,” may continue if the facility has a certified lightning protection system and the organization’s commander grants approval to continue. All other non-propellant or non-ordnance activities may continue in the facility during the Lightning/Thunderstorm Watch.

d. Upon issuance of the Lightning/Thunderstorm Warning, a space launch complex, explosive/missile processing facility, launch facility, storage facility, or any other hazardous operating location that has a certified lightning protection system does not require evacuation; and all non-propellant or non-ordnance activities may continue in the facility during the Lightning/Thunderstorm Warning. *EXCEPTION: If either of the following conditions apply, all personnel shall evacuate to at least the public transportation route (PTR) distance regardless of the lightning protection system: Condition 1: There is exposed solid propellant. Condition 2: There is an explosive initiation device that cannot be placed in a safe configuration.*

NOTE: The intent of paragraphs c. and d. is to allow all non-ordnance and non-propellant activities to continue in facilities with certified lightning protection systems during a Lightning/Thunderstorm Watch or Warning. A “certified” lightning protection system is inspected and maintained in accordance with AFI 32-1605 or National Fire Protection Association Standard 780. These are the minimum lightning protection requirements imposed by 30 SW Safety. Range Users may be more conservative at their own discretion.

e. Upon issuance of the Lightning/Thunderstorm Warning, any operation involving propellant or ordnance activities in a space launch complex, explosive/missile processing facility, launch facility, storage facility, or any other hazardous operating location that does not have a certified lightning protection system shall evacuate to at least the PTR distance.

f. If a Lightning/Thunderstorm Watch or Warning has not been previously issued or the Lightning/Thunderstorm Watch or Warning “valid

time” is earlier than forecast, the propellant or ordnance activities shall be terminated at the safest point and the area secured.

g. Lightning/Thunderstorm Watch and Warning notifications and Range User action requirements for propellant or ordnance activities apply to both day-to-day and day-of-launch operations.

h. Range Users working an approved operation involving propellant or ordnance activities during a Lightning/Thunderstorm Watch can call 30 WS (x6-8022) to get an update of the status of the watch. To ensure the consistent and accurate relay of information, Range Users should designate a single point of contact to make these calls, preferably the individual in charge of the operation. **NOTE:** Examples of approved activities are installation of electrical cables, mechanical components, flight hardware, stud standoff, and wing installation. Examples of unapproved activities are handling of rocket motors or launch vehicles by lifting, mating, or roll transfer; fuel transfer and pressurization; and ordnance installation and connection.

6.5.6 Operating Restrictions Due to High Winds

6.5.6.1 For Winds of 18-29 Knots as Measured on or Closest to Specific Facilities

No work shall be performed on the exterior surface of umbilical or mobile service towers or other tall structures unless spider staging or similar suspended work devices are safely secured to the structure.

6.5.6.2 For Winds of 30 Knots or More as Measured on or Closest to Specific Facilities

a. No work shall be performed on the exterior surfaces of umbilical or mobile service towers or other tall structures except for emergency tasks.

b. Work performed during emergency conditions shall be approved by Operations Safety or Range Safety and all suspended work devices shall be secured to the structure.

6.5.7 Hazardous Ground Operations General Requirements

6.5.7.1 Pathfinder Requirements

a. In coordination with the Range User, Range Safety shall determine which procedures require a pathfinder and its necessary fidelity.

b. Prior to the first use of applicable hazardous

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procedures, including contingency, such as operations with live ordnance, pressure systems, or propellant, pathfinder operations shall be conducted at the Ranges using inert or dummy ordnance, non-pressurized systems, or non-fueled systems.

1. Handling operations shall be performed with an inert unit which simulates the flight unit in form, fit, function, weight, and center of gravity.

2. Pressure and propellant system operations shall be performed with a unit which simulates flight unit valve connections.

3. Pathfinder operations shall use GSE that will be used for flight operations.

4. Range Safety and the Range User shall jointly develop acceptance criteria for pathfinder operations and evaluate whether the acceptance criteria was met.

6.5.7.2 Hazardous Ground Operations Training and Certification

a. All personnel performing hazardous operations shall be trained and certified.

b. Hazardous operations training shall include, but not be limited to, the following topics:

1. Hazard recognition
2. Cause and effect relationships
3. Hazard prevention and control measures
4. Inspection of equipment
5. Buddy system requirements
6. Use of checklists
7. Range Safety and Operations Safety authority

8. Human error

9. Safeguards

10. Safety devices

11. Protective equipment

12. Monitoring and warning devices

13. Emergency procedures

c. On-the-job training shall supplement classroom instruction.

d. Unique personnel training and certification requirements for hazardous operations such as ordnance, crane operations, and SCAPE shall be specified in the appropriate procedures.

e. A list of personnel training, certification, and experience requirements shall be submitted as part of the Range User Training Plan to Range Safety for review and approval 30 calendar days prior to the operation and shall be included in the GOP.

6.5.7.3 Control of Access to Hazardous Op-

erations

Personnel limits, entry control, and control areas shall be established for all hazardous operations.

6.5.7.3.1 Personnel Limits for Hazardous Ground Operations.

a. Personnel limits shall be established for all hazardous operations and tasks and approved by Range Safety. Deviation from approved access list numbers requires Operations Safety or Range Safety approval. **NOTE:** Very Important Person (VIP) visits shall be coordinated with the Chief of Safety prior to entering a hazardous area.

b. The supervisor in charge of the building or operation is responsible for maintaining personnel load limits for a single building or operation.

6.5.7.3.2 Control of Access to All Hazardous Operations.

a. Hazardous areas shall be fenced, barricaded, or cordoned off and personnel access control maintained at a central control point.

b. Access roads shall be closed by barricades, guards, or signs during hazardous operations for positive control of personnel and vehicles. Emergency vehicles shall not traverse the controlled area if another route is available.

c. When hazardous operations are covered by Operations Safety, Operations Safety shall control access.

6.5.7.3.3 Personnel Restrictions for Hazardous Ground Operations.

a. Non-essential personnel shall leave hazardous areas (safety clearance zones) prior to the start of operations.

b. Whenever a warning light status is changed or an audible signal is sounded, a public address (PA) announcement shall precede it and identify the reason for the change.

c. Each facility and/or area shall have instruction signs informing personnel of the area aural and warning light scheme prior to entry.

d. The buddy system shall be used in all hazardous operations.

e. Area Warning Lights. Personnel with the appropriate badge and security clearance have access to areas as follows: **NOTE:** Exceptions to these requirements require permission of the Chief of Safety or a designated representative.

1. A flashing green light indicates the controlled area is open to normal work. Hazardous

commodities may be present in the area but no hazardous operations are in progress. Access is controlled by Security/HOS.

2. A flashing amber light indicates a hazardous operation is in progress in the controlled area. Non-essential personnel shall be cleared from the controlled area. Personnel shall not enter without permission from Operations Safety or, in the absence of Operations Safety, the entry control authority.

3. A flashing red light indicates an emergency situation in the controlled area. All personnel shall evacuate the controlled area to the EEAP. This signal shall be accompanied by the sounding of an audible alarm and a PA announcement. This signal is also used to clear all personnel from a launch complex prior to a launch. At the WR, a flashing red light also designates a dangerous operation for ballistic missile operations; for example, Flight Operations Test and Evaluation (FOT&E) where work is performed under the strict control of technical orders (T.O.s).

6.5.7.4 Hot Work Operations

6.5.7.4.1 Hot Work Operating Standards. Hot work (open flame) operations including welding, soldering, cutting, brazing, grinding, or heating of materials in such a manner as to cause a source of ignition shall be conducted in accordance with AFOSH 127-5, 29 CFR 1910.252, and ANSI Z49.1.

6.5.7.4.2 Hot Work Operations Training and Certification. All welders shall be trained and certified by competent authority to standards no less than those established by the American Welding Society (AWS).

6.5.7.4.3 Hot Work General Operating Requirements.

a. A written permit shall be obtained from the Fire Marshall prior to performing hot work.

b. Locations where hot work will be routinely performed may operate on an indefinite permit if that area is subject to periodic Fire Department inspections.

c. A fire watch shall be maintained during and after the hot work until such time the fire watch determines that the combustion hazard no longer exists.

d. The requirement for the Fire Department to perform the fire watch shall be determined on a

case-by-case basis by the Fire Marshall and Range Safety.

e. Proper housekeeping and protective shields and barriers shall be used to prevent inadvertent combustion.

f. Combustibles shall be kept at least 35 ft away from the operation.

g. A suitable fire extinguisher shall be available.

6.5.7.4.4 Hot Work Within Ordnance or Propellant Areas. Hot work within ordnance or propellant areas shall be coordinated with Range Safety or Operations Safety as well as the Fire Department.

6.5.7.4.5 Hot Work on Containers and Lines That May Have Contained Explosives or Flammables. Hot work shall not be performed on containers and lines that may have contained explosives or flammables and have not been properly cleaned and purged.

6.5.7.5 Control of Hazardous Energy Sources

6.5.7.5.1 Hazardous Energy Sources Standards.

a. Hazardous energy sources shall be controlled through a lockout/tagout program that complies with the requirements of 29 CFR 1910.147, AFOSH 127-45, and ANSI Z244.1.

b. Range Users shall have a program to control hazardous energy sources by locking and tagging.

6.5.7.5.2 Lockout/Tagout Training and Certification. Personnel shall be trained and certified in the lockout/tagout process.

6.5.7.5.3 Lockout/Tagout Procedures. Lockout/tagout procedures shall be developed by Range Users and approved by Range Safety (ER)/Operations Safety (WR).

6.5.7.5.4 Lockout/Tagout Operations. Whenever work is to be accomplished where the start-up or energizing of equipment may cause a hazard to personnel, the equipment or its controls shall be locked in the SAFE position and controlled by the personnel potentially exposed. *EXCEPTION: Hazardous equipment that cannot be physically locked shall be modified to incorporate a locking capability or be scheduled for replacement. As an interim measure, the equipment shall be tagged out of service and a knowledgeable person posted*

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to watch the controls while personnel are in a potentially hazardous position.

a. Locks shall be installed prior to the following situations:

1. Personnel are out of sight of the control device

2. The personnel site is left unattended

3. The possibility exists of an unauthorized person operating the control device while personnel are exposed to the hazard

b. A tag shall be installed to identify the fact that the equipment is under the control of a work team.

c. Tags shall include the following information:

1. The reason for placing the tag

2. The name, organization, and phone number of the person placing the tag

3. The date and time of tagging

d. Locks and tags shall be removed only by the personnel who installed them or by their supervisor in their absence.

6.5.7.6 Confined Space, Tank Entry, and Tank Cleaning

NOTE: Confined spaces and their appropriate controls are defined in 29 CFR 1910.146.

a. All Range Users, contractors, and subcontractors who will be entering confined spaces (other than the contractor's equipment and flight hardware) shall contact Ground Safety at the start of the project to obtain information about the confined space.

b. Ground Safety shall provide information about the content of the space, the condition that makes it a permit-required space, and procedures implemented to protect personnel from the space.

c. Contractors entering confined spaces are responsible for the safety of their personnel and shall develop and use their own entry program. **NOTE:** Chapter 7 of AFOSH 91-25 provides details of contractor responsibilities for entering confined spaces located in AF installations.

d. If contractors encounter any difficulties during the confined space entry, they shall advise the confined space manager of the outcome.

e. AF personnel entering confined spaces shall follow all the provisions of AFOSH 91-25.

6.5.7.7 Tethering of Equipment

a. Hand-held tools, equipment, and personal

belongings shall be tethered in any area where dropped objects could pose a hazard to personnel as determined by the local supervisor or on-scene safety official.

b. Hazards to be considered in determining requirements include direct contact with personnel or the consequences of damaging critical hardware.

6.5.8 Facility Use

6.5.8.1 Facility Use General Requirements

a. Facilities shall be used within the limits of their design. For example, the Range User shall not store propellants in an industrial building that is not suited for propellant storage nor equipped to handle propellant spills.

b. Only those operations that are consistent with facility design, materials, equipment, and personnel shall be performed in the facility.

6.5.8.2 Hazardous Facility Use General Requirements

a. The use of facilities for hazardous storage or processing operations shall be approved by Range Safety. **NOTE:** Range Safety approval is required to use a facility for hazardous operations even though similar operations have been conducted in the facility in the past.

b. The OSP shall be developed by Operations Safety at the ER and the Range User at the WR.

c. Facilities used for hazardous activities shall have an FEOP and an Evacuation Plan developed by Facility Operators.

d. Simultaneous hazardous operations within the same control area are prohibited.

e. Non-hazardous operations within the same control area as an ongoing hazardous operation are prohibited unless a safe distance approved by Range Safety can be maintained.

6.5.8.3 Hazardous Facility Inspection

6.5.8.3.1 Range User Facility Inspections.

a. Facilities shall be inspected prior to first use, upon modification, prior to operations, and on a monthly basis.

b. Inspection reports shall be maintained in accordance with AFMAN 91-201, AFI 91-202, and DoD 6055.9-STD.

c. Actions shall be taken to correct discrepancies identified during inspections. **NOTE:** Records of discrepancies and discrepancy corrections shall be maintained for three years.

d. A verbal report shall be made to Range Safety (ER)/Operations Safety (WR) within the same day of the inspection if discrepancies are found that may delay a planned operation or endanger personnel or MHE used to handle critical hardware, or the critical hardware itself.

e. Written reports describing actions taken to correct discrepancies identified during inspections shall be submitted to Range Safety (ER)/Operations Safety (WR) within 15 calendar days or less if deemed necessary by either group.

6.5.8.3.2 Operation Safety Facility, Complex, and Area Inspections.

a. A systematic visual examination of facilities, related ground support equipment, and any work in progress that could cause accidental damage to property or injury to people or affect the launch schedule shall be performed by Operations

Safety. **NOTE:** This inspection deals primarily with aerospace ground equipment (AGE), launch critical associated equipment, maintenance, associated hardware, fire hazards, fall protection, and equipment on the complex.

b. A safety inspection shall be performed on launch complexes, explosives storage and processing facilities and areas, and in hazardous processing and checkout facilities according to the following schedule:

1. At least two weeks prior to a launch vehicle or payload being brought to the pad or facility

2. Within 48 h of the pad erection day

3. Immediately before the start of any hazardous or safety critical operation

4. After any major or safety-related modification has been made to facilities or equipment

c. Explosives storage and operating areas and facilities shall be inspected by Operations Safety (ER)/30 SW/SEW (WR) at least annually to ensure compliance with explosives safety criteria. **NOTE:** Area monthly records shall be reviewed during the annual inspection.

6.5.8.3.3 Facility Operator Inspections. Explosive storage and operating areas and facilities shall be inspected at least once a month by the Facility Operator.

6.5.8.3.4 Facility Spot Checks. As deemed appropriate by Range Safety, spot checks of Range facilities shall be performed to ensure compliance with this document.

6.6 MATERIAL HANDLING EQUIPMENT OPERATIONS

6.6.1 MHE Operating Standards

a. MHE operations include lifting, handling, supporting, and transporting material, equipment, or personnel. **NOTE:** Vehicles used to transport hardware onto and off of the Range are not governed by this section.

b. All equipment covered in this section shall be operated, tested, and maintained in accordance with the requirements of this document, AFOSH 91-46, and applicable military and industry standards including, but not limited to, the American National Standards Institute (ANSI), the American Society of Mechanical Engineers (ASME), the Crane Manufacturer's Association of America (CMAA), and the National Fire Protection Association (NFPA).

REFERENCED DOCUMENTS

c. All equipment used by the Naval Ordnance Test Unit (NOTU) and that has been approved by the Chief of Naval Operations, Department of Energy, and the DoD for the specific purpose for which it is used shall be considered in compliance with this document.

d. All users of MHE used to handle the critical hardware covered by this section shall have written and approved procedures that cover selection, operation, maintenance, and testing of MHE used. Operations that include maintenance of the MHE and use of these items with no safety critical or hazardous loads shall not be considered safety critical operations. Those operations that involve MHE and safety critical or hazardous loads including direct contact, such as supporting the load, or within the immediate vicinity, such as moving the MHE without a load over a hazardous commodity, shall be considered hazardous operations.

6.6.2 MHE Operator Qualification and Training

6.6.2.1 MHE Operator Qualification Requirements

a. Operators shall be mentally and physically capable of safely operating the MHE.

b. Operators shall be physically tested for vision and hearing before being assigned to operator duty and annually thereafter.

6.6.2.2 MHE Operator Training and Certification

a. Operators shall be trained in the safe operation of the MHE used and the hazards to which they are exposed.

b. Operator training shall include, but not be limited to, the following topics:

1. The requirements of the operator's manual
2. The applicable parts of AFOSH 91-46
3. The applicable parts of 29 CFR 1910, Subpart N
4. The applicable parts of ANSI B30 and other industry standards.

6.6.3 MHE Periodic Test and Inspection

6.6.3.1 MHE Test and Inspection General Requirements

a. All MHE shall be tested initially and periodically. **NOTE:** Initial test requirements are established in Chapter 3. Periodic test requirements for

specific MHE are found in specific sections of Chapter 3 and are repeated in this Chapter. Periodic test plans for MHE shall be included in the MSPSP as required in Chapter 3.

b. All MHE shall be inspected prior to use by qualified personnel using detailed checklists or procedures as a part of the MHE test and inspection program. **NOTE:** At a minimum, the inspection and rejection criteria from applicable industry standards shall be used.

c. All damaged MHE shall be removed from service until all discrepancies are corrected.

d. All MHE periodic inspections and maintenance operations shall be verified.

e. Records of MHE inspections, tests, maintenance, and modifications shall be maintained for the life of the equipment.

f. All MHE shall be marked with the due date of next inspection.

g. Load tests shall be conducted with certified weights. These weights shall be accurately identified and tagged with total weight (lb), and owner or agency identification number. **NOTE:** Calibration load devices such as dynamometers may be used to test slings and other lifting devices except cranes. Reinforcing steel (rebar) shall not be used for lift points.

h. The test weight shall be applied a minimum of 3 min.

6.6.3.2 MHE General Data Requirements

a. All MHE shall have documentation verifying that the equipment meets the applicable periodic testing requirements.

b. Data requirements are identified in the recurring data requirement sections for each type of MHE addressed.

c. Periodic test results data shall be maintained by the Range User in a periodic test file.

d. The periodic test files shall be made available to Range Safety upon request.

6.6.3.3 Non-Destructive Examination for All Crane Hooks and MHE Used to Handle Critical Hardware Having Single Failure Points

a. NDE plans shall be developed if MHE has single failure point (SFP) components or SFP welds.

b. The NDE plan shall include the following:

1. NDE technique and acceptance criteria to be used on each SFP component or SFP weld after

initial and periodic proof load tests

2. Detailed engineering rationale for each technique and acceptance criteria

3. A determination of whether the MHE or MHSE is a dedicated piece of equipment used for only one function or whether it is multipurpose

4. The environment and/or conditions under which MHE will be used and stored

5. The existence of any SFP component and SFP weld materials susceptible to stress corrosion

6. Corrosion protection and maintenance plans
c. The plan shall be submitted to Range Safety for review and approval as soon as it is developed, but no later than the MHE PDR.

d. The following are acceptable NDE standards:

1. Surface inspection in accordance with MIL-STD-6866 or ASTM-E1444

2. Volumetric inspection in accordance with MIL-STD-453 or MIL-STD-2154

3. Visual inspections accomplished by persons trained and qualified. **NOTE:** Visual inspector qualification criteria and training shall be documented in a written procedure.

4. A non-inclusive list of standards that may be used to develop NDE acceptance criteria is provided below:

(a) AWS D1.1, D1.2, D14.1, D14.2

(b) MIL-STD-278

(c) MIL-STD-2154

(d) MIL-STD-1265

(e) MIL-HDBK-1890

(f) MIL-STD-2175

(g) NAV-SHIP 250-692-2

(h) MSFC-STD-100

(i) MSFC-STD-1249

6.6.4 MHE General Operations

a. All MHE to be used for hazardous operations shall be identified to Range Safety.

b. All MHE shall be verified as safe for its intended use by Range User.

6.6.5 Cranes and Hoists Operations

6.6.5.1 Cranes and Hoists Operating Standards

All cranes and hoists shall be identified, tested, maintained, and operated in accordance with ANSI/ASME B30 series, CMAA 70 and 74, MHI Standards, AFOSH 91-46, and NFPA 70. **NOTE:** At VAFB, cranes not on VAFB exclusive Federal jurisdiction property also require inspection, test-

ing, and certification in accordance with California Occupational Safety and Health (CAL-OSHA) requirements.

6.6.5.2 Crane Operator Training and Certification

a. All operators of cranes used on the Ranges shall have the minimum training listed in AFOSH 91-46 and the minimum qualifications stated in the ASME/ANSI B30 series.

b. All operators of Range-owned or installed hoisting apparatus of over 1,000 lb capacity (hoists [fixed or traveling] or cranes [overhead or mobile]) shall be trained and certified.

c. All operators of non-Range or privately owned cranes that are used to lift critical loads are subject to the requirements stated in the ASME/ANSI B30 series.

6.6.5.2.1 Annual Crane Operator Certification.

Annual crane operator certification is required and shall be conducted in three parts:

a. Classroom Training and Testing: The Launch Base Support (LBS) contractor for ER shall perform classroom training and testing and maintain records for each operator. Lesson plans shall be submitted to Range Safety for approval. For WR, paragraph 6.6.2.2 applies.

b. Physical Examination: The medical contractor shall perform a physical examination of the operator as required by AFOSH 91-46.

c. Hands-On Training and Certification: The employer shall provide hands-on training, evaluation, and certification in the form of a card that includes the following:

1. Name of operator

2. Certification expiration date

3. Other pertinent information such as the types of equipment the operator is certified to operate

6.6.5.2.2 Types of Operator Certification.

a. Critical load (except for proof loads) hands-on training and certification shall be done on the specific device to be used for the lift.

b. Non-critical load hands-on training and certification shall be done on a crane of the same type for which personnel are to be certified such as mobile hydraulic, mobile mechanical (friction), overhead bridge, and overhead monorail.

6.6.5.2.3 Navy Area Crane Operator Certification.

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a. Portal and mobile crane operators shall be certified according to NAVFAC P-306.

b. Crane operators not certified according to NAVFAC P-306 shall be trained and certified according to this document as detailed above.

6.6.5.3 Cranes and Hoists Daily Inspections

a. Using a pre-operational checklist, daily inspections shall be conducted on the equipment to be used at the beginning of each shift.

b. Daily inspections shall cover the following items:

1. The function of all controls and brake
2. The condition of all components that can be inspected without major disassembly and whose failure would cause a safety hazard

6.6.5.4 Slack Rope Inspections

If a slack rope condition has occurred, inspectors shall be positioned to observe the rope seating in the drum and sheave grooves as the load is reapplied.

6.6.5.5 Cranes and Hoists Used to Handle Critical Hardware Periodic Test and Inspection

a. All inspections, tests, and functional validations shall be performed using written procedures that describe safety control areas, emergency procedures, and supervisor and operator responsibilities.

b. Whenever crane inspection and testing and/or maintenance is contracted out by the government or Range User, periodic inspections and tests shall be performed by the contractor; all other inspections shall be performed by the Range User, (daily, weekly, monthly; before use type inspection or checks), unless specifically stated in the contract approved by Range Safety.

6.6.5.5.1 Cranes and Hoists Used to Handle Critical Hardware Monthly Inspections.

a. Wire rope shall be inspected using a GO/NO-GO gauge at several points. Any broken wire shall be reported for evaluation.

b. Hooks shall be inspected for visible cracks or deformities. The tram points shall be measured for throat spread. A straight edge shall be used to evaluate twisting.

c. Brakes shall be inspected for the amount of lining remaining and indications of overheating or glazing. The brake shall be adjusted to specifica-

tions.

6.6.5.5.2 Cranes and Hoists Used to Handle Critical Hardware Periodic Test Requirements. At a minimum, the following tests shall be performed on cranes and hoists annually within the calendar month in which they are due:

a. *Overhead Crane and Hoist Annual No-Load Functional Test.* A complete functional test of all control systems, safety devices, and warning indicators shall be performed after the annual load test.

b. *Overhead Crane and Hoist Annual 100 Percent Rated Load Tests.* Overhead cranes and hoists shall be load tested to 100 percent of the rated load. The test shall be performed in the following sequence:

1. The test weight shall be hoisted approximately 2 ft and suspended for a minimum of 3 min to verify hoist drum rotation test weight drift, as measured, are within acceptable limits.

2. The hoist overload and overspeed detection devices shall be tested to verify that they activate when the test weight is greater than 110 percent of rated load or any overspeed.

3. Electrical power shall be removed from the crane so that the holding and emergency drum brakes are engaged. The brakes shall be manually released in such a manner that each individual brake demonstrates its ability to hold the entire test weight within acceptable drift. Electrical power shall be reapplied.

4. The test weight shall be raised to the maximum height and then lowered in three increments, stopping each time to verify there is no uncommanded drum rotation or test weight lowering.

5. The test weight shall be transported by the trolley for the full length of the bridge.

6. The test weight shall be transported the full length of the runway in one direction with the trolley as close to the extreme right hand of the bridge as practical and in the other direction with the trolley as close to the extreme left hand of the bridge as practical.

7. The test weight shall be moved throughout the complete operating envelope of the overhead crane and hoist, stopping and starting at various locations to verify smooth operation.

8. Crane controls shall be tested to verify that the use of reversing or plugging can control or stop the hoist, trolley, and bridge motion.

9. Bridge and trolley brakes shall be tested to verify that they function in accordance with CMAA 70 and 74 and ANSI B30 Series requirements.

10. The hoist emergency load lowering system shall be tested to verify that it is fail safe and functions properly. The load shall not be lowered more than a few feet. The brakes shall be inspected and adjusted afterwards.

11. Bridge, trolley, and hoists shall be tested at each available specified speed including bumping and jogging.

c. Crane and Hoist Annual NDE Requirements. The following NDE tests shall be performed as indicated:

1. After completion of the 100 percent load test, surface NDE testing shall be performed on the exposed portions of hooks.

2. After completion of the 100 percent load test, volumetric and surface NDE testing shall be performed on all modified and repaired SFP components and SFP welds located on overhead crane and hoist support structures.

3. NDE shall be performed in accordance with the Range Safety approved NDE plan on all SFP components and SFP welds located on overhead and hoist support structures.

d. Crane and Hoist Annual Inspection Requirements. Cranes and hoists shall be visually inspected per ANSI and Range Safety inspection criteria.

6.6.5.6 Cranes and Hoists Used to Handle Critical Hardware Recurring Data Requirements.

At a minimum, the following data shall be maintained in the Crane and Hoist Recurring Test Data files:

- a.* Crane and hoist design and initial test data
- b.* NDE results for crane hook and SFP components and SFP welds on crane support structures
- c.* Periodic crane and hoist test plans and test results
- d.* Crane design and test data updates
- e.* An Operations Log Book shall be maintained for all cranes lifting critical loads.

6.6.5.7 Cranes and Hoists Used to Handle Non-Critical Hardware Periodic Test Requirements

At a minimum, the following tests shall be performed on cranes and hoists every four years unless otherwise approved by Range Safety:

- a. Overhead Crane and Hoist Functional Test*

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(No-Load). A complete functional test of all control systems, safety devices, and warning indicators shall be performed after load testing.

b. Portal and Mobile Crane Load Tests. Portal and mobile cranes shall be load tested to 100 percent of rated load.

c. Overhead Crane and Hoist 100 Percent Rated Load Tests. Overhead cranes and hoists shall be load tested to 100 percent of the rated load. The test shall be performed in the following sequence:

1. The test weight shall be hoisted approximately 2 ft and suspended for a minimum of 3 min to verify the hoist drum rotation and test weight drift are within acceptable limits.

2. The test weight shall be raised to the maximum height and then lowered in three increments, stopping each time to verify there is no uncommanded drum rotation or test weight lowering.

3. The test weight shall be transported the full length of the runway in one direction with the trolley as close to the extreme right hand of the bridge as practical and in the other direction with the trolley as close to the extreme left hand of the bridge as practical.

4. The test weight shall be raised to sufficient height and at least one emergency stop shall be made at the fastest lowering speed to verify that brake application is positive and effective.

5. The test weight shall be moved throughout the complete operating envelope of the overhead crane and hoist, stopping and starting at various locations to verify smooth operation.

6. Bridge and trolley brakes shall be tested to verify that they function in accordance with CMAA 70 and 74 and ANSI B30 Series requirements.

7. Bridge, trolley, and hoists shall be tested at each specified speed, including bumping and jogging.

d. Crane and Hoist NDE Requirements. After completion of the proof load test, surface NDE shall be performed on the exposed portions of overhead, portal, and mobile crane hooks.

e. Crane and Hoist Inspection Requirements. Cranes and hoists shall be visually inspected at required intervals in accordance with ANSI B30.2 and Range Safety inspection criteria.

6.6.5.8 Cranes and Hoists Used to Handle Non-Critical Hardware Recurring Data Requirements

At a minimum, the following recurring data is required as part of the Crane and Hoist Recurring Test Data File:

- a. Crane and hoist design and initial test data updates

- b. NDE test results for crane hooks

- c. Periodic crane and hoist test plans and test results

- d. Crane design and test data updates

6.6.5.9 Cranes and Hoists Re-Test and Re-Inspection

- a. Following major maintenance or modification, initial acceptance inspection and testing shall be conducted in accordance with the requirements in Chapter 3.

- b. If an accidental overload condition occurs, cranes and hoists shall be subjected to a complete initial reinspection and retest.

- c. The equipment user shall submit a written report to Range Safety detailing the nature, cause, and effect of the overload.

6.6.5.10 Dual Crane Lift Operating Requirements

Dual crane lifts are considered hazardous operations without regard to the load. The following is required:

- a. The load shall be restricted to no more than 75 percent of capacity for each crane

- b. All mobile crane dual lifts shall require load cells and installed load indicators.

- c. A dry run with a pathfinder shall be required for all critical hardware lifts.

- d. The Dual Crane Lift Plan addressing the following information shall be submitted to Range Safety for review and approval:

1. The exact weight (+/- 1 percent) of the total load including spreader bar/beam, hoist attachments fixtures and slings

2. Any dynamic forces that affect the load

3. All crane movements, including trolley, bridge, boom up and down, and travel

4. Center of gravity established by a qualified engineer throughout the complete lift

5. Certification of cranes and crane operators

6. Soil compaction

6.6.5.11 WR First Use Tag Program

a. Range Users requesting approval of a program in which specific equipment certification expiration date and time do not start until the item is issued or installed shall provide the following documentation to Range Safety for review and approval:

1. A complete list of all items by nomenclature with identifying part numbers, rated load, maximum test load, and operation where normally tested

2. An approved quality assurance program identifying controls, inspection points, and complete First Use Tag information

3. Identification of shelf-life criteria. **NOTE:** The shelf-life shall not exceed 5 years in an environmentally controlled location without retest.

b. Range Safety shall withdraw approval upon any infraction of the program.

6.6.5.12 Mobile Cranes

a. All mobile cranes operated on the Range for permanent or short term use shall be properly inspected, functionally validated, and maintained according to AFOSH 91-46, OSHA 1910, OSHA 1926, NASA 1740.9, applicable ANSI/ASME standards, applicable state OSHA plans and the requirements identified below. These requirements apply whether the equipment is DoD or contractor owned, rented, or leased.

b. Mobile cranes shall be certified for operational use by the appropriate authorizing agency.

c. Dual crane lift operations require Range Safety approved lift plans.

6.6.6 Sling Assembly Operations

6.6.6.1 Sling Assembly Operating Standards

a. All sling assemblies shall be operated, maintained, and tested in accordance with ANSI/ASME B30.9.

b. Slings shall be visually inspected each day prior to use.

6.6.6.2 Sling Assemblies Used to Handle Critical Hardware Periodic Tests

At a minimum, the following tests shall be performed on slings annually. Unless otherwise agreed to by Range Safety, these tests shall also be performed after a sling assembly has been modified or repaired.

a. Sling assemblies shall be proof load tested to

200 percent of rated load.

b. Chain falls shall be proof load tested to 100 percent of rated load.

c. After the proof load test, NDE testing shall be performed on all sling assembly SFP components in accordance with the Range Safety approved NDE plan.

d. After the proof load test, volumetric and surface NDE shall be performed on all modified and repaired sling assembly SFP components.

e. Sling assemblies shall be visually inspected in accordance with ANSI and Range Safety inspection criteria.

6.6.6.3 Sling Assemblies Used to Handle Critical Hardware Recurring Data Requirements

At a minimum, the following data is required as part of the Sling Assembly Recurring Test Data File.

a. Sling assembly design and initial test data

b. NDE results for SFP components

c. Periodic proof load test plan and test results

d. Sling design and test data updates

6.6.6.4 Sling Assemblies Used to Handle Non-Critical Hardware Periodic Test Requirements

At a minimum, the following tests shall be performed on sling assemblies every four years. Unless otherwise agreed to by Range Safety, these tests shall also be performed after a sling assembly has been modified or repaired.

a. Sling assemblies shall be proof load tested to 200 percent of rated load.

b. Chain falls shall be proof load tested to 100 percent of rated load.

c. Sling assemblies shall be visually inspected in accordance with ANSI inspection criteria.

6.6.6.5 Sling Assemblies Used to Handle Non-Critical Hardware Recurring Data Requirements

At a minimum, periodic proof load test and inspection results are required as part of the Sling Recurring Data File.

6.6.7 Hydraset and Load Cell Operations

6.6.7.1 Hydraset and Load Cell Operating Standards

Hydrasets and load cells shall be operated, maintained, and tested in accordance with the manufacturer specifications.

6.6.7.2 Hydrasets and Load Cells Used to Handle Critical Hardware Periodic Test Re-

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quirements

At a minimum, the following tests shall be performed on all hydrasets and load cells annually. Unless otherwise agreed to by Range Safety, these tests shall also be performed after a hydraset or load cell has been modified or repaired:

- a. Hydrasets and load cells shall be proof load tested to 125 percent of rated load and calibrated.
- b. After the proof load test, volumetric and surface NDE testing shall be performed on all modified and repaired SFP components and SFP welds.
- c. After the proof load test, NDE shall be performed on all hydraset and load cell SFP components and SFP welds in accordance with the Range Safety approved NDE plan.

6.6.7.3 Hydrasets and Load Cells Used to Handle Critical Hardware Recurring Data Requirements

At a minimum, the following data is required as part of the Hydraset and Load Cell Recurring Test Data File:

- a. Hydraset and load cell design and initial test data
- b. NDE test results for SFP components and SFP welds
- c. Periodic proof load test plan and test results
- d. Design and test data updates

6.6.8 Handling Structures Operations

6.6.8.1 Handling Structures Operating Standards

All structural lifting beam operations shall meet ANSI B30.20 for Range operations.

6.6.8.2 Handling Structures Used to Handle Critical Hardware Periodic Test Requirements

a. New or modified and repaired handling structures shall be tested in accordance with either Option 1 or Option 2 of Appendix 6G. *EXCEPTION: For portable launch support frames, with a yield factor of safety less than 3, Step 17 in Option 2 is changed to read "Proof test to 150 percent times rated load" and Step 16 is eliminated.*

b. Initial tests shall be performed following modification and repair or prior to first operational use at the Range.

6.6.8.3 Handling Structures Used to Handle Critical Hardware Recurring Data Requirements

At a minimum, the following recurring data is required as part of the Handling Structure Recurring Test Data File:

- a. Handling structure design and initial test data
- b. NDE test results for SFP components and SFP welds
- c. Periodic test plans and test results
- d. Design and test data updates

6.6.8.4 Handling Structures Used to Handle Non-Critical Hardware Periodic Test Requirements

At a minimum, handling structures shall be proof load tested to 200 percent of rated load every four years. Unless otherwise agreed to by Range Safety, these tests shall also be performed after handling structure modification and/or repair.

6.6.8.5 Handling Structures Used to Handle Non-Critical Hardware Recurring Data Requirements

At a minimum, periodic proof load test results are required as part of the Handling Structure Recurring Test Data File.

6.6.9 Personnel Work Platform Operations

6.6.9.1 Personnel Work Platform Operating Standards

Personnel work platforms shall be operated, maintained, and tested in accordance with the manufacturer specifications.

6.6.9.2 Removable, Extendible, and Hinged Personnel Work Platform Periodic Test Requirements

At a minimum, the following tests shall be performed on all personnel work platforms annually:

- a. Visual inspection shall be performed on all hinges, attaching points, and other high stress or abuse prone components.
- b. NDE shall be performed on all personnel work platform SFP components and SFP welds in accordance with the Range Safety approved NDE plan.
- c. After the proof load test, volumetric NDE shall be performed on all modified and repaired SFP components or SFP welds.
- d. Unless otherwise agreed to by Range Safety, personnel work platforms that have been modified and/or repaired shall be proof load tested to 125

percent of rated load.

6.6.9.3 Removable, Extendible, and Hinged Personnel Work Platform Recurring Data Requirements

At a minimum, the following recurring data is required as part of the Personnel Work Platform Recurring Test Data File:

- a. Platform design and initial test data
- b. NDE test results for SFP components and SFP welds
- c. Periodic personnel work platform test plans and results
- d. Design and test data updates

6.6.10 MHE Operations

6.6.10.1 Lifting Operations

6.6.10.1.1 Pre-operational Lifting Requirements. The person responsible for supervising lifting operations shall ensure the following:

a. The crane has met all of its maintenance, test, and inspection requirements and is operated within its rated capacity.

b. The operator is properly certified.

c. The operator remains at the controls the entire time a load is suspended. *EXCEPTION: Exceptions shall be allowed in the interest of operational efficiency to allow lifting hardware such as slings, spreader bars, below the hook lifting devices, load cells, and hydrasets to remain suspended while unattended provided all of the following conditions are met:*

1. A procedure documenting such exceptions has been approved by Range Safety

2. The lifting hardware suspended is connected to but not supporting the weight of the objective load; for example, the launch vehicle stage, motor segment, or payload

3. The load is scheduled to be lifted within 24h

4. The load and immediate vicinity are roped off or otherwise identified to prohibit unauthorized personnel entry

5. The crane controls are locked in the OFF position

6. The restrictions against people being under the suspended lifting hardware are enforced

d. The vicinity of the lift is controlled so that:

1. Unauthorized personnel entry is precluded.

*2. Personnel or any part of their bodies are prevented from being under or in the way of the load except as noted in the **Working Under a Sus-***

ended Load section of this Chapter.

3. For cranes equipped with booms, the area is defined by the swing radius of the crane and includes all of the rotating superstructure.

4. A large enough area is cleared so as to protect against flying debris from a dropped object

e. All personnel within the controlled hoisting area wear suitable head and foot protection.

f. Previously announced lightning advisories and lightning warnings will not cause the load to be in jeopardy. **NOTE:** Unattended suspended loads require specific Range Safety approval.

g. All personnel are knowledgeable of the operation to be performed, tasks to be done, route to be traveled, and safety considerations.

h. If using a mobile crane, the following criteria shall be met:

1. The area shall be set up so that the lift is made within the shortest possible radius

2. The lift shall be made over the rear of the crane if possible

3. Outrigger floats shall be made of 4x4 in. or cross-hatched 2x4 in. lumber, a minimum of 4x4 feet square or equivalent support.

4. When using outriggers, they shall be fully extended and raise the crane so that the wheels are off the ground unless the crane is designed for partial outrigger use and has appropriate load rating charts.

5. No part of the crane or load shall pass within 10 ft of an electrical power line unless the line is de-energized and visibly grounded on both sides of the area of possible contact.

6. Outriggers and outrigger floats shall be used on flat surfaces. NOTE: Outrigger floats are required in areas that do not have a hard surface such as concrete.

i. Systems shall have sufficient assistant operators or spotters to make sure that all sides of the system are clear for operation.

j. All operators or spotters shall have aural communications for coordination between themselves when power is on the system.

k. Tag lines shall be used when there is potential for load sway which could damage the article lifted, high value equipment or flight hardware.

l. Tag line personnel shall not impart undesirable motion to the load.

6.6.10.1.2 Attaching the Load. To attach the load, the crane hook shall be positioned directly over the center of gravity of the load prior to at-

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tachment.

6.6.10.1.3 Lifting the Load.

a. On the first lift of the day or shift, or on a critical lift, the load shall be raised a few inches, then held in place momentarily, to verify that the brakes operate normally.

b. The load shall be lifted to a height sufficient to clear all obstacles in its intended path.

c. For hoist angles, cranes are designed to function with the load raised perpendicular with respect to the ground. Crane hooks shall be moved with the crane controls rather than by hand to reduce hoist angles.

1. Fleet (side) angles shall be kept as close to zero as possible. Range Safety approval is required for all anticipated fleet angles. **NOTE:** Pulling the rope perpendicular to the drum or sheave grooves (fleet or side angle) may cause the rope to jump out of the groove and become entangled on the drum or caught between the sheave and its mounting with possible catastrophic results.

2. Lead (in-line) angles shall be kept as close to zero as possible. Range Safety approval is required for anticipated lead angles exceeding 5° unless the hoist is specifically designed for greater angles. Increasing the lead (in-line) angle increases the strain on the load line, brakes, bearings, sheaves, and other crane parts.

3. When lifting a load, load lines shall not contact load girts, structural members, or any other obstructions.

d. Loads may be lifted with the load line off-perpendicular for the purpose of rotating large pieces of hardware if all of the following conditions are met:

1. There is no safer way to accomplish the rotation.

2. The angle on the load line carrying the majority of the weight does not exceed 5° unless the hoist was specifically designed for a greater angle.

3. On an installed crane, the angle is pulled in line with the rotation of the rope onto the drum (lead angle) unless the crane is equipped with a level wind device.

4. The crane is inspected to ensure that the load line does not engage the load girts, structural members, or any other obstructions at the angle to be used.

5. Prior to the lift, the crane is checked to ensure that all rope parts are properly seated in the

grooves of the drums or sheaves.

6. The load is prevented from swinging or otherwise inducing dynamic loads on the hoisting system.

e. Mobile or boom-equipped cranes shall not be used for off-perpendicular lifting due to the severe hazard of tipping the crane over or of collapsing the boom.

f. Crane maintenance instructions or checklists shall include directions to look for evidence of apparent side-pull damage during inspections.

6.6.10.2 Suspended Load Operations

6.6.10.2.1 Moving a Suspended Load.

a. Crane operations involving lifting of hazardous or explosive materials shall be limited to only those personnel required to perform the task.

b. A safety clearance zone shall be established in the vicinity around the load and all non-essential personnel cleared to a safe distance.

c. Horizontal and vertical travel speeds shall be kept at a safe level and shall be addressed, as appropriate, in procedures.

d. Each lift shall be planned so that the load will be suspended for a minimum amount of time.

e. The load shall not be lifted until immediately before intended travel.

f. The most direct route of travel shall be used.

g. Loads shall not be carried over critical hardware except when that load is being mated to the critical hardware.

h. The landing area shall be prepared so that the load may be set down immediately at the end of travel.

i. If the load remains suspended for any length of time, the safety clearance zone shall remain in force.

j. The load shall not be carried over personnel nor shall personnel be allowed to place any part of their bodies under any part of the load except as provided in the **Working Under a Suspended Load** section of this Chapter.

k. The load shall be transported as low as possible but at a height sufficient to clear all obstacles that may be in its path.

l. An alarm device or personnel accompanying the load shall be used to clear other persons out of the load path.

m. Tag lines shall be used to control movement of the load and not impart undesirable motion to the load.

n. Tag lines shall be long enough to protect personnel from being struck by the load.

o. Tag lines shall be used when there is potential for load swag which could damage the article lifted, high value equipment, or flight hardware.

p. Crane operators shall be instructed to stop motion should anyone be in the path of the load or if anyone signals to stop.

6.6.10.2.2 Working Under a Suspended Load. Circumstances sometimes dictate the additional risk of placing part or all of a person's body under a load to perform necessary work. To allow such work to proceed, the following conditions shall be met:

a. A safety analysis shall be performed in accordance with the requirements described in the **Documentation Requirements** section of this Chapter.

b. Based on the safety analysis, Range Users shall publish procedures with safety requirements to be followed by personnel working under a suspended load.

c. Each Range User or operating agency shall form a Suspended Load Committee or equivalent.

1. Contractor Safety and Operations Safety shall be members of this committee.

2. In reviewing the necessity of such exposures, the committee shall assess the procedure to be followed and analyze the hazards involved.

3. Copies of the schedule and minutes of such committee meetings shall be forwarded to Range Safety for review and approval.

d. A secondary support system shall be used to assume support of the load if enough of a person's body is exposed to receive fatal injuries under the load.

e. The task shall be treated as a "critical lift."

f. There shall be no safer way to accomplish the task.

g. The absolute minimum number of personnel may be exposed and only as much of the person's body as is absolutely necessary for the shortest time possible.

h. The load shall be in the lowest position from which the work can be accomplished.

i. The crane shall be in a static condition, with power ON, and the operator at the controls.

j. If a mobile or boom-equipped crane is used, the load shall not be greater than 75 percent of the capacity of the load rating chart while the work below the load is in progress.

k. The person with supervisory responsibility shall be present observing the task at all times.

l. During joint operations involving the USAF and NASA on the Ranges, NASA personnel and their contractors shall remain outside the vicinity of the suspended load.

m. Range Safety shall be the final approval authority for all operations requiring work under a suspended load.

6.6.10.2.3 Crane Suspended Personnel Platforms. Operations involving lifting suspended personnel platforms are prohibited except as provided by AFOSH 91-46 and 29 CFR 1926.550 (g) and specifically authorized by Range Safety.

6.6.10.2.4 Man-Rated Crane Criteria. All cranes used to suspend personnel platforms and work baskets shall meet the following requirements:

a. Crane free fall features shall be deactivated.

b. Load testing of the current configuration shall have been performed within past 12 months.

c. Two-way communication shall be maintained between the crane operator and the person in the basket.

d. The crane operator shall be appropriately qualified

e. The total weight of the loaded personnel platform and related rigging shall not exceed 50 percent of the rated capacity for the radius and configuration of the crane or derrick.

f. All design requirements of Section 3.6.2.2.11 b. shall be verified prior to operations.

6.6.11 Forklift Operations

6.6.11.1 Forklifts Used in Hazardous Areas

a. Forklifts used in areas designated Class I, Division 1, Group C or D shall be rated and placarded EX in accordance with NFPA 505 and Underwriters Laboratories (UL) 583.

b. Forklifts used in areas designated Class I, Division 2, Group C or D shall be rated and placarded EE or EX in accordance with NFPA 505 and UL 583.

c. Forklifts shall not be used in either of the above areas if the movement of the forklift increases the hazard. For example, on the launch pad with a fueled booster, forklifts may be used inside the 100-ft Class I, Division 2 area to load articles onto the structure but may not be used on the

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structure where it could accidentally strike or puncture a pressure or propellant vessel.

6.6.11.2 Forklifts Used for Critical Loads

a. Forklifts used for critical load lifts shall be approved by Range Safety.

b. Critical loads shall not exceed 75 percent of the forklift capacity.

c. At a minimum, periodic and frequent inspection program, maintenance program, checklists, and proof load tests shall be submitted to Range Safety.

6.6.12 Elevators

a. Passenger elevators not designed in accordance with Chapter 5 criteria for freight shall not be used for propellant or other hazardous commodity.

b. Freight elevators used for the movement of ordnance that has been removed from original shipping containers, toxic propellants, or other hazardous commodities shall be controlled remotely.

c. Personnel shall not ride in elevators during movement of the commodities listed in *b* above.

6.7 ACOUSTIC HAZARD OPERATIONS

6.7.1 Acoustic Hazard Operating Standards

Acoustic (noise) protection shall be provided in accordance with the requirements in 29 CFR 1910.95 and AFOSH 91-31, 161-20, and 48-19.

6.7.2 Acoustic Hazard Operations Personnel Protection Requirements

a. Unprotected personnel shall not be exposed to hazardous noise levels.

b. Hearing protection devices shall be worn as required.

6.7.3 Acoustic Operations

a. All potential noise sources in the work environment shall be identified to the Bioenvironmental Engineer.

b. Identified noise sources shall be surveyed by the Bioenvironmental Engineer or a designated representative.

c. Warning signs shall be posted in a manner to be visible prior to entering the noise hazard area.

1. Warning signs shall warn of the hazardous noise and indicate the requirement for hearing protection.

tection.

2. Any posting of hazardous noise areas shall be coordinated with and approved by the Bioenvironmental Engineer.

6.8 NON-IONIZING RADIATION OPERATIONS

6.8.1 Non-Ionizing Radiation Operating Standards

a. Personnel and electroexplosive devices (EEDs) shall not be exposed to hazardous levels of non-ionizing radiation.

b. All non-ionizing radiation operation shall be conducted in accordance with the requirements of the following standards:

1. 45 SWI 40-201 and 30 SWI 48-102 for personnel exposure limits that are subject to change and are frequency dependent

2. AFMAN 91-201, DoD 6055.9-STD, and MIL-STD-1576 for radiation limits for ordnance exposure and that are frequency dependent

3. AFMAN 91-201, DoD 6055.9-STD, and T.O. 31Z-10-4 for guidance with respect to siting ordnance

c. The use and operating location of non-ionizing radiation producing devices shall be approved by Range Safety and the RPO.

6.8.2 RF Procedures

All transmitters capable of exceeding allowable power levels shall be operated using Range Safety and RPO approved procedures with the appropriate controls established.

6.8.3 RF Operations

6.8.3.1 RF Operations General Requirements

a. Non-ionizing radiation operations involve radio frequency (RF) transmitters in the range of 3 kHz-300 GHz and optical devices such as lasers.

b. Prior to transmitting, areas in which power density levels exceed allowable biological limits shall be controlled using the appropriate warning signs, lights, and access barriers.

c. The RPO shall survey RF transmitting devices as required.

d. The Range User or site operator shall comply with the survey recommendations.

e. Where applicable, transmitter and antenna orientation limit switches and other safety devices shall be checked by site personnel prior to operation

to ensure proper function. **NOTE:** If transmission is required while performing these checks, the tests shall be performed at low output power or with a dummy load.

f. All new, modified, or relocated RF transmitters shall be reported to Range Safety and the RPO so that requirements can be established.

6.8.3.2 RF Transmission Operations for Electroexplosive Devices and Open Grain Solid Propellant

a. As determined by analyses and tests, local or Range-wide RF silence is required during periods of EED installation, removal, and electrical connection or disconnection. At a minimum, RF silence within the complex or area shall be required.

b. Radio transmitters shall be kept away from systems with installed EEDs in accordance with the guidance found in AFMAN 91-201, paragraph 2.58.

c. Transmitting devices shall be kept a minimum of 50 ft from a fueling area unless they are intrinsically safe.

6.8.4 Optical/Laser Operations

6.8.4.1 Optical/Laser Operating Standards

Optics and lasers shall be operated in accordance with 45 SWI 40-201, 30 SWI 48-102, and 10 CFR 19.

6.8.4.2 Optical/Laser Operation Personnel Protection Requirements

6.8.4.2.1 Optical/Laser Operations Training and Certification. Personnel shall be trained and certified in accordance with 45 SWI 40-201 or 10 CFR 19.

6.8.4.2.2 PPE. Approved protective eye wear and other PPE shall be worn as required.

6.8.4.3 Optical/Laser Procedures

All optical devices and lasers capable of exceeding allowable energy levels, as determined by Range Safety, shall be operated using Range Safety and RPO approved procedures with the appropriate controls established.

6.8.4.4 Optical/Laser Inspection

a. Periodic inspections shall be conducted to ensure the laser is in safe working condition and is properly protected from dangerous light radiation, temperature extremes, shatterable materials, contaminating gases, cryogenics, high voltage, and X-

rays.

b. Inspection records shall be maintained for the life of the program.

c. Inspection records shall be available at the request of Range Safety.

6.8.4.5 Optical/Laser Operations

a. All nominal hazardous procedural items shall be accomplished including, but not limited to, the following:

1. 24-h notification of Operations Safety
2. Pre-operational PA announcements
3. Clearance of safety clearance zones
4. Posting of applicable warning signs, operation of area and pad warning lights
5. Operations Safety permission prior to start of the hazardous lasing activity

b. Alignment of targets, optics, filters, and other optical/laser items shall be accomplished using non-hazardous low power lasers.

c. Active beam or target viewing shall be accomplished with closed circuit television or an optical comparator with an appropriate filter.

d. Laser beams directed toward flammable or explosive materials, pressurized systems, any other system that may become hazardous due to laser energy or directed toward sensitive components of FTSs shall not exceed allowable limits as determined by Range Safety.

e. Activated lasers shall not be left unattended.

f. Unattended lasers shall be locked out and otherwise safe.

g. Operations involving laser systems with hazardous materials shall follow the requirements for hazardous materials described in the **Hazardous Materials Operations** section of this Chapter.

h. Operations involving laser systems with pressurized subsystems such as cryogenic fluids shall follow the requirements described in the **Ground Support Pressure Systems Operations** and **Flight Hardware Pressure Systems Operations** sections of this Chapter.

i. Operations involving lasers with high voltage or capacitance shall follow the requirements for the **Electrical Systems Operations** section of this Chapter.

j. All electrical and mechanical azimuth and elevation stops, safety interlocks, shutters, and other safety devices shall be verified prior to performing each laser operation.

6.9 RADIOACTIVE (IONIZING)

REFERENCED DOCUMENTS

RADIATION) SOURCES OPERATIONS

All procedures for handling radioactive sources require Range Safety, RPO, and Medical Group approval.

a. Launch approval of radioactive (ionizing radiation) sources are addressed in Chapter 3 of this document.

b. All ionizing operations shall be planned and conducted so that personnel exposure is as low as possible, but in no case shall the maximum allowable limits be exceeded.

c. Requirements established in 45 SWI 40-201 or 30 SWI 40-101 are mandatory for CCAS and VAFB operations. All procedures for handling radioactive sources require Range Safety, RPO, and Medical Group approval.

d. CCAS Cape Support (ER) or Range Scheduling (WR), Range Safety, and the RPO shall be notified of the location of radioactive material if spilled, released, or dispensed either by design or accident.

e. Flight radioactive sources shall be installed as late in the countdown as practical.

f. Mishaps involving radioactive materials shall be reported in accordance with AFI 91-110.

6.10 HAZARDOUS MATERIALS OPERATIONS

6.10.1 Hazardous Materials Operating Standards

a. Hazardous materials shall be selected in accordance with Chapter 3 of this document.

b. Hazardous operations shall be conducted in accordance with AFOSH 161-21, 29 CFR 1910.1200, 29 CFR 1910.119 and AFOSH 91-119 for process safety management.

c. Range Users shall comply with AFOSH 91-119 and 29 CFR 1910.119 for process safety management.

d. Additional ER Requirements: Range Users shall comply with the 45 SW Process Safety Management Implementation Plan. The 45 SW point of contact for process safety management is System Safety (45 SW/SES).

e. Additional WR Requirements: Range Users shall comply with 30 SW Plan 91-119. The 30 SW point of contact for process safety management is System Safety (30 SW/SES).

6.10.2 Hazardous Materials Operations PPE

a. Proper eye, hand, body, and respiratory protection shall be worn as required.

tection shall be worn as required.

b. PPE shall be approved by Range Safety and the Bioenvironmental Engineer.

6.10.3 Hazardous Materials Procedures

Hazardous materials procedures shall include, but not be limited to, the following topics:

a. Emergency actions for unplanned events such as spills, fires, and personnel contamination

b. Actions for decontamination, neutralization, clean-up, and disposal

6.10.4 Hazardous Materials Operations

a. The use of any hazardous material is subject to Range Safety approval. **NOTE:** Hazardous material approval is normally through Bioenvironmental Engineering in the procurement process.

b. Appropriate control measures shall be established for the use of hazardous materials based on known properties. **NOTE:** If properties are unknown, testing shall be performed subject to approval by Range Safety.

c. Typical control measures for hazardous liquids include, but are not limited to, the following criteria:

1. Approved containers shall be used.

2. Containers shall remain capped (covered) when not in use.

3. Quantities shall be limited as approved by Fire Protection.

4. Work areas shall contain no more than the quantity required for a single shift.

5. Work areas shall not be used for storage unless approved storage cabinets and lockers are available.

6. Local or general exhaust ventilation shall be used to control solvent vapors from reaching toxic levels.

7. Materials that are themselves not hazardous, but that can be hazardous in conjunction with other materials, shall be controlled.

8. The location and/or facility shall be compatible with the type and quantity of hazardous material.

9. Hazardous materials and chemicals shall not be used in confined spaces without specific approval from Range Safety

10. Static producing materials, in particular materials such as plastic and non-metallic films, environmental covers, and thermal blankets shall not be used in the vicinity of ordnance or propellants.

11. Glass containers shall not be used in the immediate vicinity of flight hardware or in elevated locations so that they could fall and shattered pieces of glass strike hardware or personnel. In general, use of glass containers is discouraged.

d. The Toxic Release Contingency Plan shall be used in the event of an unplanned release.

6.10.5 Restrictions on the Use of Static-Producing and Flammable Materials

a. Static-producing and flammable materials shall not be used on or near ordnance items or in the vicinity of flammable liquids such as propellants.

b. Compliance with the restriction on static-producing materials is handled on a case-by-case basis; however, the following criteria shall be used as a guideline:

1. Materials shall not come into contact with a system having an installed EED or other ordnance.

2. Materials shall not come with 10 ft of exposed solid propellant grain; for example, no nozzle plug or cover.

3. Materials shall not come within 50 ft of exposed flammable liquids.

c. Compliance with the use of materials that could be flammable is handled on a case-by-case basis; however, all materials that are used in the vicinity of ordnance or flammable liquids such as hypergolic propellants shall pass the material tests described below.

6.10.5.1 Material Tests

a. Materials such as contamination covers, thermal blankets, splash shields, velcro, tape and any other material located in the vicinity of liquid propellant areas or ordnance areas shall be evaluated.

b. Range Users shall supply a sample of materials to KSC testing laboratory for testing, and the results shall be forwarded to Range Safety as required. **NOTE 1:** A KSC/Ranges materials list providing the test results of many types of materials is available from KSC Materials Testing Labs. **NOTE 2:** A material is considered to have good electrostatic dissipation properties if it can dissipate voltage down to 350V in 5 sec using the triboelectric test.

c. Testing shall consider the following material characteristics:

1. Ability to build up a charge (triboelectric

test)

2. Ability of that charge to decay (triboelectric test)

3. Flammability

4. Compatibility with other materials and liquids the material may come into contact with

d. Material restrictions may also arise from other limitations such as being humidity dependent (for charge dissipation) or degradable in sunlight (ultraviolet).

e. Range Safety shall approve the use of materials based on the test results. **NOTE:** Materials that do not meet this criteria may be acceptable for a particular usage as determined by Range Safety.

f. Material deficiencies shall result in operational restrictions.

6.10.6 Hazardous Commodity Lockers

6.10.6.1 Positioning and Use of Hazardous Commodity Lockers

a. Hazardous commodity lockers or cabinets shall be positioned and used for the purpose of storing flammable, toxic, or caustic materials in accordance with AFOSH 127-43.

b. The following rules govern the positioning and use of lockers and cabinets:

c. General Requirements

1. Only metal lockers shall be used for storage of hazardous commodities.

2. Metal lockers shall be grounded.

3. Only small quantities of commodities used in daily work shall be stored.

4. The lockers shall be kept locked to prevent unauthorized access.

5. Only unit containers shall be stored; for example, boxes of paint spray cans may not be stored.

6. Ordinary combustibles such as rags, packing, boxes, or loose paper material shall be removed.

7. Flammables, combustibles, and lubricants may be stored together, but they shall be grouped for identification.

8. Oxidizers shall be stored separately from fuels and shall be grouped for identification.

9. Acids and bases shall be segregated from each other and from other commodities in separate lockers.

10. Different products shall be grouped within the locker for identification.

11. Toxics shall be stored in separate lockers and grouped within the locker.

12. Lockers shall be kept clean and neat.

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13. A suitable fire extinguisher shall be positioned close to the locker or cabinet.

d. Indoor Lockers and Cabinets

1. Lockers shall be positioned so as not to impede emergency egress from the building.

2. The capacity of the locker shall not exceed 10 gal and the capacity of containers in the lockers shall not exceed 1 gal.

e. Outdoor Lockers and Cabinets

1. Lockers shall be located at least 50 ft from building entrances and be positioned so that in the event of a fire in the cabinet, there shall be no danger of the fire spreading to other buildings.

2. The capacity of the locker shall not exceed the limits specified in AFOSH 127-43, 4b(1) and NFPA30 4-3.1.

3. Not more than 120 gal of Class I, Class II, and Class III liquids shall be stored in a storage cabinet. Of this 120 gal total, not more than 60 gal shall be Class I and Class II liquids.

4. No more than three cabinets may be located in a single fire area.

6.10.6.2 Hazardous Commodity Locker Inspection

Hazardous commodity lockers shall be inspected at least weekly by the Range User.

6.10.7 Disposal of Contaminated Liquid Propellant, Gas, or Other Regulated Wastes

a. CCAS Cape Support (ER) or Range Scheduling (WR) shall be notified of any hazardous material requiring disposal. **NOTE:** If required, additional guidance shall be obtained from Civil Engineering (Environmental Coordinator) or their designated representative, the Bioenvironmental Engineer, and Range Safety

b. Disposal of toxic or contaminated liquid propellants, gases, or other wastes shall be performed using methods and techniques approved by Range Safety, the Bioenvironmental Engineer, and Civil Engineering (Environmental Coordinator) in accordance with the 45th and 30th Space Wing Operations Plan 19-14 as well as all applicable federal, state, and local regulations.

c. Range Users shall notify Civil Engineering to obtain proper clearance and support to dispose of wastes prior to the generation of such wastes.

d. As needed, those operations involving toxic propellants shall be conducted under the surveil-

lance of Environmental Health and Operations Safety to ensure the safety of personnel involved in the operation and personnel located in adjacent or downwind areas.

e. Records of management and identification of wastes shall be maintained by the organization generating the waste.

f. Records of disposal of toxic materials shall be maintained by Hazardous Waste Management (Joint Propellants Contractor for ER).

g. Hazardous procedures pertaining to liquid propellants shall be submitted to the 45th CES/CEG on the ER and to 30th CEG/CEBD on the WR for review and approval.

h. All spills or releases of hazardous substances, including petroleum products, shall be reported to CCAS Cape Support (ER) or Range Scheduling (WR) and Operations Safety immediately.

6.11 GROUND SUPPORT PRESSURE SYSTEMS OPERATIONS

6.11.1 Ground Support Pressure Systems Operating Standards

NOTE: The degree of hazard in pressure systems is proportional to the amount of energy stored, which is a function of both the pressure and the volume stored. Therefore, low-pressure, high-volume systems can be as hazardous to personnel as high-pressure systems.

a. Only pressure systems that meet the design requirements of Chapter 3 shall be operated on the Ranges.

b. The handling and storage of propellants shall be in accordance with CPIA 394 and DoD 6055.9-STD and subtier documents such as AFMAN 91-201 or Navy OP 5.

c. Propellants shall be used and stored only in Range Safety approved facilities designed and suited for that purpose and only during time periods approved by Range Safety

d. Propellants shall be used and stored only in systems that meet the design requirements of Chapter 3.

e. Portable or mobile vessels and packaging used for transportation of pressurized or hazardous commodities shall be designed, maintained, and recertified in accordance with DOT CFR 49.

f. If a DOT vessel is installed on a permanent basis, it shall fall under the recertification requirements for a fixed system.

6.11.2 Ground Support Pressure Systems Personnel Requirements

6.11.2.1 Ground Support Pressure Systems Training and Certification

All personnel who operate, test, and maintain ground support pressure systems shall be trained and certified.

6.11.2.2 Ground Support Pressure Systems PPE

6.11.2.2.1 Selection of PPE. The selection and use of personal protective equipment shall be approved by Range Safety and Bioenvironmental Engineering.

a. Approval shall be limited to a particular model number of protective equipment and a particular operation.

b. Approval of PPE for an operation depends on the type and volume of propellants involved, the size of the lines, flow rate, pressure, capability to deal with emergencies, and egress accessibility.

c. Approvals are not transferable; approval for similar operations require a re-evaluation of these parameters.

d. Protective gear shall be compatible with the propellants involved and shall be fire resistant and non-static producing as well.

e. If the protective gear has limitations, these limitations and subsequent protective actions shall be identified in the operating procedure. For example, splash suits are not to be used when hydrazine concentrations can exceed 100 ppm.

6.11.2.2.2 SCAPE, Category I or IV. SCAPE, Category I and IV is required for propellant flow and pressurization during the following operations:

a. Connection and disconnection of wet lines or contaminated (not purged and flushed) dry lines

b. Sampling operations

c. During propellant flow

d. During initial pressurization with propellants until system integrity has been verified (no leaks)

e. Connections and disconnections of tanker load/off load lines

f. Removal and replacement of components in a liquid line

g. Opening any liquid system that has not been drained, purged, and flushed with referee fluid

h. When the condition of the system is uncertain or unknown

i. The maximum operating time in a Category

I SCAPE suit is 110 min; however, Range Safety or Operations Safety can authorize on-station time not to exceed 120 min. In extreme temperatures, Range Safety or Operations Safety can restrict on-station times in Category I SCAPE suits to less than 110 min. (ER Only) Personnel using Category I SCAPE suits shall observe a 60-min rest period between consecutive SCAPE operations (for example, no double-packing).

j. For physiological purposes, the maximum operating time in a Category IV or VI SCAPE suit must not exceed 4 h at one time.

6.11.2.2.3 Splash Suits. Splash suits, with self-contained breathing apparatus or air-line respirator may be approved by Range Safety for use with systems that only contain residual vapors; no liquid in the system is allowed.

a. Removal of full protective gear after system integrity verification requires Operations Safety approval.

b. Emergency protective gear shall be available throughout operations to the crew and other personnel who might be affected in the event of a spill.

c. The following non-liquid operations require splash suits as approved by Range Safety:

1. Removal and replacement of components on purged and isolated liquid lines

2. Removal and replacement of components on vent lines

3. Connections and disconnections of drained, purged, and isolated lines

4. Pressure leak checks when required by procedure

d. With Operations Safety Manager concurrence, the WR allows the use of splash suits during propellant flow after integrity has been established.

REFERENCED DOCUMENTS

6.11.2.2.4 PPE for Cryogenic Systems.

a. All personnel performing liquid oxygen and liquid hydrogen transfer operations, repairs, or adjustments to the system shall wear flame-resistant treated, non-static producing overalls of liquid resistant material, cryogenic service gloves, hoods or face shields, and non-absorbent shoes approved by Range Safety.

b. Personnel performing operations on other cryogenic systems shall be similarly protected, except that flame-resistant treating of coveralls is not required for non-flammable commodities.

6.11.2.2.5 PPE for Hydrogen Peroxide Transfers. Hydrogen peroxide transfers require the use of boots, gloves, and face shields of material approved by Range Safety.

6.11.3 Ground Support Pressure Systems Procedures

a. Procedures shall be prepared governing the safe operation, testing, maintenance, and installation of pressurized systems by the agency performing the specific task.

b. Procedures shall be developed for all operations involving propellants and the checkout of propulsion systems.

c. Off-loading procedures for payloads and launch vehicles are required at any time propellant is loaded in flight hardware. Off-loading design as outlined in Chapter 3 of this document addresses the complete system during the complete processing flow. The off-loading procedure shall include integration of the following:

1. Hardware
 - (a) Launch vehicle
 - (b) Launch vehicle fairing
 - (c) Spacecraft
 - (d) Launch complex
 - (e) Process facility
 - (f) Transport vehicle
 - (g) Fixed GSE
 - (h) Portable GSE
2. Software Command capability
 - (a) Flight Hardware
 - (b) GSE
3. Personnel capability
 - (a) Remote
 - (b) SCAPE
 - (c) Combination of both

6.11.4 Ground Support Pressure Systems Test, Inspection, and Maintenance

6.11.4.1 Ground Support Pressure Systems General Tests

a. Pressure systems shall be initially tested in accordance with Chapter 3.

b. Any system that has been opened shall be leak tested at 100 percent maximum operating pressure (MOP) with an inert medium.

c. Pressure relief valves and flex hoses shall be retested annually.

d. Pressure gauges shall be calibrated annually.

e. After any disconnection, modification, or repair of a system, the affected part of the system shall be leak tested.

f. Any component that has been damaged, potentially damaged, repaired, replaced, or modified shall be pressure proof tested in accordance with Chapter 3.

g. After component pressure proof test, the system or subsystem shall be pressure proof tested, functionally tested, and leak tested. **NOTE:** The determination for system proof testing shall be made on a case-by-case basis.

h. New, modified, or repaired propellant systems shall be tested in accordance with Chapter 3.

i. A log shall be kept on propellant systems to keep track of use, maintenance, modification, testing, and inspection.

6.11.4.2 Ground Support Pressure Systems General Inspection

a. Prior to each operation, facilities and equipment shall be inspected by Range Users and Operations Safety to ensure a safe configuration for the facilities, equipment, and propellants involved.

b. Propellant transfer and storage areas shall be spot checked by Operations Safety, Range Safety, the Fire Department, Environmental Health; the appropriate area supervisor shall be advised of any discrepancies noted.

c. Periodic inspections shall be performed on all ground pressure systems in accordance with applicable procedures.

d. Periodic inspections shall be performed on ground based pressure vessels and liquid holding tanks in accordance with the ISI Plan. These inspections shall be performed during the following periods:

1. Certification Period: Period from initial op-

erational use of vessel and/or system until vessel and/or system requires recertification.

2. First Certification Period: Period from first recertification effort until second recertification.

3. All subsequent Recertification Periods.

4. The hazardous pressure system operator shall retain all documentation generated as a result of the recertification effort and place this documentation in the system ISI certification and recertification file.

6.11.4.3 Ground Support Pressure Systems General Maintenance

a. Prior to replacement, storage, or repair of hypergolic or toxic system components, the system shall be purged and flushed of all residual contaminants and appropriately capped, bagged, and labeled prior to moving the component.

b. A record shall be kept on the certification of system and component cleanliness.

6.11.4.4 Ground Support Pneumatic Systems Tests

6.11.4.4.1 Periodic Test Requirements for Ground Support Pneumatic System Components.

a. Flex hoses shall be hydrostatically proof tested to 1.5 times their MAWP once a year unless otherwise approved by Range Safety.

b. All permanently installed flex hoses shall be visually inspected over their entire length at least annually for damaged fittings, broken braid, kinks, flattened areas, or other evidence of degradation.

c. Pressure gauges and transducers shall be calibrated once a year.

d. Pressure relief valves shall be tested for proper setting and operation once a year.

6.11.4.4.2 Testing Modified and Repaired Ground Support Pneumatic Systems.

a. Any pressure system or system component including fittings or welds that has been repaired, modified, or possibly damaged after having been hydrostatically tested shall be retested hydrostatically to 1.5 times MAWP prior to reuse. **NOTE:** Replacement of gaskets, seals, and valve seats that do not affect structural integrity does not require a retest.

b. After hydrostatic testing, modified or repaired pneumatic systems shall be leak tested at the system MOP prior to normal use. **NOTE:** This test shall be conducted at the Ranges unless prior ap-

proval from Range Safety as been obtained.

c. After hydrostatic testing, modified or repaired pneumatic systems shall be revalidated and functionally tested at the system MOP prior to reuse.

d. All pneumatic system mechanical joints affected in the disconnection, connection, or replacement of components shall be leak tested at the system MOP before being placed back in service.

6.11.4.4.3 Ground Support Pneumatic Systems Tagging.

a. After test and inspection, ground support pneumatic system components shall be tagged.

b. Tags shall provide the date of the last inspection and pressure proof load test and the component MAWP.

6.11.4.5 Ground Support Hydraulic Systems Tests

6.11.4.5.1 Periodic Test Requirements for Ground Support Hydraulic System Components.

a. Flex hoses shall be hydrostatically proof tested to 1.5 times their MAWP once a year, unless otherwise approved by Range Safety.

b. All permanently installed flex hoses shall be visually inspected over their entire length at least annually for damaged fittings, broken braid, kinks, flattened areas, or other evidence of degradation.

c. Pressure gauges and transducers shall be calibrated once a year.

d. Pressure relief valves shall be tested for proper setting and operation once a year.

6.11.4.5.2 Testing Modified and Repaired Ground Support Hydraulic Systems.

a. Any hydraulic system or system component including fittings or welds that has been repaired, modified, or possibly damaged after having been hydrostatically tested shall be retested hydrostatically to 1.5 times MAWP prior to reuse. **NOTE:** Replacement of gaskets, seals, and valve seats that do not affect structural integrity does not require a retest.

b. After hydrostatic testing, modified or repaired hydraulic systems shall be leak tested at the system MOP prior to normal use. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety as been obtained.

c. After hydrostatic testing, modified or repaired hydraulic systems shall be functionally tested at the system MOP prior to being place back in

REFERENCED DOCUMENTS

service.

d. All hydraulic system mechanical joints affected in the disconnection, connection, or replacement of components shall be leak tested at the system MOP before being placed back in service.

6.11.4.5.3 Ground Support Hydraulic Systems Tagging.

a. After test and inspection, ground support hydraulic system components shall be tagged.

b. Tags shall provide the date of the last inspection and pressure proof load test and the component MAWP.

6.11.4.6 Ground Support Hypergolic Systems Tests

6.11.4.6.1 Periodic Test Requirements for Ground Support Hypergolic Systems.

a. Flex hoses shall be hydrostatically proof tested to 1.5 times their MAWP once a year, unless otherwise approved by Range.

b. All permanently installed flex hoses shall be visually inspected over their entire length at least annually for damaged fittings, broken braid, kinks, flattened areas, or other evidence of degradation.

c. Pressure gauges and transducers shall be calibrated once a year.

d. Pressure relief valves shall be tested for proper setting and operation once a year.

6.11.4.6.2 Testing Modified and Repaired Ground Support Hypergolic Systems.

a. Any hypergolic system or system component including fittings or welds that has been repaired, modified, or possibly damaged after having been hydrostatically tested shall be retested hydrostatically to 1.5 times MAWP prior to reuse. **NOTE:** Replacement of gaskets, seals, and valve seats that do not affect structural integrity does not require a retest.

b. A hypergolic system that has been modified or repaired shall be leak tested at the system MOP prior to its normal use. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety as been obtained.

c. After hydrostatic testing, modified or repaired hypergolic systems shall be functionally tested at the system MOP prior to being placed back in service.

d. All hypergolic system mechanical joints affected in the disconnection, connection, or re-

placement of components shall be leak tested at the system MOP before being placed back in service.

6.11.4.6.3 Ground Support Hypergolic Systems Tagging.

a. After test and inspection, ground support hypergolic system components shall be tagged.

b. Tags shall provide the date of the last inspection and pressure proof load test and the component MAWP.

6.11.4.7 Ground Support Cryogenic Systems Tests

6.11.4.7.1 Periodic Test Requirements for Ground Support Cryogenic Systems.

a. Flex hoses shall be hydrostatically proof tested to 1.5 times their MAWP once a year, unless otherwise approved by Range Safety.

b. Pressure gauges and transducers shall be calibrated once a year.

c. Pressure relief valves shall be tested for proper setting and operation once a year.

6.11.4.7.2 Testing Modified and Repaired Ground Support Cryogenic Systems.

Any cryogenic system component that has been repaired or modified shall be retested by the following sequence:

a. The component shall be hydrostatically tested to 1.5 times the component MAWP. **NOTE:** The fluid shall be at ambient temperature

b. A hydrostatic test using an inert cryogenic fluid at or below the expected lowest temperature shall be performed in accordance with the requirements in Chapter 3, section 3.11.5.11.1, **Hydrostatic Tests.**

c. The component shall be reinstalled in the system and a leak check performed in accordance with the requirements in Chapter 3, section 3.11.5.11.3, **Pneumatic Leak Tests.**

6.11.4.7.3 Ground Support Cryogenic Systems Tagging.

a. After test and inspection, ground support cryogenic system components shall be tagged.

b. Tags shall provide the date of the last inspection and pressure proof load test and the component MAWP.

6.11.4.8 Ground Support Pressure Vessels and Liquid Holding Tanks Recertification

NOTE: These requirements are repeated from

Chapter 3. Data shall be submitted as part of the MSPSP as required in Chapter 3.

6.11.4.8.1 Ground Support Pressure Vessels and Liquid Holding Tank Recertification Standards. Recertification of ground based pressure vessels and liquid holding tanks shall be performed in accordance with ESMC TR-88-01.

6.11.4.8.2 Ground Support Pressure Vessels and Liquid Holding Tank General Recertification Criteria. The recertification period for ground based pressure vessels and liquid holding tanks shall not exceed the shortest period based on the following criteria:

- a. The shortest service life based on an assessment of in-service failure mechanisms in accordance with the ISI plan
- b. Twenty years for systems and for vessels that can be 100 percent inspected both internally and externally
- c. Ten years for systems and for vessels that cannot be 100 percent inspected internally but can be 100 percent inspected externally
- d. Five years for systems and for vessels that cannot be 100 percent inspected either internally or externally
- e. Manufacturer recommendation

6.11.4.8.3 Ground Support Pressure Vessel and Liquid Holding Tank Recertification Criteria.

a. All ground based pressure vessels and liquid holding tanks shall be recertified when one or more of the following changes or conditions occur:

1. The vessel or tank is planned for service at a higher or lower temperature than the previous certification and/or recertification.
2. The vessel or tank was removed from service and deactivated without protection from environmental effects; for example, the vessel is not stored inside an environmentally controlled building and does not have a positive internal pressure.
3. The vessel or tank was relocated from another installation, agency, or source.
4. There is a change of service or commodity, resulting in a new failure mechanism or a change in failure mechanisms.
5. The vessel or tank was repaired or modified.
6. The vessel or tank has reached the end of its certification or recertification period.

b. Portable or mobile vessels and packaging used for transportation of pressurized or hazardous commodities shall be maintained and recertified in

accordance with 49 CFR. **NOTE:** If a DOT vessel is installed on a permanent basis, it shall fall under the recertification requirements for a fixed system.

c. Periodic inspections shall be performed on hazardous pressure systems in accordance with the ISI Plan (See the **Inservice Operating, Maintenance, and Inspection Plan** section of Chapter 3). These inspections shall be performed during the following periods:

1. From initial operational use of the vessel and/or system until the vessel and/or system requires recertification. (Called recertification period)
2. Period from first recertification effort until second recertification. (Called first recertification period)
3. All subsequent recertification periods.

d. The hazardous pressure system operator shall retain all documentation generated as a result of the recertification effort and place this documentation in the system certification and recertification file located at the Ranges.

6.11.4.8.4 Ground Support System Engineering Assessment and Analysis.

a. *General Requirements*

1. An engineering assessment and/or analysis shall be performed prior to the start of the first recertification period.
2. The engineering assessment of the design, fabrication, material, service, inspection, and testing shall be evaluated against the latest codes, standards, regulations, and requirements identified in this document.
3. Discrepancies with the latest requirements shall be resolved by repair, modification, analysis, inspection, or test.

b. *Design, Fabrication, and Installation Deficiencies.* At a minimum, the following potential design, fabrication, and installation type deficiencies shall be addressed:

1. Design deficiencies such as design notches, weld joint design, and reinforcements
2. Material deficiencies such as laminations, laps, seams, cracks, hardness variations, or notch brittleness
3. Welding deficiencies such as cracks, incomplete fusion, lack of penetration, overlap, undercut, arc strikes, porosity, slag inclusions, weld spatter, residual stresses, and distortion
4. Installation deficiencies such as fit-up, alignment, attachments, and supports

c. *Operations and Maintenance Deficiencies.*

REFERENCED DOCUMENTS

At a minimum, the following potential operation and maintenance deficiencies shall be assessed:

1. Refurbishment damage
2. Modification and repair deficiencies
3. Operation beyond allowable limits or improper sequence
4. Maintenance deficiencies

d. Analysis Methodology. The engineering analysis shall be performed as follows:

1. A stress analysis of all vessels and piping shall be available for evaluation or performed to verify that stresses are within allowable limits of current codes, standards, and regulations as identified in this document.

2. The number of stress cycles experienced by the vessel during the Certification Period as well as the number of cycles expected during the First Recertification Period shall be determined.

3. A safe-life analysis shall be determined in accordance with the following requirements:

(a) A fatigue analysis shall be performed to determine the remaining cycles to failure.

(b) A fracture mechanics safe-life analysis shall be performed on vessels with a burst-before-leak failure mode and on vessels whose structural integrity can not be determined by NDE (the vessel can not be 100 percent inspected internally or externally). Failure mode determination shall be in accordance with Section 3.12.2.

(c) If performed, the fatigue and fracture mechanics analysis shall be reviewed and approved by Range Safety.

6.11.4.8.5 Ground Support Pressure Vessels and Liquid Holding Tank Recertification Requirements.

a. Vessels and packaging designed to 49 CFR specifications shall be retested to DOT requirements.

b. All vessels, tanks, and systems shall be hydrostatically proof tested at ambient temperatures to 150 percent of the system MOP.

c. Vessels designed to ASME Section VII, Division 2 that are prohibited from pressure testing to 150 percent of the MOP shall, at a minimum, be hydrostatically proof tested to 125 percent of system MOP.

d. Cryogenic systems shall be tested in accordance with the testing requirements in the **Testing Cryogenic Systems After Assembly** section of Chapter 3 of this document unless otherwise agreed

to by Range Safety.

e. Before and after proof tests, a 100 percent visual inspection of all joints and connections shall be performed. **NOTE:** Parts that indicate a change in volume, permanent deformation, leaks, or cracks shall be rejected.

f. A 100 percent visual inspection of the external surfaces of a vessel and system and 100 percent of the internal surfaces of vessels shall be performed.

1. Any signs of corrosion, dents, or other damages shall be identified and annotated on permanently maintained recertification documents.

2. For corroded areas, the corrosion shall be removed.

3. The entire surface area that was affected by the corrosion shall be measured using ultrasonic testing (UT) to determine the remaining wall thickness.

4. Wall areas that are below the minimum required thickness and other unacceptable findings shall be fixed prior to placing the system back into service.

5. The susceptibility effects of corrosion such as cracking, delamination, or intergranular attack shall be assessed.

g. All weld joints on vessels and systems with pressure greater than 500 psig or containing a hazardous fluid shall be 100 percent volumetrically surface inspected.

1. Radiographic examination shall be used to the maximum extent possible.

2. UT shall be used if radiographic testing (RT) is determined to be ineffective.

3. Surface and volumetric testing shall be performed after the proof test.

h. All components and systems shall be leak checked and functionally tested.

1. Leaks shall be repaired.

2. Components that do not function properly shall be repaired or replaced prior to starting the subsequent recertification period.

6.11.4.8.6 Ground Support Pressure Vessel and Liquid Holding Tank Recertification Documentation. Documentation shall be maintained in accordance with ESMC TR-88-01.

6.11.5 Ground Support Pressure Systems Operating Requirements

6.11.5.1 Ground Support Pressure Systems

General Operating Requirements

Only pressure systems that meet the design requirements of Chapter 3 of this document shall be used.

6.11.5.1.1 Ground Support Pressure Systems Marking.

a. Warning signs shall be posted to keep personnel out of areas where pressurization is taking place.

b. High and ultra-high pressure systems shall be marked with DANGER signs indicating the maximum pressure that could be involved.

c. Pressure relief valves that present a noise hazard on activation shall be marked with DANGER signs.

6.11.5.1.2 Ground Support Pressure Systems Remote Pressurization.

a. Remote pressurization is required for the following conditions:

1. Initial pressurization of any vessel or system with an inert medium

2. Any pressurization that will exceed MOP

3. Any system or vessel whose design or condition is considered unknown or questionable by Range Safety

b. All personnel shall be evacuated whenever pressure exceeds the MAWP.

c. Suitable barriers shall be used to protect personnel. **NOTE:** The Range User and Range Safety shall determine the adequacy of the blast shield for the pressure and volume of the system.

6.11.5.1.3 Ground Support Pressure Systems Pressurization Operations.

a. Pressure systems shall be inspected upon arrival on the Ranges or prior to first operation.

1. Where there is evidence that systems have been damaged or overstressed, replacement or, at a minimum, remote initial pressurization shall be required.

2. Range Users who do not perform initial pressurization remotely shall certify that no evidence of damage or overstress exists to Range Safety.

b. A system and/or facility check shall be made prior to the start of the pressurization operation.

c. Personnel present during any pressurization shall be limited to those in direct support of the operation.

d. If a leak occurs during pressurization, the system and/or subsystem shall be depressurized prior to adjusting any fittings.

e. Flexible hose shall be secured along its length at 6 ft intervals.

f. Bolts and fittings shall not be loosened or torqued while the system is under pressure.

g. Any system that requires devices such as pressure regulators, pressure-reducing valves, safety valves, or pressure relief valves shall not be activated unless the devices are in place and in operable condition. **NOTE:** Only qualified and authorized personnel are allowed to change the setting of these valves and regulators with Range Safety approval.

h. When changes are made, valves and regulators shall be tested to ensure they are operating at the desired settings, and documentation of the settings shall be made.

6.11.5.1.4 Ground Support Pressure Systems Entry, Maintenance, and Repair.

a. Ground Support Pressure Systems Entry and Repair Requirements

1. Prior to entry into or repair of a pressurized system, depressurization of that portion of the system is mandatory.

2. The steps listed below shall be followed:

(a) A minimum of two block valves shall be closed between the portion of the system to be opened and the source of pressure.

(b) The section of line to be opened and the section between the block valves in series shall be vented (depressurized) to atmospheric pressure prior to the start of work and remain vented (depressurized) during all phases of work.

(c) Whenever operations permit, the entire system shall be depressurized before a portion of the system is isolated, vented, and opened.

(d) Venting a pressure system shall be accomplished through vent valves. Regardless of pressure, venting shall never be accomplished by loosening or removing a fitting.

(e) Lock-out devices and warning tags shall be attached to the valves that are isolating the area where system entry will be made.

(f) The isolated area shall be verified as being depressurized prior to opening.

REFERENCED DOCUMENTS

b. Open System Work Precautions

1. Whenever a depressurized section of a pressurized facility system is to be entered, it is considered open system work and the following precautions shall be observed:

(a) Authorization for entry is required from the responsible complex or area supervisor.

(b) Personnel limits shall be established in a Range Safety approved procedure.

2. When it is necessary to remove components from the system, due care shall be exercised to prevent moisture or particle contamination from outside sources.

3. Lockout devices and tagging shall be used to ensure systems or subsystems are not operated while work is being performed on the system.

4. Work requiring lockout and tagging includes the following:

(a) The system is depressurized for maintenance.

(b) The work to be performed extends to another shift, either same crew next day or a different crew the same day.

(c) The work site is left unattended.

(d) The valve is not visible at all times.

(e) Valves may be rendered inoperative by the following methods:

(1) Passing a metal chain through the hand wheel and the valve yoke or around the bottom of the valve body or pipe, and then locking the chain

(2) Making the valve inaccessible by locking the housing that encloses the valve, locking the cover of a valve pit, or removing or locking the hand wheel extension of an underground valve or a valve that cannot be reached from the ground or a valve platform

(3) Locking and tagging electrical controls of valves with electric motor actuators

5. The following criteria shall be observed when removing locks and tags and returning the system to service:

(a) Lockout devices used to render a valve inoperative shall be removed only by an authorized work crew after all work has been accomplished and, when applicable, approved by the proper authority.

(b) Tags shall be removed only by the crew placing the tag.

(c) Removed tags shall be returned to the crew office and mated with the tear off portion of

the tag.

(d) Both tag and tear off portion shall then be filed or disposed of in accordance with current practice.

6.11.5.2 Ground Support Pressure Systems With Liquid Propellant Operations

In addition to the requirements noted above, the following requirements shall be adhered to when operating, testing, and maintaining ground support pressure systems containing liquid propellants.

6.11.5.2.1 Ground Support Pressure Systems With Liquid Propellants General Operating Requirements.

a. The Fire Department shall be notified of the presence of propellants in any facility as well as any specific fire fighting and spill handling support requirements.

b. During any mishap or incident: At the ER, the designated Operations Controller is the on-scene commander until relieved by the Cape Commander or Fire Chief. Operations Safety advises, ensures control, and supports, as necessary, in accordance with 45 SW OPLAN 32-1. At the WR, the Support Group Commander or Fire Chief serves as the on-scene commander and Operations Safety advises, ensures control, and supports, as necessary.

c. Simultaneous tanking of fuels and oxidizers aboard a launch vehicle/payload is prohibited.

d. Vessels, lines, and propellant loading systems shall be properly bonded and commonly grounded.

e. Vapor monitoring equipment shall be used for leak (sniff) checks and general atmosphere monitoring to determine the necessity for protective equipment. The type of vapor monitoring equipment used shall be approved by Range Safety and the Bioenvironmental Engineer.

f. A toxic vapor check shall be made by Environmental Health when personnel are in a facility that has toxic propellants contained in flight hardware and GSE at the start of each 8 h shift and prior to entering a facility in which toxic propellant has been left unattended for 8 h or more. Toxic vapor checks are performed by the Range User on the WR for contractor operations.

g. In locations where liquid propellants will be handled, water shall be available in the area in sufficient quantities for fire, spill and medical usage.

NOTE: Skin or eye contact with toxic propellants

requires flushing with copious amounts of water. For specified flush periods, consult the Material Safety Data Sheet (MSDS) for the product being used. Appropriate medical attention must be sought after flushing.

h. The supervisor shall notify Range Safety and Bioenvironmental Engineering of any injury involving toxic or non-toxic propellants.

i. Transport of more than 5 gal of hypergolic propellants requires a security escort as described in the **Convoy Operations** section of this Chapter.

6.11.5.2.2 Ground Support Pressure Systems With Liquid Propellants Pre-Operational Requirements.

a. Range Safety approved procedures shall be used for all propellant operations and the checkout of propulsion systems.

b. As required by procedure, Operations Safety and other required support shall be on hand prior to the conduct of operations.

c. Operations Safety concurrence to proceed shall be obtained prior to the conduct of operations.

d. Personnel qualification and training shall be verified by their respective supervisors.

e. Prior to starting operations, the Range User and Operations Safety shall verify that the facility and equipment are ready by performing the following checks:

1. Wet check of safety showers and water lines prior to propellant transfer

2. Accessibility and operability of emergency exit doors

3. Operability of drain and sump systems and their capability for handling a worst case spill and wash down

4. Operability of vent systems

5. Availability of fire protection

6. Proper configuration and grounding of propellant systems

7. Weather conditions

8. PA announcements warning lights and barriers

9. Implementation of access control

10. All required support on hand

11. Availability of approved operating procedures and emergency procedures

12. Removal of ignition sources from the area

Operations Safety shall inform the Launch Conductor that the appropriate roadblocks have

REFERENCED DOCUMENTS

been established, the hazard area has cleared, and propellant tanking can begin.

g. At the ER, propellant transfer shall not start when the passage of an electrical storm is imminent (within 5 nautical miles). A propellant transfer operation already in progress shall be interrupted or expeditiously concluded at the discretion of Operations Safety or the supervisor in charge of the operation. The Operations Safety Plan for each launch vehicle or facility shall detail the procedure for this situation. At the WR, the guidance provided in paragraph 6.5.5.2 shall be followed.

h. Emergency protective equipment shall be provided as required by Range Safety.

i. The Range User shall provide the maximum source strength based on quantity (gal or lb) and surface area. **NOTE:** The worst case spill (quantity) shall be based on a failure analysis provided to Range Operations Safety and CCAS Cape Support weather facility prior to the operation. This information shall be used to determine the downwind sector that shall be evacuated if a large spill occurs.

j. Where feasible, the Range User shall develop a means to minimize the surface area of spills by providing a dike or other means of containment.

6.11.5.2.3 Controls for Ground Support Pressure Systems With Liquid Propellants. **NOTE:** Leaks, spills, and venting of toxic propellants may create a toxic cloud. This toxic cloud will diffuse through the atmosphere at a rate that varies with meteorological conditions and spill size.

a. A localized safety clearance zone that limits personnel access to those individuals directly involved with the operation and who have the proper protective equipment shall be established.

b. A larger safety clearance zone that limits personnel access to those individuals directly or indirectly involved in the operation or mission shall be established. **NOTE:** The availability of fencing and Security/HOS check points is a major factor in determining this larger safety clearance zone. The TNT equivalency of the propellants involved may also be a factor.

c. The minimum downwind sector that must be immediately evacuated in the event of a major spill shall be provided to all personnel involved in the operation and controls shall be in place to implement the control of this sector. The downwind sector shall be defined in the Operations Safety

Plan.

6.11.5.2.4 Ground Support Pressure Systems With Liquid Propellants Operating Requirements.

a. Operations Safety concurrence shall be obtained prior to starting propellant transfer operations and prior to pressurization.

b. Fire Protection and Environmental Health shall be available as required by procedure.

c. All persons and vehicles not absolutely essential to the operation shall be evacuated.

d. Prior to opening a contaminated or toxic propellant system, the system shall be flushed or purged to concentration levels coordinated with Bioenvironmental Engineering and approved by Range Safety. **NOTE:** At the ER, Environmental Health shall monitor and report any levels exceeding health standard criteria to the Operations Safety Manager. At the WR, Bioenvironmental Engineering and Environmental Health monitor for AF operations only. Contractors are responsible for monitoring their own systems.

e. The handling and transfer of toxic materials and propellants shall be monitored by Operations Safety to ensure the safety of personnel involved in the operation and personnel downwind of the operation.

f. Vapor monitoring shall be continuous whenever personnel are in enclosed areas having toxic propellants present.

g. At the ER, in the case of a lightning warning (lightning within 5 nautical miles), the system shall be secured; the complex, storage, or operating area shall be cleared; and the required actions called for in procedures and Operations Plans shall be taken. (See Appendixes 6C, 6D, and 6E.) At the WR, the guidance provided in paragraph 6.5.5.2 shall be followed.

h. Reentry into the area of a launch vehicle and/or payload with fuel and oxidizer aboard shall be held to a minimum and shall be subject to approval by Operations Safety.

i. Reentry into the area of a launch vehicle and/or payload with only fuel aboard shall also be held to a minimum and shall be subject to the approval of the task or area supervisor.

j. Tanking of toxic or cryogenic liquids aboard a launch vehicle or payload shall be performed as late in the countdown as practical.

k. The appropriate actions and evacuations shall take place in the event of an emergency such

as a propellant spill.

l. Cape Support (ER) and Range Safety (ER) or Range Scheduling (WR) and Operations Safety (WR) shall be notified of any propellant mishap and incidents, including near misses.

6.11.5.3 Releases of Toxic Vapors and Liquids

a. All releases of toxic vapors and liquids shall comply with AFI 32-4002, *Hazardous Material Emergency Planning and Response Compliance*; 30 SW Instruction 91-106, *Toxic Hazard Assessments*; 30 OPLAN 32-1, *Vandenburg Air Force Base Disaster Preparation Operations Plan*; 45 SW *Launch Toxic Hazard Control Plan*; 45 SW Range Safety Operations Requirements number 19, *Toxic Hazard Control Daily and Launch Operations*; Combined Emergency Management Plan (CEMP); 45 SW OPLAN 32-1, Volume II, *Disaster Preparedness Operations Plan*; and 45 SW OPLAN 32-3, Volume I, *Hazardous Materials Response Plan*.

b. At the ER, any plans to vent toxic vapors requires coordination with Bioenvironmental Engineering and Environmental Health and Range Safety approval. At the WR, venting operations are conducted in accordance with 30 SWI 91-106 and the applicable facility or operations plan.

c. The actual venting operation shall not start without Operations Safety approval.

d. Venting restrictions and controls shall be identified in the appropriate Operations Safety Plan or operating procedure.

e. Venting operations require that the appropriate downwind sector be evacuated.

f. Environmental Health shall be present to verify concentration levels at the control area boundary.

g. Security/HOS shall maintain the appropriate road blocks.

h. Planned releases shall be in accordance with permits maintained by Civil Engineering.

6.11.5.4 Emergency Decontamination of Facilities and Personnel

Emergency decontamination of facilities and personnel shall be accomplished under Operations Safety direction with Environmental Health and the Fire Department performing the decontamination, if required.

6.11.5.5 Handling Leaks and Spills of Liquid Propellant

6.11.5.5.1 PPE for Treating Spills. Personnel treating or flushing major spills of toxic and corrosive propellants shall wear the proper protective clothing and equipment.

6.11.5.5.2 Leak and Spill Procedures.

a. Range Users and supporting agencies shall develop procedures for handling major and minor leaks and spills.

b. Each area that contains liquid propellants shall have a Range Safety approved plan for evacuation based on spill size (quantity and surface area). **NOTE:** At the ER, an evacuation zone for a small spill (for example, a gallon of hypergolic propellant) is typically 700 ft downwind or more and approximately 200 ft radially if the spill is allowed to spread out on a flat surface. At the WR, required evacuations are 2,000 ft upwind or as published in the Operations Safety Plans and Toxic Hazard Zones (THZs).

1. The plan shall describe the localized safety clearance zone, the general support (larger) safety clearance zone, and the minimum downwind sector to be evacuated in the case of a large spill.

2. The downwind sector shall be based on the following factors:

(a) Maximum source strength based on quantity (gal or lb) and surface area. The Range User shall determine a worst case spill (quantity) based on a failure analysis

(b) Maximum vapor concentration acceptable for personnel exposure

(c) Average weather criteria such as wind direction, wind speed, temperature, temperature lapse rate. **NOTE:** These variables can be obtained from the Range Weather Officer.

c. These procedures shall be in accordance with the applicable Operations Safety Plan, and shall be submitted to Range Safety for review and approval.

d. Procedures shall address the topics covered in the **Disposal of Contaminated Liquid Propellant, Gas, or Other Regulated Wastes** section of this Chapter.

6.11.5.5.3 Handling Minor Leaks or Spills.

a. Minor leaks or spills can be washed or flushed with water into collecting tanks or holding basins if no ecological or health hazard is involved. **NOTE:** Refer to CPIA 394 for information on treating spills.

REFERENCED DOCUMENTS

b. Operations Safety shall be notified of minor leaks and spills and subsequent actions.

6.11.5.5.4 Handling Major Leaks or Spills.

a. Major leaks or spills shall be handled according to the situation with the objective of minimizing injury to personnel and damage to facilities and equipment in accordance with 45 SW OPLAN 32-1 Volume II, 45 SW OPLAN 32-3, Volume I,

30 SW OPLAN 32-1, and 30 SWI 91-106. If the requirements in this section are in conflict with the aforementioned OPLANS, the OPLANS shall be complied with.

b. The following actions shall be taken:

1. Time and the situation permitting, the source of the propellant flow and pressure source shall be shut down.

2. All personnel shall be evacuated out of the area including the minimum downwind sector. Travel shall be upwind or cross-wind to the minimum evacuation radius as defined in the Facility Operating Plan, Operations Safety and Area Safety Plan, or the Range User emergency procedure, and away from the downwind sector.

3. Injured or trapped personnel shall be rescued. **NOTE:** Appropriate PPE shall be used.

4. Operations Safety shall obtain the real-time downwind sector from the Range Weather Officer and modify the evacuation area accordingly.

5. The 30th Command Post (866-9961) or CCAS Cape Support (853-5211) shall notify the following personnel or agencies:

- (a) Fire Department
- (b) Operations Safety
- (c) Cape/VAFB Medical
- (d) Security Police
- (e) Environmental Health
- (f) Disaster Preparedness
- (g) Environmental Engineering
- (h) Range Weather Operations (RWO) to

put the MARSS system on printout and stand by to provide downwind cloud isoplots and activate the Toxic Release Contingency Plan (Cape Aural Warning Plan) on the ER and Toxic Hazards Corridors on the WR as required. The RWO shall have data regarding spill site location and the type and amount of material involved to properly prepare downwind cloud dispersions forecasts.

6. Adjacent areas shall be alerted.

7. Personnel shall be available to direct emergency crews and to provide information to assist them.

8. All personnel shall report to the supervisor at the designated assembly point for head count.

6.11.5.5.5 Handling Cryogenic or Toxic Liquid Spills.

a. Spills of cryogenic liquids shall be flushed with large amounts of water into the surrounding ground surface or a holding basin.

b. Spills of toxic or corrosive propellants, or

those that could affect the public health or ecology, shall normally be flushed with water or another neutralizing agent into a collecting tank to be disposed of in accordance with approved procedures.

- a. Refer to CPIA 394, Vol. III; the Medical Department; and the Florida Department of Environmental Protection (FDEP) (ER only) for guidance.

6.12 FLIGHT HARDWARE PRESSURE SYSTEMS OPERATIONS

6.12.1 Flight Hardware Pressure Systems Operating Standards

NOTE: The degree of hazard in pressure systems is proportional to the amount of energy stored, which is a function of both the pressure and the volume stored. Therefore, low-pressure, high-volume systems can be as hazardous to personnel as high-pressure systems.

a. Only pressure systems that meet the design requirements of Chapter 3 shall be operated on the Ranges.

b. The handling and storage of propellants shall be in accordance with CPIA 394 and DoD 6055.9 STD or subtier documents such as AFMAN 91-201 or Navy OP 5

c. Propellants shall be used and stored only in Range Safety approved facilities designed and suited for that purpose and only during time periods approved by Range Safety.

d. Propellants shall be used and stored only in systems that meet the design requirements of Chapter 3.

6.12.2 Flight Hardware Pressure Systems Operations Personnel Requirements

6.12.2.1 Flight Hardware Pressure Systems Training and Certification

All personnel who operate, test, and maintain flight hardware pressure systems shall be trained and certified.

6.12.2.2 Flight Hardware Pressure Systems Operations PPE Requirements

6.12.2.2.1 Selection of PPE. The selection and use of personal protective equipment shall be approved by Range Safety and Bioenvironmental Engineering.

a. Approval shall be limited to a particular model number of protective equipment and a par-

REFERENCED DOCUMENTS

ticular operation.

b. Approval of PPE for an operation shall depend on the type and volume of propellants involved, the size of the lines, flow rate, pressure, capability to deal with emergencies, and egress accessibility.

c. Approvals are not transferable; approval for similar operations shall require a re-evaluation of these parameters.

d. Protective gear shall be compatible with the propellants involved, and fire resistant and non-static producing as well.

e. If the protective gear has limitations, these limitations and subsequent protective actions shall be identified in the operating procedure; for example, splash suits are not to be used when hydrazine concentrations can exceed 100 ppm.

6.12.2.2.2 SCAPE, Category I and IV. SCAPE, Category I or IV shall be required for propellant flow and pressurization during the following operations:

a. Connection and disconnection of wet lines or contaminated (not purged and flushed) dry lines

b. Sampling operations

c. During propellant flow

d. During initial pressurization with propellants until system integrity has been verified (no leaks)

e. Connection and disconnection of vehicle load/off-load lines

f. Removal and replacement of components in a liquid line

g. Opening any liquid system that has not been drained, purged, and flushed with referee fluid

h. When the condition of the system is uncertain or unknown

6.12.2.2.3 Splash Suits. Splash suits, with self-contained breathing apparatus or air-line respirator may be approved by Range Safety for use with systems that only contain residual vapors; no liquid in the system is allowed.

a. Removal of full protective gear after system integrity verification requires Operations Safety approval.

b. Emergency protective gear shall be available throughout operations to the crew and other personnel who might be affected in the event of a spill.

c. The following non-liquid operations require splash as approved by Range Safety:

1. Removal and replacement of components

on purged and isolated liquid lines

2. Removal and replacement of components on vent lines

3. Connection and disconnection of drained, purged, and isolated lines

4. Pressure leak checks when required by procedure

d. The WR allows the use of splash suits during propellant flow after integrity has been established with Operations Safety Manager concurrence.

6.12.2.2.4 PPE for Cryogenic Systems.

a. All personnel performing liquid oxygen and liquid hydrogen transfer operations, repairs, or adjustments to the system shall wear flame-resistant treated, non-static producing overalls of liquid resistant material, cryogenic service gloves, hoods or face shields and non-absorbent shoes approved by Range Safety.

b. Personnel performing operations on other cryogenic systems shall be similarly protected, except that flame-resistance treating of coveralls is not required for non-flammable commodities.

6.12.2.2.5 PPE for Hydrogen Peroxide Transfers. Hydrogen peroxide transfers require the use of boots, gloves, and face shields of material approved by Range Safety.

6.12.3 Flight Hardware Pressure Systems Procedures

a. Procedures shall be prepared governing the safe operation, testing, maintenance, and installation of pressurized systems by the agency performing the specific task.

b. Procedures shall be developed for all operations involving propellants or the checkout of propulsion systems.

c. Off-loading procedures for payloads and launch vehicles are required at any time propellant is loaded in flight hardware. Off-loading design as outlined in Chapter 3 of this document addresses the complete system during the complete processing flow. The off-loading procedure shall include integration of the following:

1. Hardware

(a) Launch vehicle

(b) Launch vehicle fairing

(c) Spacecraft

(d) Launch complex

(e) Process facility

- (f) Transport vehicle
- (g) Fixed GSE
- (h) Portable GSE
- 2. Software Command Capability
 - (a) Flight hardware
 - (b) GSE
- 3. Personnel capability
 - (a) Remote
 - (b) SCAPE
 - (c) Combination of both

6.12.4 Flight Hardware Pressure Systems Test, Inspection, and Maintenance

6.12.4.1 Flight Hardware Pressure Systems General Tests

- a. Pressure systems shall be initially tested in accordance with Chapter 3 of this document.
- b. Any system that has been opened shall be leak tested at 100 percent MOP with an inert medium.
- c. Any disconnection, modification, or repair of the system shall necessitate leak testing the affected part of the system.
- d. Any component that has been damaged, suspected to be damaged, repaired, replaced, and/or modified shall be proof tested in accordance with Chapter 3 of this document.
- e. After the component proof test but prior to installation, the system or subsystem shall be proof tested, functionally tested, and leak tested. **NOTE:** The determination for system proof testing shall be made on a case-by-case basis.
- f. New, modified, or repaired propellant systems shall be tested in accordance with Chapter 3 of this document. A log shall be kept on propellant systems to keep track of use, maintenance, modification, testing, and inspection.

6.12.4.2 Flight Hardware Pressure Systems General Inspection

Prior to use and prior to each operation, facilities and equipment shall be inspected by Range Users and Operations Safety to ensure a safe configuration for the facilities, equipment, and propellants involved.

6.12.4.3 Flight Hardware Pressure Systems Purging

- a. Prior to replacement, storage, or repair of hypergolic or toxic system components, the system shall be purged and flushed of all residual contaminants and appropriately capped, bagged, and labeled

prior to movement.

- b. A record shall be kept on the certification of system and component cleanliness through launch.

6.12.4.4 Testing Modified and Repaired Flight Hardware Pneumatic Systems

- a. Any flight pressure pneumatic system element that has been repaired, modified, or damaged after having been proof tested shall be retested at proof pressure prior to its normal use.

b. A modified or repaired pneumatic system shall be leak tested at the system MOP prior to its normal use. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

- c. A modified or repaired pneumatic system shall be revalidated and functionally tested at the system MOP prior to its normal use.

d. If any pneumatic system element such as valves, regulators, gauges, and tubing has been disconnected or reconnected for any reason, the affected system or subsystem shall be leak tested at MOP.

6.12.4.5 Testing Modified and Repaired Flight Hardware Hydraulic Systems

- a. Any hydraulic system element that has been repaired, modified, or damaged after having been proof tested shall be retested at proof pressure prior to its normal use.

b. A modified or repaired hydraulic system shall be leak tested at the system MOP prior to its normal use. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

- c. A modified or repaired hydraulic system shall be revalidated and functionally tested at the system MOP prior to its normal use.

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d. If any hydraulic system element such as valves, regulators, gauges, or tubing has been disconnected or reconnected for any reason, the affected system or subsystem shall be leak tested at MOP.

6.12.4.6 Testing Modified and Repaired Flight Hardware Hypergolic Systems

a. Any hypergolic system element that has been repaired, modified or damaged after having been proof tested shall be retested at proof pressure prior to its normal use.

b. A modified or repaired hypergolic system shall be leak tested at the system MOP prior to its normal use. **NOTE:** This test shall be conducted at the Ranges unless prior approval from Range Safety has been obtained.

c. A modified or repaired hypergolic system shall be revalidated and functionally tested at the system MOP prior to its normal use.

d. If any hypergolic system element such as valves, gauges, and tubing has been disconnected or reconnected for any reason, the affected system or subsystem shall be leak tested at MOP.

6.12.4.7 Testing Modified and Repaired Flight Hardware Cryogenic Systems

a. Any cryogenic system element that has been repaired, modified or possibly damaged after the system leak test shall be retested.

b. The component retest sequence shall be as follows unless otherwise agreed to by Range Safety:

1. The component shall be hydrostatically proof test at ambient temperature to 1.5 times the component MAWP.

2. The component shall be reinstalled into the cryogenic system and leak check performed at system MOP.

3. The functional capability of the modified or repaired component shall be revalidated using the intended service fluid at system MOP.

c. If any cryogenic system element such as valves, regulators, gauges, or pipes has been disconnected or reconnected for any reason, the affected connection shall be leak checked at MOP.

6.12.4.8 Flight Hardware Pressure Systems Recertification

Recertification requirements for flight components and systems shall be performed in accordance with Chapter 3, **Flight Hardware Pressure Systems**

and Pressurized Structures.

6.12.5 Flight Hardware Pressure Systems Operating Requirements

6.12.5.1 Flight Hardware Pressure Systems General Operating Requirements

Only pressure systems that meet the design requirements of Chapter 3 of this document shall be used.

6.12.5.1.1 Flight Hardware Pressure Systems Area Posting Requirements. Warning signs shall be posted to keep personnel out of areas where pressurization is taking place.

6.12.5.1.2 Flight Hardware Pressure Systems Remote Pressurization.

a. Remote pressurization is required for the following conditions:

1. Initial pressurization at the Ranges of any vessel or system with an inert medium. *EXCEPTION: For the 30 SW, remote pressurization can be waived provided the following is provided:*

(a) *The assembled system has been proof tested at a pressure equal to 1.5 times the system MEOP or to an agreed-upon level for tanks with less than 2:1 safety factor for burst*

(b) *System configuration has not been modified or repaired subsequent to above testing. Unwelded relief or sensing devices may be replaced after system proof testing.*

(c) *Inspection of the pressure system at the launch site verifying damage has not been sustained during transportation or handling subsequent to above testing*

2. Any pressurization that will exceed MOP

3. Any system or vessel whose design or condition is considered unknown or questionable by Range Safety

b. Suitable barriers shall be used to protect personnel. **NOTE:** The Range User and Range Safety shall determine the adequacy of the blast shield for the pressure and volume of the system.

6.12.5.1.3 Flight Hardware Pressure Systems Pressurization Operations.

a. Pressure systems shall be inspected upon arrival or prior to first operation. Where there is evidence that systems have been damaged or overstressed, replacement or, (at a minimum) remote initial pressurization shall be required.

b. A system and/or facility check shall be made prior to the start of the pressurization operation.

c. Personnel present during any pressurization shall be limited to those in direct support of the operation. All personnel shall be evacuated whenever pressure exceeds the MEOP.

d. If a leak occurs during pressurization, the system and/or subsystem shall be depressurized prior to adjusting any fittings.

e. Bolts and fittings shall not be loosened or torqued while the system is under pressure.

f. Any system that requires devices such as pressure regulators, pressure-reducing valves, safety valves, or pressure relief valves shall not be activated unless the devices are in place and in operable condition. **NOTE:** Only qualified and authorized personnel are allowed to change the setting of these valves and regulators with Range Safety approval.

g. When changes are made, valves and regulators shall be tested to ensure they are operating at the desired settings, and documentation of the settings shall be made.

h. Pressure vessels that exhibit a brittle fracture or hazardous leak-before-burst (LBB) failure mode shall maintain a minimum safety factor of 2:1 during transport or ground handling operations.

i. Pressure vessels that have a non-hazardous LBB failure mode shall maintain a minimum safety factor of 1.5:1 during transport or ground handling operations.

6.12.5.1.4 Flight Hardware Pressure Systems Maintenance and Repair. When it is necessary to remove components from the system, due care shall be exercised to prevent moisture or particle contamination from outside sources.

6.12.5.2 Flight Hardware Systems With Liquid Propellants Operations

In addition to the requirements noted above, the following requirements shall be adhered to when operating, testing, and maintaining flight hardware pressure systems containing liquid propellants.

6.12.5.2.1 Flight Hardware Pressure Systems With Liquid Propellants General Operating Requirements:

a. The Fire Department shall be notified of the presence of propellants in any facility as well as any specific fire fighting and spill handling support requirements.

b. During any mishap or incident: At the ER, the designated Operations Controller is the on-scene commander until relieved by the Cape Commander

or Fire Chief. Operations Safety advises, ensures control, and supports, as necessary, in accordance with 45 SW OPLAN 32-1. At the WR, the Support Group Commander or Fire Chief serves as the on-scene commander and Operations Safety advises, ensures control, and supports, as necessary

c. Simultaneous tanking of fuels and oxidizers aboard a launch vehicle and/or payload is prohibited.

d. Vessels, lines, and propellant loading systems shall be properly bonded and commonly grounded.

e. Vapor monitoring equipment shall be used for leak (sniff) checks and general atmosphere monitoring to determine the necessity for protective equipment. The type of vapor monitoring equipment used shall be approved by Range Safety and the Bioenvironmental Engineers.

f. On the ER, a toxic vapor check shall be made by Environmental Health when personnel are in a facility that has toxic propellants contained in flight hardware and GSE at the start of each 8-h shift and prior to entering a facility in which toxic propellant has been left unattended for 8 h or more. On the WR, toxic vapor checks are accomplished by Range User for contractor operations.

g. In locations where liquid propellants will be handled, water shall be available in the area in sufficient quantities for fire, spill and medical usage. **NOTE:** Skin or eye contact with toxic propellants requires flushing with copious amounts of water for a minimum of 15 min and transport to the nearest dispensary immediately afterward unless a qualified medical technician or doctor directs other actions.

h. The supervisor shall notify Range Safety and the Bioenvironmental Engineer of any injury involving toxic or non-toxic propellants.

6.12.5.2.2 Flight Hardware Pressure Systems With Liquid Propellant Pre-Operational Requirements.

a. Range Safety approved procedures shall be used for all propellant operations and the checkout of propulsion systems.

b. As required by procedure, Operations Safety and other required support shall be on hand prior to the conduct of operations.

c. Operations Safety concurrence to proceed shall be obtained prior to the conduct of operations.

d. Fire Protection and Environmental Health personnel qualifications and training shall be verified by their respective supervisors.

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e. Prior to starting operations, the Range User and Operations Safety shall verify that the facility and equipment are ready by performing the following checks:

1. Wet check of safety showers and water lines prior to propellant transfer
2. Accessibility and operability of emergency exit doors
3. Operability of drain and sump systems and their capability for handling a worst case spill and wash down
4. Operability of vent systems
5. Availability of fire protection
6. Proper configuration and grounding of propellant systems
7. Weather conditions
8. PA announcements warning lights and barriers
9. Implementation of access control
10. All required support on hand
11. Availability of approved operating procedures and emergency procedures
12. Removal of ignition sources from the area

f. Operations Safety shall inform the Launch Conductor that the appropriate roadblocks have been established, the hazard area has cleared, and propellant tanking can begin.

g. At the ER, propellant transfer shall not start when the passage of an electrical storm is imminent (within 5 nautical miles). A propellant transfer operation already in progress shall be interrupted or expeditiously concluded at the discretion of Operations Safety or the supervisor in charge of the operation. The Operations Safety Plan for each launch vehicle or facility shall detail the procedure for this situation. At the WR, the guidance provided in paragraph 6.5.5.2 shall be followed.

h. Emergency protective equipment shall be provided as required by Range Safety.

i. The Range User shall provide the maximum source strength based on quantity (gal or lb) and surface area. **NOTE:** The worst case spill (quantity) shall be based on a failure analysis provided to Range Safety Operations and CCAS Cape Support weather facility prior to the operation. This information shall be used to determine the downwind sector that shall be evacuated if a large spill occurs.

j. Where feasible, the Range User shall develop a way to minimize the surface area of spills

by providing a dike or other means of containment.

6.12.5.2.3 Controls for Flight Hardware Pressure Systems With Liquid Propellants. NOTE: Leaks, spills, and venting of toxic propellants may create a toxic cloud. This toxic cloud will diffuse through the atmosphere at a rate that varies with meteorological conditions and spill size.

a. A localized safety clearance zone that limits personnel access to those individuals directly involved with the operation and who have the proper protective equipment shall be established.

b. A larger safety clearance zone that limits personnel access to those individuals directly or indirectly involved in the operation or mission shall be established. **NOTE:** The availability of fencing and security check points is a major factor in determining this larger safety clearance zone. The TNT equivalency of the propellants involved may also be a factor.

c. The minimum downwind sector that must be immediately evacuated in the event of a major spill shall be provided to all personnel involved in the operation, and controls shall be in place to implement the control of this sector. The downwind sector shall be defined in the Operations Safety Plan.

6.12.5.2.4 Flight Hardware Pressure Systems With Liquid Propellants Operating Requirements.

a. Operations Safety concurrence shall be obtained prior to starting propellant transfer operations and prior to pressurization.

b. Fire Protection and Environmental Health shall be available as required by procedure.

c. All persons and vehicles not absolutely essential to the operation shall be evacuated. All personnel shall be evacuated whenever pressure exceeds the MEOP.

d. Prior to opening a contaminated or toxic propellant system, the systems shall be flushed or purged to concentration levels approved by Range Safety.

e. The handling and transfer of toxic materials and propellants shall be monitored by Operations Safety to ensure the safety of personnel involved in the operation and personnel downwind of the operation.

f. Vapor monitoring shall be continuous whenever personnel are in enclosed areas having stored toxic propellants present

g. At the ER, in the case of a lightning warning (lighting within 5 nautical miles) the system shall be secured; the complex, storage, or operating area shall be cleared; and the required actions called for in procedures and Operation and Area Safety Plans shall be taken. At the WR, the guidance provided in paragraph 6.5.5.2 shall be followed

h. Reentry into the area of a launch vehicle and/or payload with fuel and oxidizer aboard shall be held to a minimum and shall be subject to approval by Operations Safety.

i. Reentry into the area of a launch vehicle and/or payload with only fuel aboard shall also be held to a minimum and shall be subject to the approval of the task or area supervisor.

j. j. Tanking of toxic or cryogenic liquids aboard a launch vehicle or payload shall be performed as late in the countdown as practical.

k. The appropriate actions and evacuations shall take place in the event of an emergency such as a propellant spill.

l. CCAS Cape Support (ER) or Range Scheduling (WR) and Range Safety shall be notified of any propellant mishap and incidents, including near misses.

6.12.5.3 Releases of Toxic Vapors and Liquids

a. All releases of toxic vapors and liquids shall comply with AFI 32-4002, *Hazardous Material Emergency Planning and Response Compliance*; 30 SW Instruction 91-106, *Toxic Hazard Assessments*; 30 OPLAN 32-1, *Vandenberg Air Force Base Disaster Preparation Operations Plan*; 45 SW Launch Toxic Hazard Control Plan; 45 SW Range Safety Operations Requirements number 19, *Toxic Hazard Control Daily and Launch Operations*; CEMP; 45 SW OPLAN 32-1, Volume II, *Disaster Preparedness Operations Plan*; and 45 SW OPLAN 32-3, Volume I, *Hazardous Materials Response Plan*.

b. Any plans to vent toxic vapors requires coordination with Bioenvironmental Engineering and Environmental Health and Range Safety approval.

c. The actual venting operation shall not start without Operations Safety approval.

d. Venting restrictions and controls shall be identified in the appropriate Operations Safety Plan or operating procedure.

e. Venting operations require that the appropriate downwind sector be evacuated.

f. Environmental Health shall be present to verify concentration levels at the control area boundary.

g. Security/HOS shall maintain the appropriate

road blocks.

h. Planned releases shall be in accordance with permits maintained by Civil Engineering.

6.12.5.4 Emergency Decontamination of Facilities and Personnel

Emergency decontamination of facilities and personnel shall be accomplished under Operations Safety direction with Environmental Health and the Fire Department performing the decontamination, if required.

6.12.5.5 Handling Leaks and Spills of Liquid Propellant

6.12.5.5.1 PPE Requirements for Treating Major Spills. Personnel treating or flushing major spills of toxic and corrosive propellants shall wear the proper protective clothing and equipment.

6.12.5.5.2 Leak and Spill Procedures.

a. Range Users and supporting agencies shall develop procedures for handling major and minor leaks and spills.

b. Each area that contains liquid propellants shall have a Range Safety approved plan for evacuation based on spill size (quantity and surface area). **NOTE:** At the ER, an evacuation zone for a small spill (for example, a gallon of hypergolic propellant) is typically 700 ft downwind or more and approximately 200 ft radially if the spill is allowed to spread out on a flat surface. At the WR, required evacuations are 2,000 ft upwind or as published in Operations Safety Plans and THZs.

1. The plan shall describe the localized safety clearance zone, the general support (larger) safety clearance zone, and the minimum downwind sector to be evacuated in the case of a large spill.

2. The downwind sector shall be based on the following factors:

(a) Maximum source strength based on quantity (gal or lb) and surface area. The Range User shall determine a worst case spill (quantity) based on a failure analysis.

(b) Maximum vapor concentration acceptable for personnel exposure.

(c) Average weather criteria such as wind direction, wind speed, temperature, and temperature lapse rate. **NOTE:** These variables can be obtained from the Range Weather Officer.

c. These procedures shall be in accordance with the applicable Operations Safety Plan, and shall be submitted to Range Safety for review and approval.

d. Procedures shall address the topics covered

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in the **Disposal of Contaminated Liquid Propellant, Gas, or Other Regulated Wastes** section of this Chapter.

6.12.5.5.3 Handling Minor Leaks or Spills.

a. Minor leaks or spills can be washed or flushed with water into collecting tanks or holding basins if no ecological or health hazard is involved.

NOTE: Refer to CPIA 394 for information on treating spills.

b. Operations Safety shall be notified of minor leaks and spills and subsequent actions.

6.12.5.5.4 Handling Major Leaks or Spills.

a. Major leaks or spills shall be handled according to the situation with the objective of minimizing injury to personnel and damage to facilities and equipment in accordance with 45 SW OPLAN and 30 SW OPLAN 355-1. If the requirements in this section are in conflict with the OPLANs, the OPLANs shall be complied with.

b. The following actions shall be taken:

1. Time and the situation permitting, the source of the propellant flow and pressure source shall be shut down.

2. All personnel shall be evacuated out of the area, including the downwind sector. Travel shall be upwind or cross-wind to the minimum evacuation radius as defined in the Facility Operating Plan or the Range User emergency procedure and away from the downwind sector.

3. Injured or trapped personnel shall be rescued. **NOTE:** Appropriate PPE shall be used.

4. Operations Safety shall obtain the real-time downwind sector from the Range Weather Officer and modify the evacuation area accordingly.

5. The CCAS Cape Support (ER) or Range Scheduling (WR) shall notify the following personnel or agencies:

- (a) Fire Department
- (b) Operations Safety
- (c) Cape Medical
- (d) Security Police
- (e) Environmental Health
- (f) Disaster Preparedness
- (g) Environmental Engineering
- (h) RWO to put the MARSS system on

printout and stand by to provide downwind cloud isoplots and activate the Toxic Release Contingency Plan (Cape Aural Warning Plan) on the ER

and Toxic Hazards Corridors on the WR as required. RWO shall have data regarding spill site location and the type and amount of material involved to properly prepare downwind cloud dispersions forecasts.

6. Adjacent areas shall be alerted.

7. Personnel shall be available to direct emergency crews and to provide information to assist them.

6.12.5.5.5 Handling Cryogenic or Toxic Liquid Spills

a. Spills of cryogenic liquids shall be flushed with large amounts of water into the surrounding ground surface or a holding basin.

b. Spills of toxic or corrosive propellants, or those that could affect the public health or ecology, shall normally be flushed with water or another neutralizing agent into a collecting tank to be disposed of in accordance with approved procedures.

c. Refer to CPIA 394, Vol. III; the Medical Department; and FDEP (ER only) for guidance.

6.12.6 Flight Graphite Epoxy Composite Overwrapped Pressure Vessels Operations

Ground operations requirements for graphite epoxy (Gr/EP) composite overwrapped pressure vessels (COPVs) can be found in the 23 November 1993 letter, "Interim Safety Requirements for Design, Test, and Ground Processing of Flight Graphite Epoxy (Gr/EP) Composite Overwrapped Pressure Vessels (COPVs) at the Kennedy Space Center (KSC), Cape Canaveral Air Force Station (CCAFS), and Vandenberg Air Force Base (VAFB)" issued by the Director, Safety and Reliability, NASA, KSC and the Chiefs of Safety, USAF, 30 SW and 45 SW. **NOTE:** The requirements stipulated in this letter are interim requirements for Gr/EP COPVs. Final requirements will be incorporated in this document when the results of the GR/EP COPV test programs are complete.

6.13 ORDNANCE OPERATIONS

6.13.1 Ordnance Operations Procedure Requirements

a. All ordnance operations shall be covered by a Range Safety approved operating procedure.

b. Ordnance operations conducted in ordnance facilities shall be specified in procedures and/or operating instructions approved by Range Safety

c. Procedures shall include transportation to and from the facility.

6.13.2 Ordnance Transportation, Receipt, and Storage

6.13.2.1 Ordnance Transportation, Receipt, and Storage Standards

a. All ordnance transportation, receipt, and storage shall be performed in accordance AFMAN 91-201 and AFMAN 91-201, VAFB Sup 1 (WR).

b. Over-the-road and rail shipments to and from the Ranges shall comply with Department of Transportation (DOT) requirements. **NOTE:** Receipt inspection requires DOT violations to be reported. See paragraph 6.13.2.4.

c. To be acceptable for transportation by any mode, explosives shall have the following items provided and verified prior to shipment:

1. Proper DOT classification for transport.

NOTE: For air transport, refer to AFJMAN 24-204.

2. An assigned hazard classification hazard class and/or division; storage compatibility group; DOT class, markings, shipping name and label; and the United Nations (UN) serial number.

3. The availability of adequate and suitable storage space on Ranges. **NOTE:** Availability of adequate and suitable storage space depends on the hazard classification, the size of the storage containers, and temperature and humidity requirements.

4. The availability of proper connectors and cabling for ordnance checkout if Range facilities and equipment are to be used.

d. All ordnance air shipments shall comply with the requirements of the International Air Transport Association (IATA) for commercial air shipments and AFJMAN 24-204 for military air shipments as well as DOT requirements.

6.13.2.2 Ordnance Transportation General Requirements

6.13.2.2.1 Transportation Restrictions. Launch vehicles, payloads, spacecraft, and vehicle stages shall not be shipped to the Ranges with ordnance such as EEDs installed unless prior written approval has been obtained from Range Safety.

6.13.2.2.2 Ordnance Services Coordination. Plans for shipment of ordnance to CCAS shall be coordinated with CCAS Ordnance Services. Plans for shipment of ordnance to VAFB shall be coordinated with 30 SW/SEGW.

6.13.2.2.3 Ordnance Transportation Address.

All ordnance shipments including Category B EEDs shall be addressed as follows:

To: Transportation Officer

Patrick Air Force Base, FL 32925

Marked for: Manager, Ordnance Services
Bldg. 72905, Cape Canaveral Air Station,
FL

Special Markings: Name of Program

Name of Project Monitor or Office

Complete Address

From: Sender's Name and Address

or:

To: Transportation Officer

Vandenberg Air Force Base, CA 93437

Marked for: 30 TRANS/LGTT

2010 New Mexico Street

Vandenberg Air Force Base, CA 93437

Name of Project Monitor and Office

Complete Address

From: Sender's Name and Address

6.13.2.3 ER Ordnance Delivery and Receipt

a. Ordnance deliveries shall be scheduled through CCAS Cape Support (853-5211) on the ER and deliver only to Range Safety approved facilities.

b. Operations Safety shall be notified of ordnance deliveries on CCAS.

c. Ordnance shipments arriving at the Range shall be escorted from the gate to the proper storage area.

d. After receipt at fuel storage Area (FSA) 2 at CCAS, all ordnance transportation shall be performed by CCAS Ordnance Services unless specifically approved by Range Safety.

e. All ordnance transportation shall be approved by Range Safety.

6.13.2.4 Ordnance Shipment Inspection

a. As soon as possible after receipt, a receiving inspection shall be conducted by ER Contractor Ordnance Services or 30 SW TMO and the Range User to ensure that no damage has occurred during shipment.

b. Any shipment discrepancy or DOT violation shall be reported to the Transportation Management Office (TMO) and Range Safety.

6.13.2.5 Ordnance Storage

a. Ordnance and propellants shall be stored in facilities specifically designed for that purpose and approved by Range Safety and/or the Department of

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Defense Explosive Safety Board (DDESB). **NOTE:** Processing facilities shall not be used for the storage of ordnance.

b. Instructions for disposing of stored ordnance items shall be furnished by the Range User to Ordnance Services upon project termination or when ordnance items are no longer required.

6.13.3 Ordnance Systems Grounding

6.13.3.1 Ordnance Systems Grounding PPE

a. Personnel handling, installing, or electrically connecting ordnance or working within 10 ft of exposed, solid propellant grain shall wear Range Safety approved, flame-retardant, non-static producing, long-sleeve, cuff-less, full-body garments (coveralls) with leg stats, conductive shoes, or wrist stats. **NOTE:** If required, Range Users shall submit a sample of the garment for testing.

b. Other persons who may come in contact with ordnance, test equipment when ordnance is connected, flight hardware when ordnance connections are not complete shall wear the same coveralls described in *a* above.

c. Sweaters and jackets shall not be worn as outer garments over protective coveralls.

d. When solid and/or liquid propellants are present, smocks shall not be used as a substitute for full body protection (coveralls).

e. More stringent controls shall be used by the Range User when necessary to enforce Range Safety policy. For example, it may be necessary to require all personnel entering a particular control area to wear the proper coveralls.

6.13.3.2 Ordnance Processing Restrictions on the Use of Static-Producing Materials

a. Static-producing materials shall not be used on or near ordnance items or in the vicinity of flammable liquids such as propellants.

b. Compliance with the restriction on static-producing materials is handled on a case-by-case basis; however, the following criteria shall serve as a guideline:

1. Materials shall not come into contact with a system having an installed EED or other ordnance.

2. Materials shall not come within 10 ft of exposed solid propellant grain; for example, no nozzle plug or cover.

c. Further restrictions and testing require-

ments are provided in the **Restrictions on the Use of Static-Producing and Flammable Material** section of this Chapter.

6.13.3.3 Ordnance System Static Ground Point Test

Static ground points in all ordnance and propellant operating and storage facilities shall be tested according to the **Grounding Systems Test Requirements** section of this Chapter.

6.13.3.4 Ordnance Systems Grounding Operations

6.13.3.4.1 Ordnance Systems Grounding Operations General Requirements.

a. Ordnance associated equipment such as handling fixtures and missile structures shall be provided to ensure that an electrostatic charge can not build up to levels that can cause ignition of the ordnance.

b. Platforms and ladders shall be grounded when used in conjunction with vehicles and/or payloads containing ordnance.

c. Launch complex service towers are not necessarily good electrical conductors due to corrosion, paint, and questionable bonding of work platforms to ground. Conductive mats that are grounded to the service tower shall be used. Wrist stats shall be required if proper grounding cannot be attained.

d. Grounding system megger checks shall not be made after initiators are installed or electrically connected unless proper fault protection is provided; for example, fuses placed in the leads, as approved by Range Safety.

6.13.3.4.2 Ordnance Systems Grounding Pre-Operational Checks.

a. When leg stats or conductive shoes are required, grounding of personnel shall be verified using a conductive shoe tester prior to the start of an ordnance operation. **NOTE:** Leg stat or conductive shoe resistance shall not exceed 1 megohm.

b. When wrist stats are required, grounding of personnel shall be checked with an ohmmeter. **NOTE:** Wrist stats are required to have a resistance between 10 kilohms and 1 megohm. The standard resistance is 100 kilohms.

c. To ensure grounding of personnel, conductive floors shall be verified in all ordnance and propellant operating facilities prior to operations.

d. Conductive floors and terminals shall be

verified to be electrically bonded to a grounding system common to the EED prior to operations.

e. Static ground points shall be verified to have a resistance to ground of 25 ohms or less using the methods of measuring resistance to earth described in IEEE-142.

6.13.3.4.3 Ordnance Systems Grounding Operating Requirements.

a. Touching a grounded surface is required prior to handling an EED.

b. When hoisting ordnance with a crane, a trailing ground connection to the facility ground shall be maintained during the hoist.

c. Metal shipping containers shall be grounded prior to opening the containers.

d. Before removing an ordnance item from a shipping container, the specific ordnance item shall be grounded.

e. When hoisting ordnance with a crane, the ordnance and/or container and the hook shall be commonly grounded before connecting the hook to the ordnance and/or container.

6.13.4 Ordnance Operations

6.13.4.1 Ordnance Operating Standards

a. All ordnance operations on the Ranges are considered hazardous and are subject to stringent controls.

b. Ordnance operations shall be conducted in accordance with AFMAN 91-201 and DoD 6055.9-STD.

c. All initiators are considered Category A until Range Safety concurs with the Category B designation.

6.13.4.2 Ordnance Facility Inspection

a. All new or modified explosives and propellant facilities shall be inspected prior to first use by Operations Safety (ER)/30 SW/SEW (WR).

b. An annual explosive safety inspection shall be conducted by Operations Safety (ER)/30 SE/SEW (WR) to determine compliance with explosives safety criteria as defined in this document, other DoD and USAF standards (for example, AFMAN 91-201 and DoD 6055.9-STD), and the provisions of Explosives Safety Plan 1 (ESP 1). (See Appendix 6D.)

c. The annual inspection shall include, but not be limited to, the following explosives storage and operating areas:

1. Launch complexes
2. Assembly area processing facilities
3. Support facilities

4. Solid and liquid propellant storage areas

d. The results of the annual explosives safety inspection shall be reported under the provisions of ESP 1.

e. Ordnance facilities shall be inspected monthly by the Facility Manager.

6.13.4.3 Ordnance Operations General Requirements

a. All ordnance operations on the Ranges shall be monitored and approved by Range Safety.

b. Testing of any ordnance circuit or device that could result in personnel injury or death (if the ordnance should fire) shall be conducted with no personnel exposed (remotely, in a test cell, or behind a barricade or shield.) **NOTE:** Operations Safety shall represent Range Safety during on-site ordnance activities.

c. Operations Safety shall be present to monitor all ordnance operations designated by Range Safety and shall spot check all other ordnance operations. **NOTE:** Examples of Operations Safety coverage during ordnance operations are as follows: the receipt of ordnance at the assembly and/or processing area; resistance and continuity checks; "No voltage" (stray voltage) checks; Category A ordnance installation and electrical connection; solid propellant work involving open grain; handling of liquid and solid propellant motors, segments, stages, or payloads; cycling and checkout of S&As or other safety devices; destruct system checks; any render-safe operations; ordnance removal; launch operations.

d. Ordnance electrical continuity and resistance checkout shall not be conducted at a launch complex or vehicle or payload assembly area without the written approval of Range Safety.

e. All test equipment used to check out ordnance shall be approved by Range Safety prior to use on the Ranges. **NOTE 1:** A list of currently approved instruments shall be maintained by ER Operations Safety and 30 SW/SES. **NOTE 2:** Applied current shall not exceed 10 percent of the no-fire current of any EED in the circuit, or 50 mA, whichever is less.

f. No current, voltage, power, energy, or other type of energy source shall be applied to any ordnance device outside of an approved test facility or with personnel in the immediate vicinity of the ordnance device except under the following conditions:

1. The operation is covered by an approved procedure
2. Approved equipment is used
3. The system or subsystem is approved

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g. RF silence is required during periods of ordnance installation, removal, and electrical connection and disconnection aboard a vehicle and/or payload. **NOTE 1:** Where practical, the RF control area shall include the entire facility and/or complex. **NOTE 2:** Radiating payloads are handled on an individual basis.

h. The Explosive Ordnance Disposal Team (EOD) shall be provided with familiarization of the vehicle and/or payload ordnance systems.

i. For each electrically initiated ordnance device installed on the vehicle and/or payload, the following tools and equipment shall be supplied to EOD in the event of a malfunction that requires render-safe actions or a mishap recovery effort:

1. One complete set of shielding caps (current design)
2. One set of safety pins
3. Special tools used in installation, removal, and safing the ordnance

6.13.4.4 Ordnance Operations Pre-Operational Requirements

6.13.4.4.1 Operations Safety and Range User. Prior to giving concurrence for any ordnance operations to begin, Operations Safety and the Range User shall ensure the following:

- a. All necessary controls are established
- b. Test equipment and the system conform to a configuration approved by Range Safety
- c. Radio transmissions are not made within 25 ft of launch vehicles and/or payloads containing EEDs or other RF susceptible ordnance
- d. All ordnance circuit control switches and firing line interrupt switches are in the off (OPEN) position before electrical connection of ordnance and thereafter when pad access is required
- e. Personnel and explosive limits are enforced
- f. Proper safety clearance zone has been established and cleared prior to starting the hazardous operation
- g. Proper signs are posted, warning lights are operating, barricades are established, and Security/HOS is posted
- h. Proper aural warnings and announcements have been made
- i. All serial numbers, calibration dates, proof test dates, and other equipment requirements have been verified prior to operations

6.13.4.4.2 Pre-Installation Checkout of Ord-

nance Items.

a. The pre-installation checkout of all ordnance items shall be performed only at Range Safety approved test facilities.

b. Requests to use alternate facilities shall be submitted in writing to Range Safety.

6.13.4.4.3 Ordnance NO VOLTAGE Checks.

a. Prior to any ordnance electrical connection, NO VOLTAGE (stray voltage) checks shall be performed on all launch vehicle and payload ordnance electrical connectors.

b. These checks shall be made first with power ON, then with power OFF, and include all pin-to-pin and pin-to-case combinations.

c. The power ON configuration requires the launch vehicle and payload to be powered up in launch configuration. **NOTE:** This configuration requires the payload and upper stage to be powered (along with the launch vehicle) in launch configuration on the launch complex unless the payload does not have any electrical interfaces with the upper stage.

d. The power ON check may be performed anytime in the launch processing after the launch vehicle, upper stage, and payload are mated provided the electrical system is not altered prior to final ordnance electrical connection.

e. The power OFF configuration requires the launch vehicle and payload to be powered down.

f. Power OFF checks shall be made immediately prior to ordnance electrical connection.

g. If a number of connections must be made in the same general area of the launch vehicle and payload, power OFF checks may be made on all of the connectors prior to ordnance electrical connection. **NOTE:** These connections shall be made before any electrical configuration or system changes such as bringing power back up occur.

h. Shielding caps shall not be removed from EEDs until electrical connection to the ordnance is to be made.

i. The resulting measured signal (current, voltage, power, energy) from a NO VOLTAGE check shall not be capable of producing a current greater than 20 dB below the no-fire current of the EED. **NOTE:** The NO VOLTAGE test procedure shall specify the maximum acceptable reading.

j. Meters that are used for NO VOLTAGE checks shall have a valid calibration seal.

k. On the ER only, the integrity of the meter

and test leads shall be demonstrated to Operations Safety prior to use. Fixed- or facility-test instrumentation that is used in place of portable GSE shall have a procedure that verifies the integrity of the system. **NOTE:** A copy of the completed procedure shall be provided to Operations Safety.

6.13.4.5 Ordnance Operating Requirements

a. All ordnance and propellant operations shall be conducted in accordance with written procedures approved by Range Safety.

b. Ordnance operations shall not be conducted when the relative humidity is less than 35 percent.

c. Ordnance and propellant operations shall not be conducted except in facilities specifically designed for this purpose and approved by Range Safety and the DDESB.

d. At the ER, ordnance items shall not be handled, installed, or electrically connected when the passage of an electrical storm is imminent (within 5 nautical miles). Operations Safety Plans shall detail the procedures to be followed for different configurations. At the WR, the guidance provided in 6.5.5.2 shall be followed.

e. Ordnance items, particularly Category A initiators, shall be installed and electrically connected as late in the countdown as possible.

f. A rotation test shall be performed on all launch vehicle and/or payload S&As after installation and erection on the launch pad but prior to final connection to the ordnance train. This test shall be performed using the launch day system configuration such as monitor circuitry, power sources, and circuits for cycling the S&A.

g. The ordnance train shall be disconnected from the S&A output during all checkout operations except during the following circumstances:

1. Single complete rotation test (SAFE to ARM to SAFE)

2. Final rotation to ARM on the last day of the count

h. When the S&A is rotated on the pad, all personnel shall be cleared to an area designated in the OSP.

i. EMI testing shall not be conducted with initiators installed on the vehicle or payload without Range Safety approval.

6.13.4.6 Laser Initiated Ordnance Operations Personnel Access Criteria

a. For laser initiated ordnance (LIO) systems, the following personnel access criteria are required:

1. For unlimited personnel exposure during LIO tests: three independent verifiable circuit inhibits (dual-fault tolerance)

2. For essential personnel exposure during LIO tests: two independent circuit inhibits (single-fault tolerance)

3. For no personnel exposure during LIO tests: one circuit inhibit

b. One inhibit shall be a disconnection of the ordnance train at the LIO or the destruct charge/solid rocket motor igniter (other ordnance end item).

6.13.5 Explosive Ordnance Disposal

6.13.5.1 Rendered Safe Ordnance

All damaged ordnance shall be rendered safe by the AF EOD Team.

6.13.5.2 Obtaining EOD Services

AF EOD services may be obtained by calling Cape Support (853-5211) or Patrick AFB Command Post (494-7001) on the ER or Range Scheduling (276-8825) on the WR.

6.13.5.3 Range Safety Approval of Shipment of Damaged or Rendered Safe Ordnance

a. Shipments of damaged or rendered safe ordnance from the Ranges or the downrange stations shall be approved in writing by Range Safety.

b. This approval and/or certification shall accompany the shipment.

c. A DOT exception shall normally be obtained by the Range User before AF EOD will release damaged ordnance.

6.13.6 Ordnance Facilities Operations

a. Ordnance items shall not be delivered to, placed in, or processed through facilities or locations on the Ranges, or downrange stations unless the facility or area has been approved for such operations by Range Safety.

b. Ordnance deliveries from storage to the Range User shall be coordinated with ER Operation Safety Manager and 30 SW/SEGW.

c. All facilities in which ordnance operations are conducted or stored shall be properly equipped, display the correct explosive safety markings, and otherwise meet the minimum explosives safety standards cited in AFMAN 91-201 and DoD 6055.9-STD and subtier documents and this document.

d. All operations and activities within an explosives sited facility must be ordnance-related and

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require Range Safety approval.

6.14 ELECTRICAL SYSTEMS OPERATIONS

6.14.1 Electrical Systems Operating Standards and Definitions

6.14.1.1 Electrical Systems Operating Standards

a. As applicable, AF Pamphlet 85-1, T.O. 00-25-232, and the National Electric Code (NEC) shall be followed in the design, maintenance, and conduct of electrical systems operations at the Ranges.

b. Workplace electrical safety shall be in accordance with NFPA 70E, AFI 32-1064, and OSHA 1910, Subpart S.

6.14.1.2 Definition of Hazardous (Classified) Locations for Electrical Equipment Operations

Hazardous (classified) locations are defined in Article 500 of the NEC and NFPA 497A; however, some explosives and propellants are not covered. For Range installations, the following paragraphs define the minimum requirements to be applied in the definitions of locations in which explosives, pyrotechnics, or propellants are or are expected to be present. These requirements shall be followed unless less stringent classifications are justified and approved as part of the design data submittal process. Range Safety and the Fire Department shall approve all potential safety critical facility hazardous location designations. (See Appendix 6I for a Hazardous Area Classification decision flowpath.)

a. Class I, Division 1

1. Locations in which flammable liquids, vapors, or gases may be present in air during normal operations

2. Locations in which ignitable concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage

3. Locations in which the breakdown or faulty operation of equipment or processes might release ignitable concentrations of flammable gases or vapors and might also cause simultaneous failure of electrical equipment

4. As a baseline, these include the following locations:

(*a*) Within 25 ft of any vent opening unless the discharge is normally incinerated or scrubbed to non-flammable conditions (less than 25 percent of

LEL). This distance may be increased if the vent flow rate creates a flammability concern at a distance greater than 25 ft.

(*b*) Below grade locations in a Class 1, Division 2 area.

b. Class 1, Division 2

1. Locations in which volatile flammable liquids or flammable gases are handled, processed or used, but in which the liquids, vapors, or gases will normally be confined in closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or system or in case of abnormal operation of equipment

2. Locations in which ignitable concentrations of gases or vapors are normally prevented by positive mechanical ventilation and which might become hazardous through failure or abnormal operation of ventilation equipment

3. Locations adjacent to a Class 1, Division 1 location and to which ignitable concentrations of gases or vapors might occasionally be communicated unless communication is prevented by adequate positive pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided. **NOTE 1:** This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used but, in the judgment of Range Safety and the Fire Department, would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of an accident, the adequacy of ventilating equipment, the total area involved, and the record of the Range User with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location. **NOTE 2:** Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions. **NOTE 3:** As determined by Range Safety and the Fire Department, locations may actively change classification depending upon the flammable fluid system activity and configuration. For these types of locations, fixed or permanently installed electrical equipment shall be designed for the worst case hazardous envi-

ronment. **NOTE 4:** Portable electrical equipment shall be designed for the worst case hazardous environment in which it will be used. Portable equipment that is not designed for use in a particular hazardous environment is not allowed in that environment or shall be locked out from use in that environment.

4. As a baseline, Class 1, Division 2 locations include the following equipment or areas:

(a) Storage vessels (including carts and drums) - 25 ft horizontally and below to grade and 4 ft vertically above the vessel (25 ft in any direction for hydrogen)

(b) Transfer lines - 25 ft horizontally and below to grade and 4 ft above the line (25 ft in any direction for hydrogen)

(c) Launch vehicle - An analysis shall be performed per API 500 RP 500. The minimum distances shall be 100 ft radius horizontally from and 25 ft vertically above (100 ft for hydrogen) the highest leak or vent source and below the vehicle to grade.

(d) Enclosed locations such as rooms, work bays, and launch complex clean rooms that are used to store and handle flammable and combustible propellants when the concentration of vapors inside the room resulting from a release of all fluids stored and handled equals the LEL. **NOTE:** The quantity of fluids used in the analysis shall be the maximum amount allowed in the quantity distance site plan.

c. Hazardous Commodity Groups. Hazardous commodities are grouped by similar characteristics. **NOTE:** These fuels shall be considered ignitable regardless of the ambient temperature. The following fuels shall be categorized as follows:

1. Group B - Liquid or gaseous hydrogen
2. Group C - Hypergolic fuels such as N_2H_4 , MMH, UDMH, A-50
3. Group D - Hydrocarbon fuels
4. Group D - Oxidizers. Oxidizers shall be considered Group D hazardous substances in addition to the fluids listed in Section 500-3 of the NEC.

d. Exposed Solid Propellants. The atmosphere within 10 ft of exposed solid propellant shall be classified as a Class 1, Division 2, Group D location. Solid rocket motors are considered exposed in the following situations:

1. The motor nozzle is not attached and the aft end of the motor does not have a cover
2. The motor nozzle is attached but does not have a nozzle plug
3. The unassembled motor segments do not have front and rear covers

4. The igniter is removed from the motor and cover is not provided

6.14.1.3 6.14.1.3 Photography

6.14.1.3.1 Photography General Requirements.

a. Manual (with a photographer) photography shall not be allowed in a hazardous (Class I, Division 1) environment.

b. Remotely operated, hazard-proofed cameras and UL listed lighting sources shall be used for Class I, Division 1 environments as well as for Class I, Division 2 environments that cannot be verified as non-hazardous.

6.14.1.3.2 Class 1, Division 2 Photography Requirements. Requirements for the use of cameras and camera flash attachments in areas containing solid and liquid propellants that would normally be classified as Class I, Division 2 are listed below:

a. Before and during the use of photography equipment within 100 ft of a flight vehicle propellant system or within 25 ft of propellant storage vessels, the operating environment of the photography equipment shall be verified to be free of hazardous vapors.

b. Before bringing photography equipment into an area, all ordnance installation and/or connection operations and liquid propellant system operations that affect propellant systems within 100 ft of the photography equipment shall cease.

c. The user of the photography equipment shall certify to Range Safety in writing that the camera and/or flash attachments have no external sparking/arcing capability. Information, including vendor specifications, shall be made available to Range Safety upon request.

d. Camera batteries shall be securely installed in the camera or in a protective case. Battery replacement shall occur away from the vehicle. No battery charging shall take place in a hazardous area.

e. All electrical equipment that is brought into the hazardous area shall remain in the tethered possession of the photographer and his/her assistant(s).

f. The camera shall be tethered to the photographer.

CHAPTER 6

GROUND SUPPORT PERSONNEL, EQUIPMENT, SYSTEMS, AND MATERIAL OPERATIONS SAFETY REQUIREMENTS

g. Photography using heat-producing, expendable flash bulbs such as flash cubes and sun-guns is not permitted within 100 ft of hazardous liquid propellant systems or solid propellant grain.

h. Cameras and/or flash attachments shall be enclosed or otherwise contained to prevent parts from falling into or contacting flight hardware.

i. The maximum operating temperature of the camera and/or flash attachment shall not exceed 80 percent of the ignition temperature for any vapor that may occur in the operating environment of the photography equipment.

Cameras and/or flash attachments to be used inside solid rocket motor bores shall be designed and specified for that particular use.

6.14.2 Electrical Systems Operations Personnel and Special Insulated Equipment

6.14.2.1 Personnel Equipment

Personnel wearing conductive grounding devices shall not operate electrically powered devices which could result in a shock hazard.

6.14.2.2 Special Insulated Equipment

a. If live electrical maintenance or repair work must be performed, special insulated equipment shall be provided.

b. Special insulated equipment includes, but is not

limited to the following:

1. Insulated hook sticks for opening and closing disconnect switches
2. Insulated fuse sticks for removing and installing cartridge type fuses
3. Rubber insulating sleeves and gloves
4. Rubber insulation floor mats
5. Rubber insulating line conductor hose
6. Dielectric hard hats

6.14.3 Electrical Systems Procedures

a. Procedures shall be written for all electrical maintenance and repair work.

b. Procedures shall include, but not be limited to, the following topics:

1. Tagging and locking out control switches
2. Use of approved non-conductive fuse pullers
3. Provision and use of PPE
4. Grounding of equipment and personnel
5. Use of "Buddy System" (mandatory when working on energized equipment and circuits)
6. Safety precautions to be followed when working on energized equipment and circuits
7. Fire Protection and equipment
8. Knowledge of resuscitation procedures

6.14.4 Electrical Equipment and Systems Test, Inspection, and Maintenance

6.14.4.1 Grounding Systems Tests

6.14.4.1.1 Grounding Systems General Tests.

a. Grounding system tests for lightning protection, electrical fault protection, and static protection systems shall be performed for all facilities and/or locations (including launch complexes) used to store, handle, or process ordnance or liquid propellants.

b. Facility Operators and Range Users shall inspect their portable and movable equipment connections to ground before starting operations each day the equipment is to be used.

6.14.4.1.2 Grounding Systems Test Plan and Test Frequency Criteria.

a. A floor plan layout showing all grounding system test points shall be developed by the Facility Operator and/or the Range User.

b. Based on the floor plan, the following tests shall be conducted:

1. Lightning protection system resistance to ground shall be tested annually to the following criteria:

(a) 10 ohms or less for the counterpoise system

(b) 10 milliohms from the terminal to the counterpoise system

2. The lightning protection system shall be inspected visually and mechanically twice a year.

3. The facility static/electrical ground system resistance shall be tested annually to a criteria of 25 ohms or less using the methods of measuring resistance to earth described in IEEE-142.

4. Facility equipment connections to the facility ground system shall be visually inspected prior to each use and tested every two months to a criteria of 1 ohm or less. **NOTE:** During this test, ground support equipment and flight hardware containing hazardous commodities may be disconnected but do not have to be removed from the facility.

5. Conductive floors shall be visually inspected and tested twice a year to a criteria of test-point to test-point resistance of 250,000 ohms or less. **NOTE:** Hazardous commodities shall be removed before testing.

6. All resistance measurements shall be taken with a currently calibrated instrument in accordance with a Range Safety approved procedure.

7. Measuring devices such as megohm meters (meggers) shall be current-limited by use of fuses or equivalent devices when the facility contains electrically connected EEDs.

8. Procedures shall require testing to demonstrate a resistance of 1 ohm or less measured from the equipment surface to the facility ground point.

9. Test and inspection results shall be provided to the facility custodian and be available at the facility.

6.14.4.2 Electrical Equipment Inspection

Electrical equipment shall be inspected prior to use.

6.14.4.3 Electrical Equipment Maintenance

a. Electrical equipment shall be properly maintained in serviceable condition.

b. Conductors with worn, abraded, or defective insulating material shall be repaired or replaced prior to the circuit being energized.

c. Electric motors shall be properly maintained and excess dust and oil shall be removed from motors by vacuum cleaning or wiping.

6.14.5 Electrical Systems Operating Requirements

6.14.5.1 Electrical Systems General Operating Requirements

NOTE: Excessive humidity, wet areas, lack of protective matting, or equipment with exposed contacts to ground may require low or lesser voltage to be designated as high voltage. If these conditions exist, they increase the hazards.

a. Personnel working with high voltage equipment shall not wear conductive grounding devices.

b. Supervisors shall be responsible for assuring that safe working conditions are provided; the work is done in a safe manner; and frequent inspections of equipment, materials, and the work site are conducted.

c. Whenever maintenance or repair work is performed on potentially hazardous energized electrical equipment or circuits, there shall be a minimum of two people present (buddy system).

d. Rescue and first aid equipment shall be readily available in areas where electrical maintenance and repair work is being performed.

e. Personnel exposed to electrical circuits shall not wear loose clothing, rings, watches, or other metallic objects that can act as conductors of electricity.

f. Only Underwriters' Laboratories (UL) or Factory Mutual (FM) listed weather proof or water-tight equipment shall be used in areas subject to excessive moisture.

g. Only explosion and/or hazard-proofed equipment shall be used in potentially hazardous atmospheres.

h. Before working on capacitor circuitry, external power and short terminals shall be disconnected and discharged to ground.

i. If power lines are required to extend across outside work areas, they shall be protected by a wooden cover or elevated so as not to interfere with personnel, vehicles, or equipment traffic.

j. Electrical equipment cords shall have an equipment grounding conductor and shall be grounded when in use. Unless double insulated, the equipment exterior shall be securely bonded and grounded.

k. Dead-end wires shall be completely insulated.

6.14.5.2 Electrical Systems Pre-Operational Requirements

a. With the exception of test and check-out, all electrical equipment and circuits shall be de-energized before any work is started on these circuits or equipment through a scheduled power outage.

b. Power outages in facilities shall be coordinated with the affected parties.

c. The line switch shall be locked out and tagged in accordance with the **Control of Hazardous Energy Sources** section of this Chapter whenever work is being done on circuits.

d. Electrical conductors shall be routed to eliminate tripping hazards or contact with energized lines.

6.14.5.3 Electrical Systems Operating Requirements

a. If panel covers are removed or left open to obtain power where none is available, a DANGER HIGH VOLTAGE sign shall be placed next to the open panel. When cable connections are made, the panel cover shall be installed, if possible, using as many attach points that are available to secure it.

b. Insulated fuse pullers shall be used for removal of fuses. Only fuses of proper rating shall be used in circuits. No other material shall be used in place of a fuse.

c. Personnel who are exposed to energized circuits for electrical activities such as troubleshooting, maintaining, or repairing electrical equipment energized with 25 volts or more shall stand on non-conductive matting.

d. Grounding or shorting sticks (or cables) shall be used on potentially "hot" circuits and shall not be removed until repairs are completed.

6.14.6 Battery Operations

6.14.6.1 Battery Operating Standards

a. An approved means of disposal or transportation to an off-site approved disposal site shall be in place prior to receipt of the batteries on the Ranges.

b. The means of disposal shall be in accordance with DOT and EPA requirements and carry DOT and EPA approvals.

6.14.6.2 Battery Operations Personnel Requirements

6.14.6.2.1 Battery Operations Training and Certification.

a. A training program shall be generated and approved by the Range User for all personnel handling batteries.

b. For personnel handling lithium batteries, a training program shall be reviewed and approved by Range Safety. **NOTE:** Personnel who handle batteries that have a Underwriters Laboratory (UL) listing and are intended for public use are exempt from these requirements.

6.14.6.2.2 Emergency First Aid and PPE Requirements.

a. Emergency First Aid

1. An emergency eye wash and shower shall be provided in locations where batteries are serviced. They shall be installed in accordance with AFOSH 127-32 and ANSI Z358.1. **EXCEPTION:** *An emergency eye wash and shower are not required if batteries are present but will not be serviced in that location.*

2. An emergency first aid kit, containing a burn neutralizer shall be provided.

b. PPE. The following PPE shall be provided in accordance with AFOSH 91-66 and used when servicing or handling batteries:

- 1.* Front and side face and eye protection
- 2.* Rubber gloves
- 3.* Rubber apron
- 4.* Foot protection

6.14.6.3 Battery Procedures

a. Procedures for battery receipt, transportation, checkout, handling, installation, safing, packing, storage, and disposal shall be developed and submitted to Range Safety for review and approval.

b. Specific safing operations of batteries shall be in battery handling and checkout procedures.

c. Battery handling and checkout procedures shall include the following topics:

1. A list of proper handling equipment
2. Identification of specific personnel qualified to safe batteries if in a unsafe condition
3. Identification of the exact location of the storage site of depleted or unsafe batteries

6.14.6.4 Lithium Batteries Special Requirements

NOTE: Batteries that have a UL listing and are intended for public use are exempt from these requirements.

a. Range Safety shall approve temporary lithium battery storage and handling facilities. These facilities shall be used only for lithium batteries and shall not be used for other purposes. **NOTE:** Lithium batteries shall not be stored permanently on the Ranges.

b. The Range User shall provide certification with the lithium battery confirming that all safety critical steps and processes agreed to by Range Safety during the battery development phase have not been altered.

c. Prior to delivery of lithium batteries to the Ranges, an approved off-site disposal contract shall be in place for the batteries in any condition.

6.14.6.5 Battery Maintenance, Storage, and Operations

a. Rechargeable storage batteries and batteries requiring activation at the Ranges shall be handled only in designated battery shops and areas equipped for servicing and recharging in accordance with the **Battery Storage and Processing Area Design Requirements** in Chapter 5 of this document.

b. Separate areas shall be provided for servicing of batteries that have incompatible electrolytic solutions; for example, acid and alkaline.

6.15 MOTOR VEHICLE OPERATIONS

6.15.1 Motor Vehicle Operating Standards

All vehicle operations shall comply with federal, state, Air Force, and Range laws and regulations including, but not limited to, the following criteria:

- a.* Proper licensing of operators
- b.* The use of vehicle restraint devices such as seat belts
- c.* Restrictions on wearing head phones or ear speaker type radios while operating a vehicle
- d.* The use of spotters when backing with restricted rear vision vehicles

6.15.2 Motor Vehicle Operating Require-

ments

6.15.2.1 Use of Spotters and Chocks

a. Maneuvering in the vicinity of hazardous commodities requires the use of a spotter.

b. When backing, chocks shall be used to prevent contact.

6.15.2.2 Gasoline and Diesel Vehicle Operations Approval

Gasoline or diesel vehicle operations within buildings shall be as approved by the Bioenvironmental Engineer.

6.15.2.3 Ordnance and Propellant Area Parking

6.15.2.3.1 General Parking Requirements.

a. Vehicle parking in areas sited and used for ordnance or propellants shall be in accordance with the applicable Safety Plan. (See Appendixes 6C, 6D, and 6E.)

b. These Safety Plans shall be developed by Operations Safety using AFMAN 91-201 and DoD 6055.9-STD for criteria

6.15.2.3.2 General Parking Restrictions.

1. Designated parking areas shall be used.
2. Privately owned vehicles shall not be parked within the fenced-in area of hazardous processing facilities.
3. No vehicle shall be parked within 25 ft of lines containing liquid propellants.

4. No vehicle shall be parked within 50 ft of storage tanks containing liquid propellants.

5. When required, delivery vehicles are exempt from the preceding requirements during loading and off-loading and shall be removed immediately afterwards.

6. While parked, the parking brake shall be engaged and wheels shall be chocked.

6.15.2.3.3 Restricted Parking Areas. All government, private, and contractor-owned vehicles are prohibited from parking in the following areas under the following conditions:

1. Within the FHA once the FHA has been established

2. In the BDA during wet dress rehearsal (cryogen tanking)

3. Within the launch complex fence line during core vehicle tanking (other than cryogenics that are tanked) after the BDA/FHA is established

4. Within the launch complex fence line during fueled spacecraft/upperstage mating operations

6.15.2.4 Internal Combustion Engine Vehicles

Motor vehicles or equipment using internal combustion engines shall require spark arresters and carburetor flame arresters under the following conditions:

a. When transporting explosives that have exposed grain, scrap, waste or items visibly contaminated with explosives

b. When operating internal combustion engines within the control area during propellant transfer operations or continuously within POL and/or propellant storage areas

6.15.2.5 Hazardous Commodities Vehicle Transportation Standards

Vehicles transporting hazardous commodities shall meet DOT and DoD (for example, AFMAN 91-201 and DoD 6055.9-STD) regulations.

6.16 CONVOY OPERATIONS

NOTE 1: At the ER, all transportation of oversized loads (larger than 12 ft in width, 13.5 ft in height, or 55 ft in length) is considered a hazardous operation. **NOTE 2:** At the ER, if the convoy is to travel onto KSC, 45 SPW/JOP 15E-3-50 is applicable. **NOTE 3:** At the WR, all convoys shall be conducted in accordance with 30 SPS/SPOS OI 31-1010, Volume 2, Chapter 5.

6.16.1 Convoy Transportation Procedures

A procedure for transportation shall be submitted to Range Safety for review and approval.

6.16.2 Convoy Operations Requirements

The Range User and/or the agencies responsible for the transportation of a load shall ensure the following items are performed:

a. The load or commodity to be transported shall be identified.

b. The convoy shall be scheduled through CCAS Cape Support (853-5211) at the ER and through Range Scheduling (30 RANS/DOS 276-8825) at the WR.

c. A convoy commander shall be designated.

d. If flight hardware or hazardous commodities are involved, a Security/HOS escort shall be arranged.

e. At the ER, as required by Range Safety, Operations Safety approval shall be obtained prior to start of the convoy if hazardous commodities or flight hardware are involved.

f. When transporting hazardous commodities, the transfer route shall be chosen to minimize exposure to populated areas and critical facilities. **NOTE:** Transfer should occur during off-peak traffic and population hours.

g. The selected route shall be identified and the following items noted:

1. Horizontal and vertical clearances

2. The hazardous commodity transported

3. Population along the route

4. Traffic that may be encountered

5. Condition of surface being traveled upon

6. Distance of route

h. Radio contact shall be maintained with the convoy commander for all elements of the convoy.

i. At a minimum, the following items of equipment are required:

1. Flashlights if transport occurs during periods of darkness

2. Emergency apparatus such as fire extinguishing equipment, reflectors, and flares

j. Proper environmental health required by the commodity transported shall be ensured.

k. As required by Range Safety, areas shall be cordoned off.

l. Emergency actions shall be taken to secure the item being transported in the event of a mishap.

m. A pre-operational check of the loaded vehicle and trailer shall be conducted.

n. A convoy commander pre-departure briefing

guide and requirements shall be prepared and conducted. The briefing guide includes such information as hazards, communication checks, and stop points.

6.17 LAUNCH OPERATIONS

6.17.1 Launch Operations Procedures

At a minimum, procedures for the launch countdown and prelaunch count shall contain the following Operations Safety functions for the specific launch vehicle and payload systems:

- a.* Monitoring and verifying no-voltage checks, installation, and hookup of destruct ordnance
- b.* Approval to start ordnance tasks
- c.* Monitoring the installation and electrical hookup of ordnance
- d.* Approval to start propellant transfer and launch vehicle tanking
- e.* Approval to start pressurization
- f.* Initiating holdfire when safety constraints or emergency situations dictate
- g.* At the ER, monitoring and verifying FTS checkout
- h.* At the ER, conducting holdfire checks

6.17.2 Operations Safety Launch Countdown

6.17.2.1 Operations Safety Launch Countdown General Requirements

Operations Safety OSM and/or OST shall perform the following launch countdown general functions:

- a.* Verification that the permanent fire fighting and cooling water systems are operating properly and that adequate water, at the correct operating pressure, is available until after launch or until the test is scrubbed and propellants have been detanked
- b.* Monitoring and verifying destruct Safe & Arm Device (S&A) rotation on the pad
- c.* Requesting and verifying RF silence as required
- d.* Monitoring and verifying FTS checkout
- e.* Immediately notifying Range Safety of any airborne FTS discrepancy, component, subsystem, or system failure
- f.* Conducting holdfire checks
- g.* Verifying removal of the FTS and ignition S&A safety pin and Explosive Bridgewire (EBW) circuitry safing plug and clearing the Flight caution area prior to launch
- h.* Verifying reinsertion of the FTS and ignition S&A safety pin and EBW circuitry safing plug in the event of a scrub as directed by Range Safety

i. Verifying reinsertion of the Category A ordnance safety device in the event of a scrub as directed by Range Safety

j. Calling a HOLD during a test or actual launch countdown or preventing further progress of a test when, in the opinion of the OSM, such action is necessary in the interest of safety

6.17.2.2 Operations Safety Launch Countdown Pre-Operational Requirements

Operations Safety shall perform the following launch countdown pre-operational requirements:

- a.* At the ER, within five calendar days of F-0 day, monitoring and verifying S&A and EBW detonator electromechanical checks at the Range Contractor solid propellant test facility or other locations
- b.* At the ER, ensuring that the command receivers are not turned on during any time that ordnance of the FTS is electrically connected unless Range Control Officer concurrence has been given of the OSM
- c.* Monitoring and verifying no-voltage checks, installation, and hookup of the FTS ordnance
- d.* Verifying that the Launch Disaster Control Group (LDCG) is in place at the "fall back" position for each static firing or launch

6.17.2.3 Launch Countdown Operations

a. At the ER, to ensure proper operation, the holdfire and firing line interrupt capability shall be checked out at a mutually agreed time on the launch pad as close to launch as practical with Operations Safety present.

b. At the ER, results of the checkout shall be reported by Operations Safety Console in the blockhouse/Launch Control Center/Launch Support Center, or on board ship to the Mission Flight Control Officer (MFCO) during the launch countdown.

c. At the time specified in the applicable documents (Range User launch countdown/pre-count), the OSM shall be on station at the Operations Safety Console in the blockhouse/Launch Control Center, or on board ship if a sea launch is scheduled, and at the launch area.

d. At the ER, the OSM shall clear all non-essential personnel from the Blast Danger Area when required. At the WR, the OSM shall clear the Hazard and Caution Areas when required.

e. The OSM shall control all warning devices provided to indicate hazard conditions. For all launches except at the WR, the Monitor and Control Officer (MC) controls warning devices for ballistic

launches.

f. The OSM shall declare caution and danger periods at the times such action becomes necessary in the interest of safety.

g. At a mutually agreed upon point in the count-down at the ER, the OSM shall report verbally to the MFCO, "The Flight Caution Area is clear;" at the WR, the OSM shall send a green light signal. (See Chapter 7 for further information.)

h. The blockhouse door Security Guard shall permit no one to leave the blockhouse unless specifically authorized by the OSM.

i. Where applicable, blockhouse air conditioning air intakes shall be closed prior to booster ignition.

j. Searchlight and photographic supervisors shall report to Operations Safety when clearing the complex and upon arrival at the "fall back" position.

k. The OSM shall initiate HOLDFIRE when safety constraints or emergency situations dictate.

6.17.3 Launch Abort and Misfire/Hangfire Operations

Any failure to launch or ignite properly shall be treated as a hangfire until it can be definitely established that a misfire has occurred or until the 30-min waiting period has elapsed. The 30-min waiting period is not applicable to ballistic vehicles at the WR where it is dictated by T.O.s.

6.17.3.1 Common Abort or Misfire/Hangfire Operations

a. The Range Safety System shall remain configured in a manner that will enable the MFCO to take destruct action if necessary until Operations Safety has verified to the MFCO that the launch vehicle is no longer in a launch configuration.

b. In the event of a launch abort or misfire or following expiration of the 30-min waiting period in the case of a hangfire with solid propellant stages, or a solid propellant and starter devices, the OSM shall perform the following activities: **NOTE:** The 30-min waiting period is not applicable to ballistic vehicles at the WR where it is dictated by T. O.s.

1. Ensure the ignition firing circuit has been disabled.

2. Allow rotation of the destruct S&A rotors to SAFE with approval of the MFCO.

3. Verify to the MFCO that the destruct S&A devices are in the SAFE position.

4. Allow the command receivers to be turned OFF after coordination with the MFCO.

5. Verify to the MFCO that the safety pins are

reinstalled.

6. Make a launch complex inspection in conjunction with the Launch Agency and allow access to the launch complex for work when it is safe to do so.

7. Adjust or lift road blocks as required.

8. When no further launch attempt is contemplated, verify that hazardous ordnance items are disconnected electrically and shielded and, if required, removed for return to the storage area.

9. Request support by the Explosive Ordnance disposal (EOD) team when disarming of ordnance systems or components cannot be accomplished in normal methods.

c. If necessary, the EOD team shall initiate RENDER-SAFE procedures.

6.17.3.2 Launch Vehicles Using Liquid Propellant Stages Abort or Misfire/Hangfire Operations

a. In the event of launch abort or misfire/hangfire, the Range User shall depressurize the vehicle propellant tanks and pressure systems to safe.

b. Operations Safety shall monitor the detanking of propellants where applicable.

6.17.3.3 Launch Vehicles Using Solid Propellant Stages or Solid Propellant Starting Devices Abort or Misfire/Hangfire Operations

a. In the event of hangfire, Operations Safety (ER)/FSPO (WR), the Range User, and 45 or 30 RANS shall ensure that the Range Safety System shall remain configured in a manner that will enable MFCOs to take destruct action, if necessary, in the event of unscheduled launch. **NOTE :**The waiting period in this configuration is a minimum of 30 min during which time the Flight Caution Area shall remain cleared.

b. For vehicles using solid propellant stages or solid propellant starting devices, Operations Safety shall restrict access to the pad until it can be verified that power did not reach the initiator (misfire) or it is assumed that power did reach the initiator (hangfire) and a 30-min waiting period has elapsed.

6.17.4 Launch Disaster Control Group Operations

6.17.4.1 Launch Disaster Control Group Duties and Responsibilities

a. ER. The duties and responsibilities of the ER LDCG are defined in the 45 SPW OPLAN 32-1, Vol II; the Safety Operating Plan for the 45 SW Launch Disaster Control Group; and the Safety Operating Plan for LDCG Procedures.

b. WR. The duties and responsibilities of the WR LDCG are defined in applicable Launch Support Plans.

6.17.4.2 LDCG Operations Requirements

a. During major launch operations, the LDCG shall be available for immediate response to a launch vehicle and/or payload impact on the Ranges, KSC, or the public domain.

b. The Range User shall have the required vehicle launch crew necessary to support the LDCG Commander at fallback at least 60 min prior to T-0.

NOTE: If more than one fallback position is used, the crew should report to the primary fallback area.

c. Crews for securing the complex after a normal launch shall not be located in the same area as the LDCG. **NOTE:** These crews shall be located so as not to interfere with LDCG operations.

6.17.5 Post-Launch Operations

a. Immediately after a launch, Operations Safety shall inspect the pad for personnel hazards such as contamination, exposed wiring, damaged high pressure systems, or damaged propellant tanking systems.

b. The blockhouse OSM shall coordinate with the Safety Technical Director and the Range User to determine when it is safe to permit personnel to leave the blockhouse or shelter and when it is safe to operate the pad for normal work.

c. Operations Safety shall direct Security/HOS to ad-just or lift road blocks as warranted by existing conditions.

d. Fire, medical, and pumping station support shall be released when no longer needed and normal security measures are instituted.

APPENDIX 6A GROUND OPERATIONS PLAN

6A.1 INTRODUCTION

6A.1.1 Purpose

The Ground Operations Plan (GOP) provides a detailed description of the hazardous and safety critical operations associated with a missile system and its associated ground support equipment. It is the medium from which Missile Systems Pre-Launch Safety approval is obtained from the Ranges along with the Missile Systems Pre-Launch Safety Package (MSPSP) required in Chapter 3.

6A.1.2 Content

This Appendix contains the content preparation instructions for the data generated by the requirements delineated in Chapter 6.

6A.1.3 Applicability

The requirements in this Appendix are applicable to all launch vehicle and spacecraft contracts.

6A.1.4 Submittal Process

The GOP submittal periods are as follows:

- a.* Preliminary drafts of the GOP shall be provided to Range Safety 45 days prior to the cDR, the PDR, and the CDR but not later than one year prior to the projected date hardware will arrive at the Ranges.
- b.* The final GOP shall be submitted 45 calendar days prior to the delivery of hardware on the Ranges.

6A.1.5 Final Approval

The GOP shall be approved by Range Safety prior to the start of any hazardous operations on the Ranges.

6A.2 PREPARATION INSTRUCTIONS

6A.2.1 Content

The GOP contains a description of planned operations, including backout, and the associated hazard analysis of those operations. Where applicable, previously approved documentation may be referenced throughout the package.

6A.2.2 Format

Contractor format is acceptable provided the information described below is provided.

6A.2.2.1 Table of Contents and Glossary

The GOP shall contain a table of contents and a glossary.

6A.2.2.2 Introduction

The Introduction shall address the purpose and scope of the GOP.

6A.2.2.3 General Description

The General Description section shall present an overview of the system and the processing flow as a prologue to the hazardous and safety critical operation descriptions. The following items are included in this section:

- a.* General flow of system integration and testing
- b.* Facilities to be used
- c.* Generic timeline with sufficient granularity to identify the major hazardous and/or FTS operations

6A.2.2.4 Ground Operations

The Ground Operations section shall identify the ground processing flow including all hazardous and safety critical operations. The following items are included in this section:

- a.* List of all non-hazardous, hazardous, and safety critical procedures by title and numerical designation with an indication as to which have been designated as hazardous or related to FTS operation
- b.* Procedure Descriptions. Procedure descriptions shall include separate listing of tasks so that hazardous tasks within each procedure can be identified.
- c.* Procedure Task Summaries. Task summaries for each procedure shall include the following information:
 1. Each separate task
 2. Responsible agency
 3. Objective
 4. Initial and final configuration
 5. Equipment and support required
 6. Description
 7. Hazards and precautions
 8. List of approved PPE and detection equipment used in ground operations.
- d.* Flow Chart. A flow chart indicating expected time sequence and location of each individual procedure and task shall be included. Each flow chart block used shall be assigned a maximum of one procedure and include the following information:
 1. Identifier for each procedure
 2. Procedure number
 3. Hazardous, non-hazardous, or safety critical designation

APPENDIX 6A

GROUND OPERATIONS PLAN

4. Task summary number(s)
- e. Identification of Emergency and Abort/Back-out Actions
- f. A list of personnel training, certification, and experience requirements for each type of hazardous operation such as ordnance, crane, and propellant operations.

6A.2.2.5 Off-Site Processing

The Off-Site Processing section shall include the following information:

- a. A detailed description of the off-site build-up and transport configuration of the launch vehicle and payload that will be transported to the Range
- b. A description of the tests performed on hazardous and safety critical systems such as rotation of S&A devices, no voltage checks on ordnance systems, pressure checks of pressure and propellant vessels, RF radiation measurements, and preliminary FTS checks

6A.2.2.6 Operating and Support Hazard Analysis

An Operating and Support Hazard Analysis (O&SHA) shall be performed for each procedure and the results summarized in the GOP.

- a. The O&SHA shall identify and evaluate the safety considerations associated with environments, personnel, procedures, and equipment involved throughout the operational phase of the program and shall meet the intent of Appendix 1B, O&SHA requirements.
- b. O&SHAs shall be conducted for activities such as testing, installation, maintenance, support, transportation, storage, operations, and training.
- c. O&SHAs shall coincide with the flow chart task summaries in **6A.2.2.3 General Description**.
- d. O&SHAs shall incorporate a worksheet associated with each specific flow block in the flow chart and shall include the following information:
 1. The general hazard group
 2. The specific hazard condition

3. The effect if the hazard is not controlled
4. Hazard control hardware
5. The hazard control procedure
6. Hazard control personnel
7. Reference to the flow block task number
- e. Proposed work under a load safety analysis shall be included in this section.

6A.2.2.7 Range User Plans

The following plans shall be included in or added as appendixes to the GOP.

- a. Range User Training Plan
- b. Accident Notification Plan
- c. Emergency Response Plans for Graphite Epoxy Composite Overwrapped Pressure Vessels

6A.2.2.8 Compliance Checklist

- a. A Compliance Checklist based on a non-deliverable O&SHA and the requirements of Chapters 3 and 6 for each task may be submitted in place of a formal submittal of the O&SHA described in **6A.2.2.6 Operating and Support Hazard Analysis**.

- b. The task breakout shall be associated with each specific flow block in the flow chart described in **6A.2.2.3 General Description**.

- c. The Compliance Checklist shall include the following information:

1. EWRR 127-1 Criteria/Requirement
2. O&SHA reference hazard group and hazard condition
3. System and specific procedure and task within the procedure
4. Compliance
5. Noncompliance
6. Not applicable
7. Resolution
8. Reference

- d. Copies of all Range Safety approved non-compliances associated with hazardous or safety critical operations shall be included.

6A.2.2.8 Changes

The Change section contains a summary of all changes to the latest edition of the GOP. All changes shall be highlighted using change bars or similar means of identification.

APPENDIX 6B

HAZARDOUS AND SAFETY CRITICAL PROCEDURE REQUIREMENTS

6B.1 INTRODUCTION

6B.1.1 Determination of Hazardous and Safety Critical Procedures

The Ground Operations Plan (GOP) (Appendix 6A) is the basic document used to initially determine the classification of a procedure. Specifically all procedure description and task summaries along with the associated Operating & Support Hazard Analyses (O&SHAs) are reviewed. This review validates the Range User's determination of Hazardous, Non-Hazardous, and Safety Critical procedures. Once the classification of Hazardous, Non-Hazardous, and Safety Critical is determined, the procedures are submitted for review and approval as described in the documentation section of this Chapter. During review of the initial draft procedures, a determination is made for Operations Safety attendance and notification. The basic rules for inclusion of Operations Safety into hazardous and safety critical procedures is defined in the Operations Safety responsibility list. This list shall be used for writing the initial draft procedures. The initial review by Range Safety shall determine if Operations Safety notification or attendance shall be required. Also, the review of the draft procedures allows a second opportunity to ensure the classification is appropriate.

6B.1.2 Purpose

Hazardous and safety critical procedures provide a detailed, step-by-step description of the manner in which hazardous and safety critical operations will be accomplished. The procedures are the medium from which approval to start any hazardous or safety critical operation is obtained from the Ranges.

6B.1.3 Content

This Appendix contains the content preparation instructions for the data generated by the requirements delineated in Chapter 6 of this document.

6B.1.4 Applicability

This Appendix is applicable to the following:

- a. All launch vehicle, payload, or service contractors performing hazardous or safety critical operations on the Ranges
- b. Construction and management contracts for hazardous facilities

6B.1.5 Submittal Process

The hazardous procedure submittal process is as follows:

- a. One copy of procedures involving hazardous or safety critical operations shall be submitted to Range Safety and one copy to Operations Safety for review and approval. The Range User shall review, approve, and sign the final procedures to be submitted to Range Safety for approval.
- b. For new programs, final Operations Safety and Range Safety comments, reviews, and approvals shall be provided to the Range User 45 calendar days after receipt of the procedure.
- c. For existing programs, final Operations Safety and Range Safety comments, reviews, and approvals shall be provided to the Range User 30 calendar days after receipt of the procedure.
- d. Final approved, published procedures incorporating Range Safety comments shall be submitted to Range Safety at least seven calendar days prior to the conduct of the operation.

6B.1.6 Final Approval

Hazardous and safety critical procedures shall be approved prior to starting any hazardous or safety critical operations on the Ranges.

6B.2 PREPARATION INSTRUCTIONS

6B.2.1 Content

Hazardous or safety critical procedures shall be written in a logical format with clear instructions as to the tasks to be performed and hazards and precautions involved.

6B.2.2 Cover Page

- a. A cover page with the procedure title and required approval signatures and date shall be provided. The signature page shall contain a block for Range Safety signature approval.
- b. The cover page shall indicate that the procedure covers hazardous or safety critical operations.
- c. The words *Draft* or *Preliminary* shall appear on any signed procedure that does not have the required Range Safety approval.

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HAZARDOUS AND SAFETY CRITICAL PROCEDURE REQUIREMENTS

d. The cover sheet shall state “Warning: This Procedure Contains Hazardous (or Safety Critical) Operations” and shall be outlined with a border and marked in bold print.

e. The cover sheet shall indicate revision level.

6B.2.3 Purpose Section

a. The purpose section shall provide a brief synopsis of all major tasks in each operating procedure.

b. The synopsis shall include the following information:

1. A brief description of the tasks, operations, tests, or checkouts to be performed.

2. The facility and area where the procedure is to take place

3. The departure and arrival locations if transportation is required

4. For launch vehicle and payload tests, when the test is normally performed in relation to launch day (for example, L-5)

6B.2.4 Identification of Specific Hazards

The following specific hazards shall be identified in each procedure:

a. The quantity and hazard classification of ordnance and propellants involved

b. The hazardous and non-hazardous configurations of the system prior to, during, and upon completion of the operation

6B.2.5 List of Safety Precautions

As applicable, a list of the following precautions shall be incorporated in each procedure:

a. Warnings

b. Cautions

c. Note inhibits

d. Safety devices

e. Control areas

6B.2.6 Facility Configuration Inspections

The procedure shall indicate the specific facility and safety clearance zone control area to be used.

a. The requirements for the performance of facility configuration inspections shall be incorporated in the procedures.

b. The facility configuration inspection requirements shall address verification of the following:

1. Facility explosive limits

2. Facility personnel limits

3. Posting of fire symbols when ordnance and propellants are moved into or out of a facility

6B.2.7 PPE and Emergency Equipment

a. PPE and emergency equipment requirements for each operation shall be incorporated in hazardous procedures.

b. The PPE and emergency equipment shall address the following:

1. PPE requirements according to the manufacturer model number, MIL-SPEC, or standard for compliance

2. The occasions for the use of PPE

3. Types of emergency equipment required

4. Location of the emergency equipment during the operation

5. The number of emergency equipment units required. **NOTE:** No substitution or configuration alteration of PPE will be allowed without specific Range Safety approval.

6B.2.8 Pre-Operational Checklist of Required Tools and Equipment

a. A pre-operational checklist of all tools and equipment required for safe operations shall be incorporated in the procedures.

b. For safety critical equipment, the following information shall be included:

1. Manufacturer, model, and serial number

2. Location of the equipment during the operation

3. The number of units required

4. The required monitoring devices and their alarm settings

5. Proof test requirements

6. Non-destructive examination requirements

7. Calibration requirements

6B.2.9 Support Personnel Requirements

a. Range User and Range support personnel requirements such as Operations Safety, Fire, Medical, and Security/HOS personnel shall be incorporated in the procedures. **NOTE:** In a multi-task procedure, the times these support personnel are needed shall be stipulated.

b. The following support personnel requirements shall be addressed:

1. The hazardous periods when personnel limits shall be enforced

2. The minimum essential personnel by functional title and number required

3. The Operations Safety notification in all cases. **NOTE:** Operations Safety presence and concurrence is required prior to beginning all hazardous

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HAZARDOUS AND SAFETY CRITICAL PROCEDURE REQUIREMENTS

operations unless determined otherwise by Range Safety.

4. Special training, certifications, or experience requirements

6B.2.10References to Applicable Documents

a. All applicable documents, drawings, and specifications shall be referenced in the procedures.

b. If a specific operations safety plan or other safety plans apply to the procedure, they shall be listed in the procedure reference section.

c. EWRR 127-1 shall be listed in the procedures.

d. Procedures shall not use excessive second tier references.

6B.2.11CCAS Cape Support and WR Range Scheduling Notification

Notification of CCAS Cape Support (853-5211) on the ER and Range Scheduling (276-8825) on the WR 24-h prior to the planned start of the operation shall be incorporated in the procedures.

6B.2.12 Pre-Task Briefing

a. A step for the conduct of a pre-task briefing shall be incorporated in the procedures.

b. The following topics shall be addressed:

1. Operational hazards

2. Precautions

3. Emergency actions

4. Critical task items

5. Procedure flow

6. Operational discipline

7. Communication discipline

c. Specification that the briefing shall be repeated if a shift change is required.

6B.2.13 Step-by-Step Directions

a. Step-by-step directions, written in clear language, with sufficient detail to allow a qualified technician or mechanic to clearly understand and follow them, shall be incorporated.

b. The procedure shall contain applicable data sheets, figures, and schematics to document or clarify system parameters and connect points.

6B.2.14Identification of Hazardous and Safety Critical Portions of Procedures

a. The beginning and end of a hazardous or safety critical portion of a procedure shall be incorporated according to the following criteria:

1. A "Warning" shall be used to identify hazards to personnel.

2. A "Caution" shall be used to identify hazards to equipment.

3. A "Note" shall be used to indicate an operating procedure of such importance that it must be emphasized.

b. The activation of warning lights, Public Address (PA) announcements, and notification to Security/HOS of any controlled areas, if not accomplished as a pre-task item, shall be incorporated.

c. Safety highlights such as evacuations, safety clearance zones, clearances, activation of aural and visual warnings shall be detailed prior to the hazardous sequence and in the applicable section of the procedure.

6B.2.15Emergency Shutdown and Backout Steps

Emergency shutdown and backout procedures or steps necessary to safe the system or facility in the event of a mishap, incident, or abort shall be incorporated.

6B.2.16 Transmittal of Procedures

Procedures shall be forwarded to Range Safety with a transmittal letter containing the following information:

a. Need Date (minimum of 30 calendar days review time required for existing programs; 45 for new programs)

b. Procedure title and number

c. Program identified or other identifier to ensure that the proper Range Safety point of contact receives the procedure

d. Special instructions for such items as review and comment and final copy for filing

e. Pertinent information such as "procedure is non-hazardous," "procedure change does not affect the hazardous portion of the procedure nor otherwise have a safety impact," or "all previous comments have been incorporated"

f. If the procedure has been previously submitted as a draft or with a different revision number, clarify the extent of the changes.

6B.3 EXAMPLES OF HAZARDOUS PROCEDURES

Examples of hazardous procedures include, but are not limited to, the following topics:

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HAZARDOUS AND SAFETY CRITICAL PROCEDURE REQUIREMENTS

a. Pressurized Propellant Systems: Pressurization (pneumastat and hydrostat), loading and unloading, sampling, leak testing, venting.

b. Launch Vehicle and Payload Systems: Pressurization, loading and unloading, leak test, erection and lifting with ordnance and/or propellant, application of power with ordnance and/or propellant, safe and arm pin removal, mate and demate operation

c. Hazardous Facilities: High pressure systems, propellant flows in ground systems, propellant cart loading, ordnance checkout and installation, X-ray operations, cryogenic operations, fixture proof tests, emergency blackout procedures

d. Ordnance: Bore scope, X-ray, continuity test, propellant trimming, installation, electrical connection and disconnection

e. Work involving lasers, high energy RF emissions, radioactive materials, and hazardous materials

6B.4 CHANGES

Changes to previously submitted procedures shall be noted with change bars or a similar method of marking.

APPENDIX 6C OPERATIONS SAFETY PLANS

6C.1 ER OPERATIONS SAFETY PLANS

DELTA II COMPLEX 17 Operations Safety Plan and Safety Operations Plans (SOPs)

DELTA II AREA 57 Safety Plan and SOPs (Solid Motor Facility)

DELTA II AREA 55 Safety Plans and SOPs

DELTA II HANGAR M AREA Safety Plans and SOPs

DELTA II HAZARDS PROCESSING FACILITY AREA Safety Plan/SOP

ATLAS/CENTAUR Operations Safety Plan and Safety OP Plan

TITAN IV COMPLEX 40 Operations Safety Plan and SOPs

TITAN IV COMPLEX 41 Operations Safety Plan and SOPs

Operations Safety Plan for METEOROLOGICAL ROCKETS

TRIDENT I (CA)/II(D5) Operations Safety Plan and SOPs 1-5

EXPLOSIVE SAFE AREA EPA-60A, Area Safety Plan and Safety Op Plans

Safety OP Plans for Solid Rocket Booster Recovery and Disassembly Facility (Hangar AF)

NAVSTAR Processing Facility Safety Plan

Propellant Servicing Facility Safety Plan

DSCS III PROCESSING Facility Operations Safety Plan

Propellant Conditioning Facility Safety Plan

Payload Spin Test Facility Safety Plan

SHUTTLE PAYLOAD INTEGRATION FACILITY Safety Plan

COMPLEX 20 AND AREA 59 Operations Safety Plans and SOPs

SMAB EAST BAY and CENTER HIGH BAY Safety Plan

SMARF Operations Safety Plan

6C.2 WR OPERATIONS SAFETY PLANS

LMSC Building 3000 Safety Plans

SLC-4 Launch Complex Safety Plan

Lockheed Martin Astronautics Integrated Safety Plan for SLC-3E and SLC-3W

NASA Ground Safety Plan Off-Site Facility

Integration Processing Facility Safety Plan Space Launch Complex 6

Integration Processing Facility (IPF) Safety Plan

Astrotech Space Operations, L.P. Safety Standard Operating Procedure at VAFB.

Orbital Sciences Corporation Space Systems Division Facility Safety Plan for VAB.

Delta, SLC-2 VTC Safety Plan

NOTE: Additional plans shall be developed for facilities, systems, and operations as needed.

APPENDIX 6D

ER EXPLOSIVE SAFETY PLANS

1 Conducting Scheduled Inspections of Explosives and Propellant Facilities on CCAS and Downrange Stations

2 Disposition of Unserviceable, Obsolete, Excess, and Suspended Ordnance Items

201 Fuel Storage Area I (FSA-1), Liquid Propellants

302 Handling Explosives at CCAS Wharves

303 Loading and Unloading Aircraft with Explosives or Other Hazardous Material at CCAS Auxiliary Air Field

304 Loading and Unloading Aircraft with Explosives at Downrange Bases

305 On-Loading/Off-Loading Explosives Laden Trailer on Flatcars (TOFC) at the Railroad Loading Dock in the ITL Area

307 HANDLING TRIDENT Missile Motors between the TITAN ITL Transfer Dock

308 Handling OTTO Fuel

309 Moving Trident D-5 Motors Through the Titan ITL Area

501 Demonstrations Involving Explosives

502 Conducting Hazardous Operations in Explosives Operating Buildings

601 Storage of Explosives at Downrange Bases

901 Transporting Explosives at CCAS

902 Transporting Explosives at Downrange Bases

903 Motor Vehicle Transportation of Liquid Propellants and other Hazardous Chemicals at CCAS

NOTE: Additional plans shall be developed for facilities, systems, and operations as needed.

APPENDIX 6E

MISCELLANEOUS SAFETY PLANS

SOP for Storage and handling of Acoustic Recoverable Deep Ocean Transponders and Lithium-Sulfur Dioxide Battery Assemblies

SOP for 45 SW LDCG

Danger Area Information Plan

Toxic Materials Release Contingency Plan (Cape Aural Warning Plan)

Ionizing Radiation and Radioactive Material Safety Operating Plans

DOT 5C Hydrazine Drum Storage and Operation Plan - Fuel Storage #1 CCAS Cape Support

SOP for Post Launch Safing Operations

SOP for Hazardous Material Debris Water Recovery Operation

APPENDIX 6F
OVERHEAD CRANES AND HOISTS INSPECTION AND TEST SCHEDULE

Category	Nomenclature	Operational Checks	Frequency			
			Structural/ Mechanical/ Electrical Checks	Rope/Hook Checks	Load Test	Hook Test
I	Enclosed environment; frequent or daily use (critical loads)	D	SA	M	A	A
IA	Enclosed environment; general use (critical loads)	P/U	SA	M	A	A
IB	Enclosed environment; idle 6 months (critical loads)	P/U (Q)	SA	P/U (M)	A	A
IC	Enclosed environment; standby (critical loads)	P/U (A)	SA	P/U (M)	P/U (1)	P/U (1)
II	Semi-enclosed environ- ment; frequent or daily use (critical loads)	D	Q	M	A	A
IIA	Semi-enclosed environ- ment; frequent or daily use (critical loads)	P/U	Q	M	A	A
IIB	Semi-enclosed environ- ment; idle 6 months (criti- cal loads)	P/U (Q)	P/U (Q)	P/U (M)	A	A
IIC	Semi-enclosed environ- ment; standby (critical loads)	P/U (SA)	P/U	P/U (M)	P/U (1)	P/U (1)
III	Exposed environment; frequent or daily use (critical loads)	D	M	M	A	A
IIIA	Exposed environment; general use (critical loads)	P/U	P/U (M)	M	A	A
IIIB	Exposed environment; idle 6 months (critical loads)	P/U (Q)	P/U (M)	P/U (M)	A	A
IIIC	Exposed environment; standby (critical loads)	P/U (Q)	P/U	P/U (M)	P/U (1)	P/U (1)
IV	Enclosed environment; frequent or daily use (non-critical loads)	D	A	M	BE	A
IVA	Enclosed environment; general use (non-critical loads)	P/U	A	M	BE	A
IVB	Enclosed environment; idle 6 months (non-critical loads)	P/U (Q)	A	P/U (M)	BE	A

Category	Nomenclature	Operational Checks	Frequency
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			Structural/ Mechanical/ Electrical Checks	Rope/Hook Checks	Load Test	Hook Test
IVC	Enclosed environment; standby (non-critical loads)	P/U (A)	P/U	P/U (M)	P/U (2)	P/U (1)
V	Semi-enclosed environ- ment; frequent or daily use (non-critical loads)	D	SA	M	QR	A
VA	Semi-enclosed environ- ment; general use (non- critical loads)	P/U	SA	M	QR	A
VB	Semi-enclosed environ- ment; idle 6 months (non- critical loads)	P/U (Q)	P/U (6)	P/U (M)	QR	A
VC	Semi-enclosed environ- ment; standby (non- critical loads)	P/U (SA)	P/U	P/U (M)	P/U (2)	P/U (1)
VI	Exposed environment; frequent or daily use (non-critical loads)	D	SA	M	QR	A
VIA	Exposed environment; general use (non-critical loads)	P/U	SA	M	QR	A
VIB	Exposed environment; idle 6 months (non-critical loads)	P/U (Q)	P/U (6)	P/U (M)	QR	A
VIC	Exposed environment; standby (non-critical loads)	P/U (Q)	P/U	P/U (M)	P/U (2)	P/U (1)

LEGEND

A - Annually
 SA - Semi-Annually
 D - Daily (If used daily; otherwise prior to use)
 M - Monthly
 Q - Quarterly
 QR - Quadrennially
 P/U - Prior to use
 P/U(1) - Prior to use if longer than 1 year

P/U(2) - Prior to use if longer than 2 years
 P/U(6) - Prior to use if longer than 6 months
 P/U(M) - Prior to use if longer than 1 month
 P/U(Q) - At least quarterly and prior to use
 P/U(SA) - At least semiannually and prior to use
 P/U(A) - At least annually and prior to use

NOTE: If a crane has been secured/mothballed, all checks shall be made prior to use.

APPENDIX 6F

OVERHEAD CRANES AND HOISTS INSPECTION AND TEST SCHEDULE

SCOPE OF CHECKS/TESTS

Operational Checks: Operation of all controls, limits and safety circuits, and a running examination of ropes.

NOTE: The frequencies indicated in the “Operational Checks” column are binding on the range contractor only when the contractor has sole operating responsibility for the equipment. Under any other operating arrangement, the range contractor shall perform these checks only as a pre-requisite to the checks and at the frequencies specified in the “Struc/Mech/Elect Checks” column.

Struc/Mech/Elect Checks: Complete examination of structure and supports, gears, wheels, bearings, and brakes.

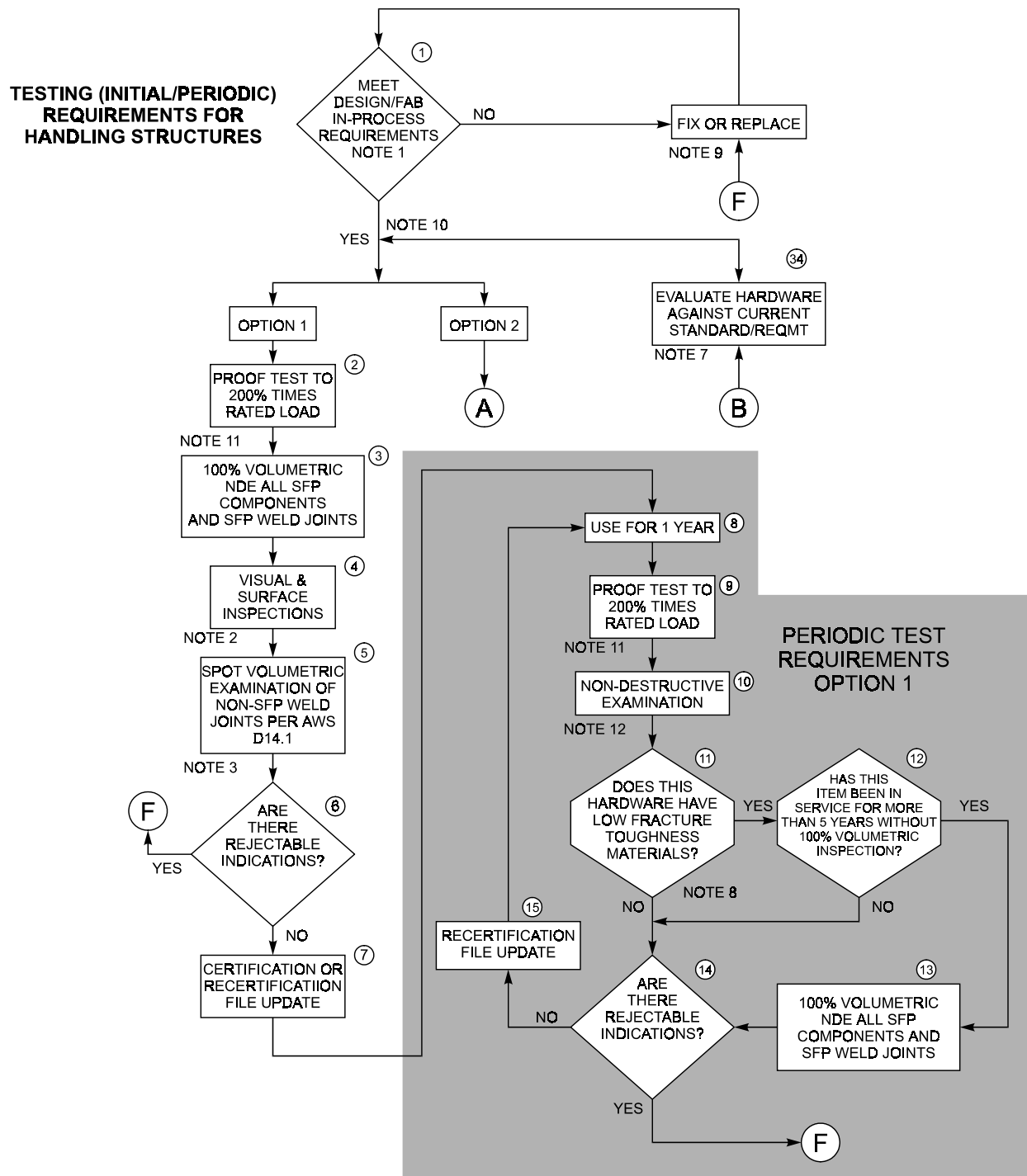
Rope/Hook Checks: Complete rope inspection for wear, broken wires, diameter reduction, and corrosion. Hook inspection for damage and distortion. **NOTE:** On installations with dead-end rope terminations, closely examine the termination to ensure the rope has not slipped in/through its fitting, and that the fitting is not cracked.

Load Test: Test initially and following major repairs, alterations and modifications to 125 percent of rated load, and thereafter to 100 percent per range policy.

Hook Test: Test by magnetic particle or other suitable crack detecting process.

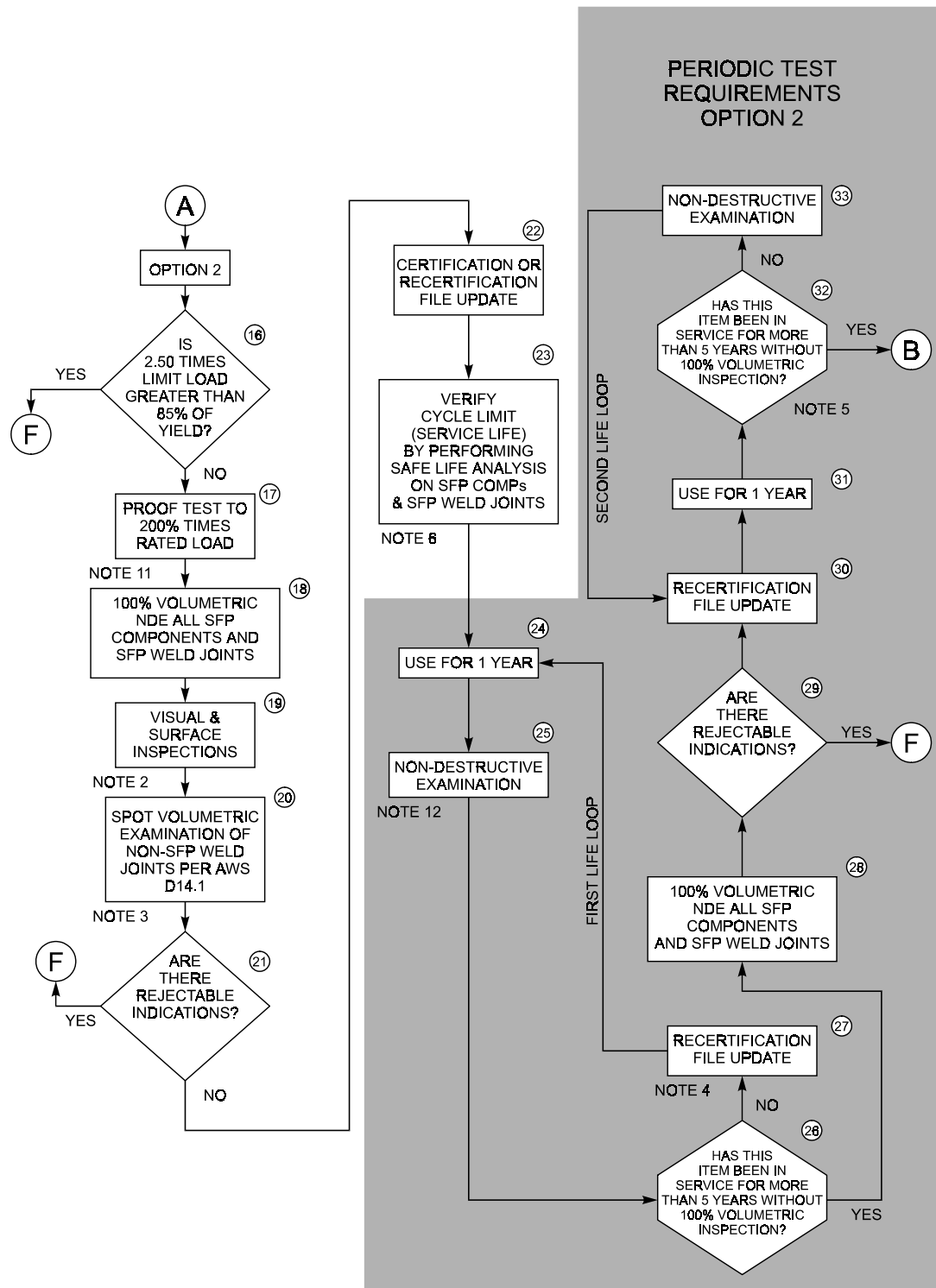
This Appendix supersedes all previous editions.

APPENDIX 6G HANDLING STRUCTURES INITIAL AND PERIODIC TEST REQUIREMENT FLOWPATH



APPENDIX 6G

HANDLING STRUCTURES INITIAL AND PERIODIC TEST REQUIREMENT FLOWPATH



APPENDIX 6G

HANDLING STRUCTURES INITIAL AND PERIODIC TEST REQUIREMENT FLOWPATH

NOTES

1. Design, Fabrication, and In-Process Requirements:
 - a. Meet EWR 127-1 design requirements for handling structures.
 - b. Identify Single Failure Point (SFP) components and SFP welds.
2. Perform 100 percent visual inspection of all components (including SFP) and weld joints (including SFP and non-SFP) and perform 100 percent surface Non-Destructive Examination (NDE) testing of all SFP components and SFP welds.
3. Perform volumetric NDE inspection of 4 inches or 10% (which ever is less) of every continuous non-SFP weld in accordance with AWS D14.1, paragraph 8.9.5.
4. A cycle count is required.
5. Material Handling Equipment (MHE) and Material Handling Safety Equipment (MHSE) that has been in service for 10 years or 2500 cycles, whichever is less, shall be evaluated against current Range Safety standards and requirements.
6. Perform safe-life analysis assuming flaws to be in the worst location (i.e. transition areas, heat affected areas, weld joints, membrane sections, and highest stressed areas). Safe-life analysis shall be performed using fatigue crack growth computer programs such as NASA/FLAGRO (JSC-22267) or other Range Safety approved computer programs or analysis methods.

NOTE: Fracture Mechanics Analysis used to established cyclic limits may assume "crack like defects", this does not imply that cracks or other rejectable indications are acceptable. The logic identified in this flow chart requires that cracks and rejectable indications be fixed.

7. Provide noncompliance issues (if any) to Range Safety for disposition.
8. All parts shall be considered to have a low-fracture toughness their material property ratio $K_{Ic}/F_{ty} < 0.33 \text{ in}^{1/2}$. If the part is a steel bolt and the K_{Ic} value is unknown, low fracture toughness shall be assumed when $F_{tu} > 180 \text{ ksi}$.
 Where: K_{Ic} = Plane strain fracture toughness.
 F_{ty} = Allowable tensile yield strength.
 F_{tu} = Allowable tensile ultimate strength.
 Reference: NASA NBH 8071.1
9. Fix hardware. This means either repair or an analytical solution is required as approved by Range Safety.
10. Periodic test and inspection requirements are identified within the gray areas of the flow chart. All other processes identified within the figure are considered initial test requirements.
11. Proof test shall be performed on fully assembled handling structures, unless otherwise approved by Range Safety. Do not proof test greater than 85 percent of yield.
12. Perform (NDE) in accordance with Range Safety approved NDE plan.

APPENDIX 6H

WESTERN RANGE SPACE AND MISSILE MISHAP PREVENTION PROGRAM FOR BALLISTIC MISSILE OPERATIONS

6H.1 INTRODUCTION

This Appendix describes procedures, requirements, and responsibilities for the VAFB Space and Missile Mishap Prevention Program applicable only to visiting DoD ballistic missile operators.

6H1.1 Policy

The policy of the mishap prevention program is to prevent mishaps or malfunctions which could result in personnel fatality or injury, or destruction or damage to property and equipment.

6H.1.2 Responsibilities

Mishap prevention is a direct function of command and because of the scope and variety of Space and Missile Operations at VAFB, command direction and support are essential.

6H.1.2.1 30 SW Commander

As the host, the 30 SW Commander has the overall responsibility for safety at VAFB. The Commander's safety responsibilities include:

- a.* Directing the development and implementation of a safety program which integrates safety policy into all operations and activities.
- b.* Taking action to abate hazards.
- c.* Ensuring supporting programs are implemented by all subordinate and tenant commanders.
- d.* Providing safety support to tenant organizations as defined in AFR 11-4 agreements.
- e.* Providing for a Radiation Safety Committee to enforce radiation protection of radioactive sources according to applicable USAF and NRC directives and licenses.
- f.* Support investigating and reporting of mishaps, including missile mishaps which include AFSPC resources; furnish investigative resources to tenants when requested.

6H.1.2.2 30th Space Wing, Chief of Safety (30 SW/SE)

All personnel are charged with performing those technical, management, and staff actions necessary to ensure comprehensive and coordinated execution of mishap prevention programs. As such, each shall:

- a.* Ensure compliance with safety directives and applicable standards and maintain formal, written plans to implement those directives and standards.

b. Provide safety policy for subordinate units involved in missile and space operations.

c. Establish and define mishap prevention criteria for hazardous operations associated with each type of missile and space system at VAFB and coordinate, as required.

d. Provide policy on the types, standards, and use of protective clothing and equipment. Such policy, when appropriate, shall be coordinated with the 30th MDG/SGPB, VAFB.

e. Furnish policy for the handling and storage of fuels, oxidizers, and other potentially hazardous materials associated with missile and space operations. Such policy, when appropriate, shall be coordinated with all appropriate agencies.

f. Conduct safety inspections of activities and facilities.

g. Initiate requests for appointing accident investigation boards and investigating officers, as required.

h. Monitor and coordinate USAF Hazard Reports as required by AFI 91-202.

i. Maintain mishap and accident records and statistics, analyze cause factors, and disseminate information on accident prevention to appropriate organizations and agencies.

j. Coordinate with the 30th Medical Group/ SGB and other directorates and agencies on mishap prevention.

k. Monitor adequacy of safety training.

l. Assign safety personnel to periodically observe hazardous operations at all levels to ensure adherence to safety principles and compliance with appropriate technical data.

1. The degree and frequency of surveillance (i.e., spot checks) necessary shall depend on factors such as the nature of the operation; the history and experience of the system; the quality of written directives available; the personnel involved (task force, local missile squadron, or contractor); the number of safety personnel available; and the type of facility.

2. A minimum number of safety personnel may be present during all hazardous operations. Sound professional judgment shall be used to keep the total number of personnel to an absolute minimum while ensuring adequate safety surveillance.

6H.1.2.3 576 Flight Test Squadron/Test and Evaluation (576 FLTS/TE)

APPENDIX 6H

WESTERN RANGE SPACE AND MISSILE MISHAP PREVENTION PROGRAM FOR BALLISTIC MISSILE OPERATIONS

a. Exercise staff supervision over missile combat crews and ensure established safety procedures are used in all missile activities under their control.

b. Coordinate with directorates and appropriate agencies on test and evaluation functions pertaining to missile ground safety.

c. Ensure prompt reporting to 576 FLTS/CC and 30 SW/SE of all personnel injuries or property damage occurring during missile ground operations under the 30 Range Sq control.

d. Obtain the required approvals from 30 SPW/SES, in coordination with 576 FLTS/CC, for 20th AF launch programs as required by Chapter 1 of this document.

e. The Command Control Directorate (DOC) shall establish policies and procedures to ensure prompt notification of required agencies per AFI 91-204, AFI 32-4001, 30 SW OPLAN 355-1, 30 SW 127-3, and this document. Additionally, DOC shall ensure prompt reporting to 30 SW/SE of all personnel injuries or property damage.

6H.1.2.4 576 Flight Test Squadron/Test Maintenance (576 FLTS/TM)

a. Exercise staff supervision of missile maintenance activities performed by 20th AF task force personnel.

b. Coordinate with appropriate agencies on functions pertaining to missile ground safety.

c. Ensure prompt reporting to 576 FLTS/CC and 30 SPW/SE of all personnel injuries or property damage occurring at launch facilities or during maintenance activities.

d. Exercise staff supervision to ensure maintenance time lines do not exceed duty limitations in AFI 21-114 and this document.

e. Ensure comprehensive plans are developed for Missile Potential Hazards, PSRE Emergency Response, and other life-threatening or potentially dangerous situations.

f. Develop Task Supervisor's safety check-lists for the operational base task forces to support the SAC Follow-on Operational Test and Evaluation program.

6H.1.2.5 30th Civil Engineering Group (30 CEG/DEO)

a. Provide personnel and equipment to support

missile operations as specified in this document and the MOSR system.

b. Establish policies and procedures governing activities of the base Disaster Control per Section 7.4.2.5 and this document in accordance with AFI 91-202.

c. Ensure compliance with established safety standards on installed missile equipment and facilities, supporting shops, and associated facilities.

6H.1.2.6 30th Medical Group

a. Provide medical personnel and equipment to support missile and space operations as required by higher headquarters directives and policies or as specified in this document and the MOSR system.

b. Monitor health problems associated with missile and space operations.

c. Conduct health hazard surveys and coordinate findings with 310th TTW and 30 SW/SE as appropriate.

d. Establish supplementary policy pertaining to medical care and support requirements for missile and space operations on VAFB. Such supplemental policies shall be coordinated with affected agencies.

e. Coordinate on specific MOSRs to ascertain compliance with medical care and support requirement policies.

f. Coordinate on and provide Bioenvironmental Engineering support as required for missile and space operations and associated facilities or as specified in the applicable MOSR.

6H.1.2.7 Tenant, Range User, Organizations Supporting Missile and Space Operations, and Contractors

a. Comply with safety standards and criteria contained in this document and other pertinent safety directives such as AFOSH and OSHA.

b. Forward recommended revisions and new safety criteria to 30 SW/SE and maintain an approved safety plan covering all activities.

c. Expeditiously report personnel injuries and property damage to the appropriate safety office as required by existing directives.

d. Conduct safety training for assigned personnel as appropriate.

6H.1.2.8 Task Supervisor

APPENDIX 6H

WESTERN RANGE SPACE AND MISSILE MISHAP PREVENTION PROGRAM FOR BALLISTIC MISSILE OPERATIONS

Task Supervisor is defined as “the person immediately responsible for all aspects, including safety, of a specific task or operation.” For example, in the Minuteman system, the dispatching maintenance team chief would be the Task Supervisor. While the requirements contained in this document are primarily designed for hazardous operations, the basic safety philosophy applies for all operations at VAFB. **NOTE:** The presence of a safety officer and NCO does not relieve the Task Supervisor of any safety responsibilities. Task Supervisors shall ensure all safety requirements are met.

a. Specific Task Supervisor safety responsibilities and requirements which shall be accomplished before and during a hazardous operation are as follows:

1. Activation of the appropriate safety clearance zone(s) using barriers, warning devices, or other means, as required.

2. Ensuring clearance of nonessential personnel from the applicable safety clearance zone before starting the operation and controlling areas thereto throughout the operation.

3. Ensuring the accomplishment of a thorough pre-task briefing, in addition to those specified in the applicable tech data. The Task Supervisor pre-briefing shall cover all special procedures to be followed during the operation.

4. Verifying communications meet established safety standards, required safety equipment is correctly pre-positioned and personnel warning devices, hazard detecting warning systems, damage control systems, and primary electrical power systems are operable before starting the operation.

5. Ensuring the necessary support personnel

required for the operation are available before starting the operation and operational control of such support elements are clearly maintained at all times throughout the task. **NOTE:** This responsibility includes briefing such support elements before the start of the hazardous operation regarding positioning, communications, and emergency actions.

6. Maintaining strict compliance with approved safety criteria, operating procedures, checklists, and other such directives appropriate to the task to be performed. **NOTE:** This requirement includes the proper use of protective clothing and equipment required to support the task.

7. Ensuring good housekeeping exists before starting the operation and ensuring the site is left in good condition upon task completion.

8. Ensuring all applicable personnel are aware of emergency procedures. **NOTE:** This responsibility includes ensuring personnel understand all warning lights, sirens, and barriers and the use and location of proper escape routes.

9. Properly announcing the start and termination of the operation and ensuring all support agencies are properly released.

10. Calling a Safety Hold or GO/NO-GO whenever any of the above requirements are not properly performed, or if the safety of the operation or personnel in surrounding areas become jeopardized.

b. Task Supervisors shall ensure all visitors are briefed on specific facility operations in progress and the inherent safety hazards present.

c. Task Supervisors safety checklists for hazardous operations and visitors safety briefing shall be developed in consonance with this document, as necessary.

1. These checklists shall be designed to assist individual Task Supervisors in activating safety clearance zones and accomplishing the safety responsibilities noted above.

2. Agencies shall use the following checklist as a guide. Before publication, coordinate checklists and have them approved by 30 SW/SE.

APPENDIX 6H
WESTERN RANGE SPACE AND MISSILE MISHAP PREVENTION PROGRAM
FOR BALLISTIC MISSILE OPERATIONS

TASK SUPERVISOR GUIDELINES
CHECKLIST FOR HAZARDOUS OPERATIONS
(may be modified as appropriate)

Pre-Task Requirements

- _____ 1. Hazardous operation identified and scheduled on MOSR.
- _____ 2. Name of Task Supervisor provided.
- _____ 3. Safety Clearance Zone(s) identified, as applicable.
 - _____ a. Hazard Area _____ (size of area, radius)
 - _____ b. Potential Hazard Corridor (PHC) identified.
(Superimposed on appropriate Safety Clearance Zone.)
 - _____ (1) Source strength based on maximum anticipated spill.
 - _____ (2) See GO/NO-GO restrictions in this document.
 - _____ (3) Operation shall not start until all facilities in the Safety Clearance Zone have been alerted or cleared.
- _____ 4. Identify essential personnel authorized to remain in Safety Clearance Zone.
- _____ 5. Ensure applicable Emergency Support Team(s) is/are present and notified per applicable MOSR.
- _____ 6. Assemble and brief applicable task personnel, to include support team elements.
 - _____ a. Type of operation and identification of Safety Clearance Zone(s).
 - _____ b. Period of activation of Safety Clearance Zones and hazards involved.
 - _____ c. Location of Emergency Support Team “control point” and access control requirements.
 - _____ d. Communication procedures and requirements.
 - _____ e. Emergency response actions and use of warning devices and barriers, etc.
 - _____ f. Emergency and personal protective clothing and equipment required.
 - _____ g. Escape routes and additional precautions to be exercised.
 - _____ h. Special procedures in addition to procedures specified in appropriate TO checklist.

APPENDIX 6H
WESTERN RANGE SPACE AND MISSILE MISHAP PREVENTION PROGRAM
FOR BALLISTIC MISSILE OPERATIONS

- _____ 7. Ensure personnel warning devices are operable as required.
- _____ 8. Ensure availability of emergency and protective clothing and equipment.
- _____ 9. Make final check that area housekeeping is adequate.
- _____ 10. Position technicians and Emergency Support Team(s), as applicable.
- _____ 11. Establish pre-task communications checks.
- _____ 12. Activate appropriate warning light and clear area of nonessential personnel.

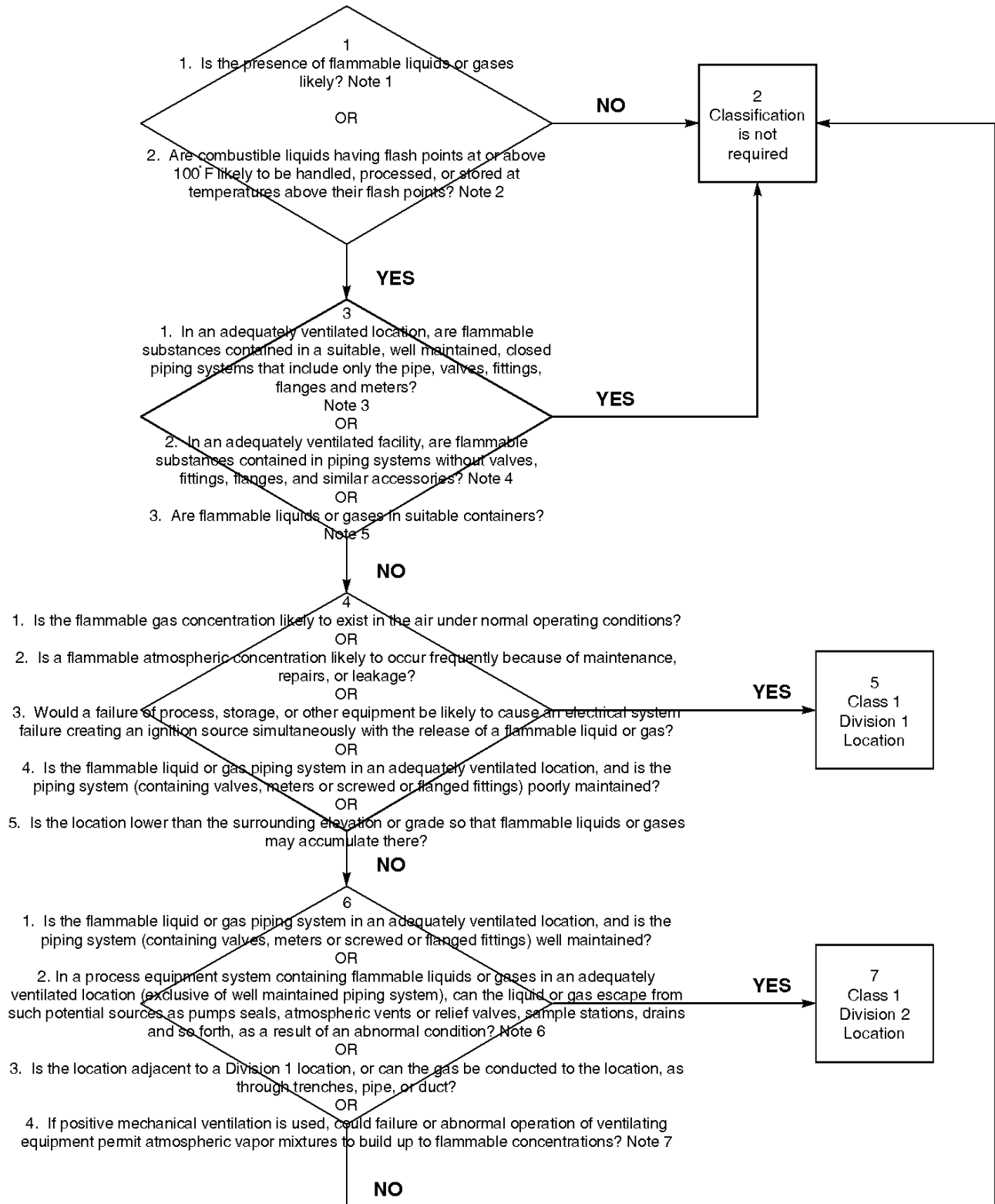
Task Requirements

- _____ 1. Control access to Safety Clearance Zone for duration of hazardous and/or dangerous period.
- _____ 2. Ensure compliance with approved checklists and established safety criteria.
- _____ 3. Monitor operating procedures as necessary to ensure proper task completion.
- _____ 4. Announce start and termination of applicable tasks, as required.
- _____ 5. Violation of approved criteria shall require a Hold be declared.

Post-Task Requirements

- _____ 1. Announce termination of hazardous operation.
- _____ 2. Extinguish warning light and deactivate Safety Clearance Zone.
- _____ 3. Dismiss support elements and ensure work area is left in proper condition.
- _____ 4. Check, clean, and return emergency equipment to proper storage.

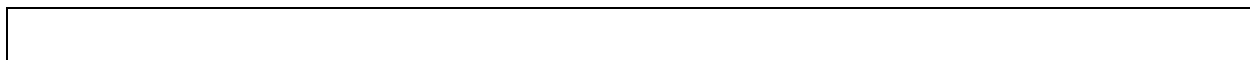
APPENDIX 6I HAZARDOUS AREA CLASSIFICATION



APPENDIX 6I HAZARDOUS AREA CLASSIFICATION

NOTES

- 1: The following are considered flammable liquids/gasses:
 - a. Unsymmetrical dimethyl hydrazine (UDMH) - Flashpoint 34⁰F
 - b. Monomethyl hydrazine (MMH) - Flashpoint 62⁰F
- 2: Hydrazine (N₂H₄) - is considered a combustible liquid.
 - a. The surface temperature of potential spill areas must also be considered.
 - b. Temperature in the area must be single fault tolerant to remain below 100⁰F.
 - c. Below grade locations may still accumulate enough N₂H₄ to become flammable at lower temperatures.
- 3: Adequate ventilation is defined by NFPA 30, *Flammable and Combustible Liquids Code*, as that which is sufficient to prevent the accumulation of significant quantities of vapor-air mixtures in concentrations over 25 percent of the lower flammability limit.
 - a. An adequately ventilated location is one of the following:
 1. An outside location
 2. A building, room, or space that is substantially open and free of obstruction to the natural passage of air, either vertically or horizontally. Such locations may be roofed over with no walls, may be roofed over and closed on one side or may be provided with suitably designed wind breaks.
 3. An enclosed or partly enclosed space provided with mechanical ventilation equivalent to natural ventilation. The mechanical ventilation system must have adequate safeguards against failure.
 - b. Lower flammability limits of specific commodities are as follows:
 1. N₂H₄ - 4.7 percent
 2. MMH - 2.5 percent
 3. UDMH - 2.0 percent
 - c. Payload propellant systems cannot normally be considered closed piping systems that include only the pipe, valves, fittings, flanges, and meters; they normally also include a pressure vessel.
- 4: Payload propellant systems cannot normally be considered piping without valves, fitting, flanges, and similar accessories.
- 5: Payload propellant systems cannot be considered suitable containers unless they meet DOT or ASME requirements or meet EWR 127-1, section 3.12 and are also protected from outside damage.
- 6: A payload propellant system would normally be considered a process equipment system. In a dynamic mode, the answer to this question will almost always be *yes*; in a static mode, the answer may be *yes* or *no* depending on past history and adequacy of protection from outside damage.
- 7: An analysis must be provided. Consideration must be given to the size of the containment area, credible potential size of the spill, adequacy of the ventilation equipment and its potential failure modes, and the specific gravity of the commodity in question.



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GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

30 SW/SEO - 30th Space Wing, Mission Flight Control

30 SW/SEY - 30th Space Wing, Flight Analysis

45 SW/SEOE - 45th Space Wing, Expendable Launch Vehicle Operations Support and Analysis

45 SW/SEOO - 45th Space Wing, Mission Flight Control

45 SW/SEOS - 45th Space Wing, Space Transportation System Operations Support and Analysis

45 SE/SESL - 45th Space Wing, Missile Systems Division, Large Vehicles Section

45 and 30 MXS - 45th and 30th Maintenance Squadrons

45 and 30 RANS - 45th and 30th Range Squadrons

45 and 30 SW/SE - 45th and 30th Space Wing, Offices of the Chiefs of Safety

45 and 30 SW/SES - 45th and 30th Space Wing, Systems Safety

45 and 30 WS - 45th and 30th Range Weather Squadrons

acceptable hazard - determining the acceptability of any hazard imposed by a missile or orbital vehicle launched from or into the Range is solely the responsibility of the Commander. The acceptability varies with operational requirements and is determined by the Commander on a case-by-case basis.

ACO - Area Control Officer, Aerospace Control Officer

adequate source - a data source that enables the Mission Flight Control Officer to determine when a launch vehicle violates established in-flight safety criteria

ARSR - Air Route Surveillance Radar

ARTCC - Miami Air Route Traffic Control Center

Back Az - Back Azimuth, a Western Range Forward Observer Ground position

BDA - Blast Danger Area

CCAS - Cape Canaveral Air Station

CCC - Central Computer Complex

CCP - Committed Coverage Plan

CCPS - Central Control Processing System

CCS - Command and Control System

CCT - Command Control Transmitter

CCTV - closed circuit television

CDITS - Command Destruct Independent Test Sets

CDR AGC - Command Destruct Receiver Automatic Gain Control (receiver signal strength)

CDS - Command Destruct System

CMEV - Command Message Encoder/Verifier

COLA - Collision Avoidance

command destruct - the process in which a command is issued from a ground station or center that, when executed by the flight system, causes the launch vehicle to destroy itself

Command System - the portion of the Range Safety System consisting of the airborne flight termination system and the ground flight termination system command transmitter system that sends ARM and DESTRUCT commands

CONDO 8 - the Eastern Range designation for the FURUNO Radar System

critical-hold scrub point - the time in the count-down when a hold would normally be expected to result in a scrubbed launch attempt

CRS - Command Remoting System

CSO - Command Systems Officer

dB - decibel; a unit of relative power. The decibel ratio between two power levels, P1 and P2 is defined by the relation $db=10\log(P1/P2)$

dBz - non-dimensional unit of radar reflectivity

DoD - Department of Defense

drag impact points - debris impact points corrected for atmospheric effect

ECP - Estimated Coverage Plan

ER - Eastern Range

Ez - vertical electric field

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

FAA - Federal Aviation Administration

failure - the inability of a system or system component to perform a required function within specified limits

fault - the manifestation of an error in software that may cause a failure

FCA - Flight Caution Area

FHA - Flight Hazard Area

Flight Caution Area - a hazardous launch area; the controlled surface area outside the Flight Hazard Area where individual risk from a launch vehicle malfunction during the early phase of flight exceeds 1×10^{-6} . When activated, only personnel essential to the launch operation (mission-essential) with adequate breathing protection are permitted in this area.

Flight Hazard Area - a hazardous launch area; the controlled surface area and airspace about the launch pad and flight azimuth where individual risk from a malfunction during the early phase of flight exceeds 1×10^{-5} . Because the risk of serious injury or death from blast overpressure or debris is so significant, only mission-essential personnel in approved blast-hardened structures with adequate breathing protection are permitted in this area during launch.

flight termination action - the transmission of thrust termination and/or destruct commands to a launched launch vehicle and/or payload

FMC - fully mission capable

FO - Forward Observer

FOA - Forward Observer Airborne

FOG - Forward Observer Ground

FSPO - a Western Range Flight Safety Project Officer

FSPOC - Flight Safety Project Officer Console

FTS - Flight Termination System

FTU - Flight Termination Unit

FURUNO - a marine band radar used for surveillance of the sea danger zone; *see also CONDO 8*

F minus Time (F-X) - the time in normal work

days prior to the scheduled launch day

h - hour, hours

hazard, hazardous - equipment, systems, events, and situations with an existing or potential condition that may result in a mishap

Hazardous Launch Areas - Safety Clearance Zones during launch operations with defined mishap probabilities, including the Flight Caution Area, Flight Hazard Area, and Launch Danger Zone

hangfire - a condition that exists when the ignition signal is known to have been sent and reached an initiator but ignition of the propulsion system is not achieved

HLA - Hazardous Launch Areas

hold - a temporary delay in the countdown, test, or practice sequence for any reason

holdfire - an interruption of the ignition circuit of a launch vehicle

independent - not capable of being influenced by other systems

IIP - instantaneous impact point

ILL - impact limit line

IP - impact prediction

impact area - an area surrounding an approved impact point based on the launch vehicle and/or payload dispersion characteristics

ISP - Intended Support Plan

KSC - Kennedy Space Center

LA-24 - a large aperture telescope with video capability located at Tranquillon Peak, Vandenberg Air Force Base

LARA - Launch Risk Analysis

launch abort - termination of a launch sequence in an unplanned manner or the failure of the launch vehicle to liftoff for reasons not immediately known

launch vehicle - a vehicle that carries and/or delivers a payload to a desired location; this is a generic term that applies to all vehicles that may be launched from the Eastern and Western Ranges,

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

including but not limited to airplanes; all types of space launch vehicles, manned space vehicles, missiles, and rockets and their stages; probes; aerostats and balloons; drones; remotely piloted vehicles; projectiles; torpedoes and air-dropped bodies

LCC - launch commit criteria

LCU - launch correlation unit

LD - Launch Director

LDCG - Launch Disaster Control Group, a team responsible for responding to launch emergencies

LDZ - Launch Danger Zone; a combination of the sea surface area and air space measured from the launch point and extending downrange along the intended flight azimuth. The size of the launch danger zone is based on the potential hazard to ships and aircraft.

L minus Time (L-X) - the absolute time prior to the scheduled launch time. L-Time may be measured in seconds, minutes, hours, days and includes all scheduled countdown holds. L-Time will always be equal to or greater than T-Time.

LRR - Launch Readiness Review

LWO - Launch Weather Officer

LWT - Launch Weather Team

MCC - Mission Control Center

MFCO - Mission Flight Control Officer - a United States Air Force Officer or civilian who monitors the performance of launch vehicles in flight and initiates flight termination action when required; the direct representative of the Range Commander during the prelaunch countdown and during launch vehicle powered flight

min - minute, minutes

misfire - a condition that exists when it is known that the ignition signal has been sent but did not reach an initiator and ignition of the propulsion system was not achieved

mission-essential personnel - the minimum number of persons necessary to successfully and safely complete a hazardous or launch operation and whose absence would jeopardize the completion of the operation; this designation also includes people

required to perform emergency actions according to authorized directives, persons specifically authorized by the Wing Commanders to perform scheduled activities, and those personnel in training. The Range Users and Wing Commanders determine, with Range Safety concurrence, the number of mission-essential personnel allowed within Safety Clearance Zones or Hazardous Launch Areas; *see also Safety Clearance Zones and Hazardous Launch Area*

Mission Rules - a document of agreements between the Range User and Range Director specifying, in detail, those requirements and procedures not covered by this document

Mission Scrub - termination of a launch operation

MOA - memoranda of agreement

MSP - Mission Support Position

NASA - National Aeronautics and Space Administration

nm - nautical miles

NMC - non-mission capable

nominal vehicle - a properly performing launch vehicle whose instantaneous impact point (IIP) does not deviate from the intended IIP locus

NOTAM - Notice to Airmen and Mariners

OD - Operations Directive

OPR - Office of Primary Responsibility

OpsSup - Operations Supplement

OR - Operations Requirement

orbital injection (insertion) - the sequence of events in time and space, whereby a vehicle achieves a combination of velocity and position such that without additional thrust at least one orbit of the earth will be made

OSC - Operations Safety console

OSM - Operations Safety Manager

PAFB - Patrick Air Force Base

PMC - partially mission capable

positive control - the continuous capability to ensure acceptable risk to the public is not exceeded

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

throughout each phase of powered flight or until orbital insertion

PP - present position

PRD - Program Requirements Document

Program - the coordinated group of tasks associated with the concept, design, manufacture, preparation, checkout and launch of a launch vehicle and/or payload to or from, or otherwise supported by the Eastern or Western Ranges and the associated ground support equipment and facilities; a Forward Observer Ground position

public safety - safety involving risks to the general public of the United States or foreign countries and/or their property

Range Contractor - the Launch Base Support and Range Technical Services contractors and all sub-contracted agencies required for operation and maintenance of the ER and similar contractors at the WR. For the purposes of this regulation, the term Range Contractor also refers to NASA and KSC contractors as applicable.

Range Users - clients of Cape Canaveral Air Station and Vandenberg Air Force Base; includes DoD, non-DoD government agencies, civilian commercial companies, and foreign government agencies that use the Eastern and Western Range facilities and test equipment to conduct prelaunch, launch, and impact operations or require on-orbit support

RAPCON - Radar Approach Control, Patrick Air Force Base

RASCAD - Range Safety Control and Display

RCO - Range Control Officer

RF - Radio Frequency

ROCC - Range Operations Control Center

RSD - Range Safety Display

RSOR - Range Safety Operations Requirement

RSLCC - Range Safety Launch Commit Criteria

RSS - Range Safety Simulator; Range Safety System; Relative Signal Strength

RSSR - Range Safety System Report

RSWC - Range Safety Wind Check

RTP - real time processing

RTS - Range Tracking System

SCO - Surveillance Control Officer

sec - second, seconds

shall - mandatory action

SMFCO - Senior Mission Flight Control Officer

SSBN - Fleet Ballistic Missile Submarine, Nuclear Powered

STS - Space Transportation System (space shuttle)

SWI - space wing instruction

SWR - space wing regulation

T minus Time (T-X) - countdown clock time; T-0 is launch time; time prior to the scheduled launch time not including built-in holds in the countdown; normally measured only in second, minute, and hour

TACAN - Tactical Air Control and Navigation

TDTS - Telemetry Data Transmitting System

THC - Toxic Hazard Corridor (ER)

THZ - Toxic Hazard Zone (WR)

TLCF - Technical Laboratory Computer Facility

TM - telemetry; vehicle systems measurements made available to ground based users via S-band downlinks

TDMA - time division multiple access

TMIG - telemetry or telemetered inertial guidance data

TNAR - Telemetry Doppler Nominal Acceleration; a Kalman filter used for tracking displays at the Western Range

Toxic Hazard Corridor - a Hazardous Clear Area; clearance of a sector in which toxic material may reach predetermined concentration levels; called Toxic Hazard Zone on the WR

GLOSSARY OF ABBREVIATIONS, ACRONYMS, AND DEFINITIONS

Toxic Hazard Zone - *see Toxic Hazard Corridor*

trilateration - the use of ranging data from three geographically suitable radar sites to produce high quality tracking data

TSO - Telemetry Systems Officer

TVSS - television skyscreen

T-X - a time late in the minus count after which a holdfire switch will not be activated

UDS - Universal Documentation System

UHF - ultra high frequency

USCG - United States Coast Guard

VEA - Vessel Exclusion Area

Vessel Exclusion Area - a hazardous launch area; a combination of the sea surface area and airspace measured from the launch point and extending downrange along the intended flight azimuth; the size of the VEA is based on hazard containment or a combination of acceptable impact probability and personnel risk

VHF - very high frequency

VSO - Video Systems Officer

VWSS - Vertical Wire Skyscreen

WR - Western Range

REFERENCED DOCUMENTS

30 and 45 SW, *Range Safety Operations Requirements (RSOR)*

30 SWI 91-106, *Toxic Hazard Assessments*

45 SWR 80-12, *TDM Data Information Required for 45th Space Wing TLM Support*

45 SWI 99-101, *45th Space Wing Mission Program Documents*

OD-16, *Range Safety Support*

OD-16, Annex A, *Mission Flight Control Training*

OD-16, Annex B, *RSOS Verification Test*

Section R Rules and Agreements, *Johnson Space Center Operational Flight Rules*

WRR 127-9, *Integrated Missile Flight Control Ground Systems*

CHAPTER 7

FLIGHT CONTROL DOCUMENTATION, SYSTEMS, AND PROCEDURAL REQUIREMENTS

7.1 INTRODUCTION

7.1.1 Purpose of the Chapter

Chapter 7 describes policies, identifies data and systems requirements, and provides procedures required to maintain positive control of launch vehicles and payloads launched on the Eastern Range (ER) and Western Range (WR). The following topics are addressed:

- 7.2 Responsibilities and Authorities
- 7.3 Flight Control Policies
- 7.4 Documentation Requirements
- 7.5 Range Tracking
- 7.6 Real-Time Impact Prediction System
- 7.7 Command and Control System
- 7.8 Timing, Countdown, and Sequencing
- 7.9 Launch Area Surveillance
- 7.10 Range Safety Display System
- 7.11 Flight Control Communication Circuits
- 7.12 Mission Flight Control Training Requirements

7.1.2 Applicability

The requirements identified in this Chapter are applicable to the flight control functions of the ER and WR. These requirements shall be used to ensure launches do not pose an unnecessary risk.

7.2 RESPONSIBILITIES AND AUTHORITIES

7.2.1 Commanders, 45th Space Wing and 30th Space Wing

As the Range Directors, the Commanders or their designated representatives are responsible for ap-

proving the Mission Rules and certifying Mission Flight Control Officers.

7.2.2 Chiefs of Safety, 45th Space Wing and 30th Space Wing

The Chiefs of Safety, 45th Space Wing (45 SW/SE) and 30th Space Wing (30 SW/SE) or their designated representatives are responsible for the following:

- a. The Range Safety Operations Requirement (RSOR)
- b. The Operations Supplement (OpsSup)
- c. Evaluating and issuing safety approval for personnel authorized to remain in hazardous launch areas
- d. Providing Range Users with a Range Safety Launch Operations Approval Letter no later than the Launch Readiness Review (LRR)
- e. Providing the final Range Safety approval to launch

7.2.3 Mission Flight Control Officers, 45th Space Wing and 30th Space Wing

Mission Flight Control Officers (MFCOs) are directly responsible to the Range Directors for implementation and execution of actions required to comply with applicable public laws and Department of Defense (DoD) directives during a launch.

a. Acting for the Range Directors, MFCOs are responsible for the following:

- 1. From a safety perspective, determining whether a launch operation should be allowed to proceed
- 2. Making Range Safety final launch recom-

mendations

3. Monitoring the progress of a launch vehicle
4. Serving as the sole authority for determining if the flight of a launch vehicle should be allowed to continue or be terminated
5. At the ER monitoring surveillance and control operations within launch surveillance areas to ensure the risks to people, aircraft, and surface vessels are within acceptable limits. At the WR the MFCO is responsible for verifying clearance to ensure safety of defined surveillance areas.

b. MFCO positions include the following:

1. Mission Flight Control Officer (MFCO)
2. Senior Mission Flight Control Officer (SMFCO)
3. Telemetry Systems Officer (TSO)
4. Forward Observer Ground (FOG)
5. ER Surveillance Control Officer (SCO)
6. ER Forward Observer Airborne (FOA)
7. ER Command Systems Officer (CSO)
8. ER Video Systems Officer (VSO)

7.2.4 Offices of the Chiefs of Safety, 45th Space Wing and 30th Space Wing

The responsibilities and authorities of Mission Flight Control, Flight Analysis, and Systems Safety, all reporting to the Chiefs of Safety, are described below.

7.2.4.1 Mission Flight Control, 45th Space Wing and 30th Space Wing

Mission Flight Control, 45th Space Wing (45 SW/SEO) and 30th Space Wing (30 SW/SEO) are responsible for the following. **NOTE:** Unless otherwise noted, all references to *Range Safety* in this Chapter refer to Mission Flight Control.

- a. Preparing the RSOR
- b. Approving Skyscreen sites
- c. Publishing and distributing the OpsSup
- d. Developing the Mission Rules in conjunction with Flight Analysis and the Range User
- e. (WR only) Publishing and distributing the RSOR

7.2.4.2 Operations Support and Analysis, 45th Space Wing and Flight Analysis, 30th Space Wing

Operations Support and Analysis, 45th Space Wing (45 SW/SEO and SEOS) and Flight Analysis, 30th Space Wing (30 SW/SEY) are responsible for

the following: **NOTE:** For the purposes of this chapter, 45 SW/SEO and SEOS and 30 SW/SEY will be referred to as 'Flight Analysis.'

- a. Issuing flight plan approval
- b. Computing flight safety criteria
- c. Directing the construction of the Range Safety Display (RSD) display backgrounds and independently verifying their accuracy
- d. Coordinating with Range Safety and the Range User on mission rules development
- e. Performing near real-time risk assessment in support of launch operations
- f. Approving mission support positions (MSPs) for supporting Range assets
- g. (WR only) Assessing environmental factors during launch operations

7.2.4.3 Systems Safety, 45th Space Wing and 30th Space Wing

Systems Safety, 45th Space Wing (45 SW/SES) and 30th Space Wing (30 SW/SES) are responsible for the following:

- a. Coordinating with Mission Flight Control and Flight Analysis on the review and approval of documents described in this Chapter
- b. Approving and certifying the airborne Range Safety System (RSS), including the Flight Termination System (FTS), the Range Tracking System (RTS), and the Telemetry Data Transmitting System (TDTS)
- c. Performing prelaunch checkouts of the RSS
- d. (ER only) Identifying safety weather constraints for launch
- e. (ER only) Assessing environmental factors during launch operations
- f. (WR only) Determining the launch countdown FTS status

7.2.4.4 Operations Safety, 45th Space Wing and 30th Space Wing

Operations Safety, 45th Space Wing (a Range Contractor under the direction of Range Safety) and 30th Space Wing (30 SW/SEGP), including the Launch Disaster Control Group (LDCG) chief, Flight Safety Project Officer (FSPO), the Operations Safety Manager (OSM), and the Area Control Officer (ACO) are responsible for performing and notifying MFCOs of the following:

- a. Verifying the Flight Caution Area (FCA) and flight Hazard Area (FHA) are clear
- b. Verifying that the blockhouse is sealed
- c. Performing HOLDFIRE checks
- d. Determining the launch countdown FTS status

7.2.5 Range Squadrons, 45th Space Wing and 30th Space Wing

The Range Squadrons, 45th Space Wing (45 RANS) and 30th Space Wing (30 RANS) are responsible for the following:

- a. (ER only) Printing and distributing the RSOR and ensuring compliance by affected agencies
- b. (ER only) Providing a 12-month forecast of expected support requirements, updated quarterly
- c. (WR only) Providing instrumentation support plans

7.2.5.1 Range Control Officers, 45th Space Wing and 30th Space Wing

The Range Control Officers (RCOs) are responsible for the following:

- a. Providing status of the ground portion of the flight termination system to the MFCO
- b. Providing status of all Range Safety required display systems and associated equipment
- c. Providing status of Range Instrumentation supporting Range Safety
- d. Ensuring that no functions are transmitted without the specific approval of the MFCO after the MFCO has assumed control of the system unless the functions are scheduled countdown items with the MFCO monitoring
- e. (ER only) Advising Miami Air Route Traffic Control Center (ARTCC) to close W-497A for all weather rocket launches from Cape Canaveral Air Station (CCAS)

7.2.5.2 Aerospace Control Officers, 45th Space Wing and 30th Space Wing

The Aerospace Control Officers (ACOs) are responsible for the following:

- a. Verifying supporting Range assets are at their respective Mission Support Positions (MSPs)
- b. Performing as the control authority for restricted air space hazardous areas
- c. Providing air space GO/NO-GO to the MFCO
- d. Managing applicable support aircraft
- e. (ER only) Issuing breakaway instructions for support aircraft in accordance with MFCO and

Flight Analysis instructions

- f. (ER only) Reporting ER launch operation information to the Launch Correlation Unit (LCU)
- g. (WR only) Providing GO/NO-GO to the MFCO for sea, air, and rail traffic

7.2.6 Weather Squadrons, 45th Space Wing and 30th Space Wing

The Weather Squadrons, 45th Space Wing (45 WS) and 30th Space Wing (30 WS) are responsible for the following:

- a. Providing all spacelift generation, execution, and recovery weather support services
- b. As members of the Launch Weather Team (LWT), evaluating Range Safety and Range User weather Launch Commit Criteria (LCC) to ensure there are no weather threats to the safe and successful launch of manned, expendable, and ballistic missile launch operations during day-of-launch operations.

7.2.7 Maintenance Squadron, 45th Space Wing

The Maintenance Squadron, 45th Space Wing (45 MXS) is responsible for providing the following information to Range Safety:

- a. Estimated Coverage Plan (ECP) intervals of usable data from each optic, radar, and telemetry (TM) data source used to comply with Flight Control and Range Safety requirements
- b. Committed Coverage Plans (CCPs)
- c. In-count resource commitment status (fully mission capable [FMC], partially mission capable [PMC], non-mission capable [NMC]) and technical evaluation of ER systems required to support Range Safety requirements. **NOTE:** This function is provided by the assigned Range Engineer on all launches.

- d. A preliminary set of ECPs shall be provided to Flight Analysis no later than 10 working days after receipt of a planning or final trajectory tape provided by the Range User; a final set of ECPs and CCPs shall be provided to Flight Analysis no later than 15 working days after the receipt of the final trajectory tape.

7.2.8 Range Users

Range Users are responsible for providing the following:

- a. Telemetry measurement lists
- b. Range User countdown checklist

c. Special command requirements and requests

7.2.9 Supporting Agencies

7.2.9.1 United States Coast Guard

The United States Coast Guard (USCG) provides support for all launches consistent with applicable memoranda of agreement (MOA). **NOTE:** Specific support requirements shall be levied by this document and the RSOR and documented in the Universal Documentation System (UDS).

7.2.9.2 ER Operations National Aeronautics and Space Administration Support

The National Aeronautics and Space Administration (NASA) provides support for ER operations from NASA sites at the Wallops Flight Facility at Wallops Island, Virginia; the Bermuda Station; and the United Kingdom consistent with applicable MOA. **NOTE:** Specific requirements shall be levied in the RSOR and documented in the UDS Program Requirement Document (PRD) and Operations Directives (ODs).

7.3 FLIGHT CONTROL POLICIES

7.3.1 Flight Termination Policy

The following conditions normally result in flight termination action by the MFCO:

- a. Valid data shows the launch vehicle has violated established flight safety criteria.
- b. The performance of a launch vehicle is obviously erratic and the potential exists for the MFCO to lose positive control. The performance of the launch vehicle may produce a gross flight deviation, and further flight is likely to increase public risk. Termination action may be taken even though the vehicle has not violated flight safety criteria.
- c. The performance of the launch vehicle is unknown and the capability exists to violate flight safety criteria. **NOTE:** If the launch vehicle has been nominal for an extended period of flight before the status becomes unknown, the MFCO may allow the flight to continue.
- d. At the written request of the Range User, the MFCO may implement special command requirements such as FUEL CUTOFF or SAFE (RF DISABLE).
- e. In all instances, the MFCO shall make a decision concerning continued flight or termination based on interpretation of real-time events and

mission rules, all available data sources, and sound judgment.

f. (ER only) The mission rules and flight termination policy for the space transportation system (STS) shall be in accordance with the *Johnson Space Center Operational Flight Rules*, Rules and Agreements, Section R.

7.3.2 Command Destruct Receiver Control

After the MFCO assumes control of the ground portion of the Command and Control System (CCS), the command destruct receivers shall not be allowed to be turned on or off without the specific approval of the MFCO unless it is a scheduled countdown item with the MFCO monitoring.

7.3.3 Launch Commit Decision

The MFCO is responsible for the launch commit decision from a safety perspective. The launch commit decision shall be based on the ability of range instrumentation to meet minimum Range Safety requirements and a real-time assessment of public safety impacts. The MFCO shall perform final checkout of Range Safety instrumentation (RSD and CCS) prior to accepting the system for launch.

7.3.4 Restrictions Applicable to Flight Control Communications and Recordings

- a. To avoid unauthorized dissemination of Flight Control communications and recordings, no individual, agency, or organization shall be permitted to monitor the MFCO composite circuits without the expressed written consent of Range Safety. Access to these circuits shall not be allowed at positions other than those specified in the applicable RSOR or OpsSup.
- b. Release of recordings of the Flight Control composite circuits to any individual, agency, or organization is prohibited without the expressed written consent of Range Safety.
- c. Range Safety shall be advised of all requests to monitor the MFCO composite circuits or requests for access to the circuit recordings.

7.3.5 Weather-Related Launch Commit Criteria

NOTE: The weather constraints or launch commit criteria (LCC) described below are critical in the launch GO/NO GO decision. If any of the LCCs

are violated, the launch can, and most probably will, be delayed.

7.3.5.1 Range Safety Natural/Triggered Lightning Avoidance Weather Launch Commit Criteria

a. The Range Safety natural/triggered lightning weather launch commit criteria is a set of rules developed to ensure the avoidance of natural and/or triggered lightning during space/ballistic launch operations. **NOTE:** Navy operations may have a reduced set of weather LCCs due to the location of launch operations.

b. Range Safety natural and/or triggered lightning LCC may be waived only under special circumstances by the 45/30 SW Commanders.

7.3.5.2 Range User Weather Launch Commit Criteria

a. The Range User weather LCC is a set of Range User defined, launch-system unique, weather LCCs applicable to a specific operation and/or launch vehicle. **NOTE:** Typical Range User LCCs may be related to temperature, wind, and/or precipitation; for example, winds greater than 40 knots prohibits launch of X vehicle or movement of the Mobile Service Tower or greater than 10 percent probability of lightning within 5 nm prohibits initiation of Shuttle External Tank fueling operations.

b. Range User weather LCCs may be waived by the Range User under special circumstances.

7.3.5.3 Range Safety Weather-Related Launch Commit Criteria

a. The Range Safety weather-related LCC is a set of LCC that involve meteorological conditions that may affect launch operations; for example, upper level winds (Flight Hazard Area), low level wind and temperature profiles (blast/toxic propagation) and/or ceiling and visibility (optical restrictions).

b. Range Safety weather-related LCCs may be waived only, under special situations, by the 45/30 SW Commanders.

7.4 DOCUMENTATION REQUIREMENTS

7.4.1 Range Safety Operations Requirements

a. Range Safety shall develop and publish an RSOR for each applicable PRD or Operations Re-

quirement (OR) prepared by a Range User.

b. The RSOR shall be approved by the Chiefs of Safety or their designated representatives and distributed no later than L-60 days. **NOTE 1:** If a systems development effort is required, this time limit is extended to L-180 days. **NOTE 2:** These time limits assume that Range User documentation is on hand no later than 30 days prior to the RSOR due date.

c. The RSOR shall document exceptions to the standard provisions of this Chapter.

d. The RSOR may also levy additional safety requirements peculiar to a launch vehicle series.

7.4.2 Operations Supplement

a. Range Safety shall develop and publish an OpsSup containing additional information or requirements particular to a given launch and which are not contained in the RSOR or this document.

b. The OpsSup shall be approved by the Chiefs of Safety or their designated representatives and distributed no later than F-5 working days for each ballistic missile or launch vehicle launch operation. **NOTE:** For STS, the time limit is F-10 days.

7.4.3 Mission Rules

Mission Rules identify flight control requirements and procedures not covered elsewhere.

a. As required, Range Safety, Flight Analysis, and the Range User may develop unique mission rules on a case-by-case basis.

b. Mission Rules shall be approved by the Wing Commanders or their designated representatives.

7.4.4 Telemetry Measurement List and Tape

a. As applicable, the Range User shall develop a Telemetry Measurement List.

1. The Telemetry Measurement List shall be furnished to Range Safety no later than L-210 days.

2. The Telemetry Measurement List shall be used by Range Safety to develop telemetry analog display requirements contained in the respective RSOR.

b. As applicable, Range Users shall develop a Telemetry Tape (preferably populated) to be used to validate Range Safety telemetry systems software modifications.

c. The data format and time line requirements for the Telemetry Measurement List and Tape are

contained in 45 SWI 99-101 and 45 SWR 80-12 for the ER and WRR 127-9 and the RSOR for the WR.

7.4.5 ER Range User Countdown Checklist

A copy of the final Range User Countdown Checklist for each operation shall be provided to Range Safety no later than F-7 days.

7.4.6 ER Committed Coverage Plans

a. The ER CCPs shall include the following information:

1. Committed coverage intervals of usable data from each data source used to comply with Flight Control and Range Safety requirements

2. The committed radar acquisition mode (optical transfer or beam intercept) for initial coverage in the launch area and tracking modes (optical, skin, beacon)

3. Committed coverage for Flight Control command systems

4. Committed coverage for telemetry (analog/-telemetry inertial guidance [TMIG])

b. A preliminary ECP shall be provided to Flight Analysis no later than 10 working days after receipt of a planning or final trajectory tape provided by the Range User.

c. The final CCP, coordinated through 45 RANS, shall be provided to Range Safety no later than 15 working days after receipt of the final trajectory tape.

7.4.7 Launch Operations Approval

a. (WR) A Range Safety Launch Operations Approval Letter to launch from or onto the WR shall be provided to the Range User no later than the scheduled LRR conducted prior to a planned launch operation. Receipt of this letter depends on the Range User having obtained the previously required approvals identified in Chapter 1 of this document.

b. (ER) Launch Operations Approval Letters are not normally used on the ER. Wing Safety's GO at the LRR constitutes approval to launch and is contingent on the Range User having obtained the required approvals identified in Chapter 1 of this document. However, a Range Safety Launch Operations Approval Letter can be provided, if requested.

c. Lack of Launch Operations Approval may result in the launch being withdrawn from the Range

schedule.

7.5 RANGE TRACKING

a. Range tracking instrumentation data is required to provide the MFCO with the following information:

1. Real-time information on in-flight vehicle behavior

2. Positive knowledge of vehicle position throughout all phases of powered flight

b. Tracking data is used to compare actual and nominal flight trajectories, verify performance in conjunction with telemetry, and identify violations of destruct lines.

c. The overall tracking systems shall be robust, highly fault tolerant, allow for catastrophic failure in a single system without loss of all tracking data, and provide for graceful degradation of the system under multiple component failures.

7.5.1 Range Tracking Instrumentation System

a. Tracking from at least two adequate and independent Range instrumentation data sources is mandatory and shall be maintained throughout each phase of powered flight from launch to establishment of the final impact point for launch vehicles with suborbital trajectories or to orbital insertion for space launch vehicles.

b. Range tracking instrumentation data sources shall be designed to ensure that no hardware or software single point of failure denies the MFCO the capability to directly monitor an in-flight launch vehicle.

7.5.2 Forward Observers

7.5.2.1 Ground Forward Observers

a. (ER only) A program vertical wire skyscreen (VWSS) manned by an FOG assigned to SEO is required for all pad launches.

b. (WR only) Two forward observers, Program and Back Azimuth, are required for all pad launches.

c. Locations of FOG sites shall be listed in the appropriate RSOR

7.5.2.2 ER Forward Observer Airborne

An ER FOA is required for all STS launches.

7.5.2.3 Television Skyscreens

a. Flight line (Back Azimuth) and Program Tele-

vision Skyscreen (TVSS) systems are required for all pad launches and shall be placed in operation no later than L-60 min.

b. The flight line (Back Azimuth) camera shall be free to move the azimuth and elevation to permit centering the launch vehicle in the field of view while tracking and shall be located within $\pm 15^\circ$ of the uprange extension of the flight line.

c. (ER only) The Program camera shall be fixed in azimuth, but be free to track in elevation.

d. (ER only) A vertical reference line and arrow indicating planned direction of flight shall be superimposed on the TVSS transmission to monitor at the MFCO console positions.

e. (WR only) The Program TV camera shall be aligned with the cursor, slightly on the downrange side of the vehicle or tallest structure.

cision authority.

7.5.2.4 Skyscreen Site Location Criteria

The following criteria shall be used in selecting skyscreen site locations:

a. TVSS Flight Line (ER only) and VWSS Program sites shall be located within $\pm 15^\circ$ of a line extending from the launch point, perpendicular to the flight azimuth.

b. (WR only) TVSS flight line (Back Azimuth) sites shall be located within $\pm 15^\circ$ of the uprange extension of the flight line.

7.5.2.5 Skyscreen Operations

The Range Technical Services Contractor (RTSC) provided skyscreen operators shall setup and complete a checkout of the skyscreen system prior to T-60 min. All skyscreen systems shall remain operational until released by the MFCO.

7.6 REAL-TIME IMPACT PREDICTION SYSTEM

7.6.1 Real-Time Impact Prediction System General Requirements

a. Present position (PP) and instantaneous impact point (IIP) solutions shall be provided for display on the RSD.

b. The data shall be computed from data supplied by the tracking sources identified in the RSOR or OpsSup as applicable.

c. PP and IIP computation and display shall be single failure tolerant.

d. (ER only) The RSD map switching algorithm shall use the prime tracking source solution for de-

e. (ER only) Radar trilateration solutions are required when available.

f. (ER only) Launch vehicle TMIG shall be allowed to compete for the alternate source position but shall be excluded from the prime source position.

g. (WR only) The RSD map panning algorithm uses the nominal dot for decision authority. The capability shall exist to allow the prime source to be designated as decision authority.

h. (WR only) TM Doppler, Nominal Acceleration, and Radar (TNAR) Kalman filter solutions are required when available.

7.6.2 System Checks

a. In accordance with established procedures, a complete end-to-end system check shall be made during the countdown using taped data inputs and RSD display tapes verified by Flight Analysis. **NOTE:** This functional check does not relieve the Range Contractor of responsibility for proper operation of the system during the launch.

b. (ER only) A listing of the sources used during the operation shall be furnished to Range Safety and 45 MXS within two working days after the launch.

c. The Central Computer Complex (CCC) shall perform wind-effects calculations for Range Safety on the morning of F-1 work day and again at approximately L-5 h on launch day for all major launches. The following procedure shall be adhered to:

1. By F-8 days, Flight Analysis shall forward a letter to the Range Contractor providing station constants, ballistic coefficients, and trajectory data to compute the effects of wind on the drag impact points.

2. On F-3 days and at L-5 h, Range Weather Operations shall provide forecasts of T-0 files. The wind files shall be used for all prelaunch safety computations.

3. The Range Safety wind check program shall be run by L-4.5 h. The results shall be made available to Flight Analysis on computer disk file.

4. If a HOLD invalidates the predicted wind data or if a later wind prediction is made, it may be necessary to repeat the above calculations as late as L-1 h.

d. (WR only) The weather data and associated safety analysis requirements shall be listed in the

RSOR.

7.7 COMMAND AND CONTROL SYSTEM

The CCS provides the MFCO with the capability to terminate launch vehicle flight if flight termination criteria are violated or mission rules call for MFCO action.

7.7.1 Command and Control System General Requirements

a. Ultra high frequency (UHF) transmission capability for flight termination commands is required throughout powered flight or until orbital insertion as dictated by the mission flown.

b. Flight control command functions, including the capability to override, shall take precedence over other commands that may be transmitted to or by command transmitter system sites.

c. The command control transmitter field intensity along the nominal trajectory shall meet the requirements in Chapter 4 of this document.

d. Each command control transmitter supporting a launch shall have a backup transmitter capable of maintaining the proper signal strength.

1. The backup command transmitter shall be activated by an automatic station guardian (failure sensing and failover switching) if the primary transmitter output falls to 50 percent of normal in an unplanned manner.

2. A pair of transmitters at a command control site, each connected to the station guardian, constitute a system.

e. When the launch vehicle airborne FTSs are active and ordnance is electrically connected, a command system shall be radiating at the proper frequency to "capture" the receivers.

f. During those periods when the FTS receiver is on, no UHF commands shall be radiated in support of another operation unless there is at least a 4 MHz frequency separation.

7.7.2 Additional WR Command and Control System Requirements

a. The CCP provided by 30 RANS shall contain coverage estimates for each applicable command transmitter site based on the theoretical nominal vehicle trajectory and expected signal attenuation.

b. The CCP shall portray site coverage with and without Range Safety decibel (dB) level pads described in 3 dB increments as described in Chapter

4 of this document.

c. The CCP shall provide the optimum command system configuration.

d. The command control system shall meet those requirements listed in WRR 127-9, Chapter 4 or equivalent.

e. The frequency separation shall be at least 3 MHz.

7.7.3 ER Command Remoting System

The ER Command Remoting System (CRS) consists of dual command message encoder/verifier (CMEV) units located in the operations control center referred to as the Central CMEVs, the command remoting links, dual site CMEVs located at each of the UHF command transmitter sites, and the Range Safety Control and Display (RASCAD).

a. The CRS monitors the status of the command transmitters located at committed sites. Based on vehicle present position and site bias, the CRS automatically selects the optimum command transmitter site to radiate an adequate carrier signal to the launch vehicle.

b. The CRS is required for the remote control of the command systems transmitters and shall be capable of enabling and disabling remote station command capability.

c. CRS manual control capability is required to back up the automatic system.

d. Indicators located immediately above the Flight Termination Unit switches on the MFCO console shall illuminate when the CRS detects a command transmission such as ARM or FIRE.

e. Command transmission shall also be displayed on the RASCAD monitor screens. CRS status indications on the RASCAD screens shall include the following information:

1. Command site readiness
2. The site transmitting the command carrier
3. Site tracking elevation angles
4. Transmitter fail over
5. System automatic and manual modes
6. MFCO command destruct capability as

ACTIVE or LOCKED OUT

7. Command issued
8. Time of transmission
9. Command remoting link health
10. Central CMEV on-line indication

7.7.4 WR Central Control Processing System

The WR Central Control Processing System (CCPS) is a multiple microprocessor-based system designed to provide operational support with at least one system failure. Its primary purpose is to communicate with the command control transmitter (CCT) sites.

a. The CCPS provides operator displays to show the status of the CCT sites, its own status, and the status of other systems.

b. The CCPS provides operator controls to allow for remote control of the CCT sites, its own configuration, and other external systems.

c. The CCPS shall meet those requirements listed in WRR 127-9, Chapter 3 or the equivalent.

7.7.5 ER Flight Termination Unit

a. An ER Flight Termination Unit (FTU) shall be located at each MFCO console position.

b. The FTU switches shall be programmable for ARM, DESTRUCT, SAFE, and other, optional commands that may be required for a mission.

1. The switches shall be programmed as specified in the applicable RSOR.

2. Switches having no functions programmed for a launch shall be disabled.

3. Each switch on the FTU shall have a status indicator located immediately above it. When an active switch is thrown, the indicator shall display the command requested and verification of transmission.

7.7.6 WR Flight Termination Unit

The WR equivalent of the Flight Termination Unit is an integral part of the CCPS and, as such, shall meet the requirements listed in WRR 127-9, Chapter 3 or the equivalent.

7.7.7 Command and Control System Check-out

Proper operation of the CCS shall be verified to and confirmed by the MFCO prior to launch.

7.8 TIMING, COUNTDOWN, AND SEQUENCING

7.8.1 MFCO Timers

a. Each MFCO shall have access to the following timers:

1. A universal, coordinated time display in h,

min, and sec

2. Countdown indicators in min and sec for the applicable Range countdown networks
3. (ER only) Two manual interval timers in sec

to be used as stopwatches. **NOTE:** The manual interval timers shall have START, STOP, and RESET push buttons

- b.* All MFCO timers shall be operational for launch.

7.8.2 ER MFCO Support Position Timers

- a.* The ER MFCO shall have access to countdown indicators for the two Range countdown networks at each of the MFCO support positions except the FO positions.

- b.* Each telemetry and command systems positions requires two manual interval timers.

7.8.3 Holdfire

A holdfire capability is mandatory for all pad launches. This requirement can be met using the Range holdfire system but may also be met by using voice communication to the Test or Launch Director who has launch sequence interrupt capability (See Chapter 3 of this document.)

- a.* At a designated time in the countdown, the HOLDFIRE switches shall be functionally checked.

- b.* The Operations Safety Manager (OSM) (ER only) and the Range User shall verify that the HOLDFIRE switches function properly and report the results to the MFCO.

7.8.4 ER T-X Time

7.8.4.1 ER T-X Time for Pad Launches

- a.* The T-X time for pad launches shall be identified by the Range User and coordinated for concurrence with Range Safety.

- b.* No hold shall be initiated after T-X for any Flight Control or Range Safety item.

- c.* The T-X time shall be designated in the OpsSup and the MFCO Countdown Checklist.

7.8.4.2 ER T-X Time for Submarine Launches

- a.* The T-X time for submarine (SSBN) launches is normally 0 seconds.

- b.* Holdfire for these launches is directed verbally and relayed from the Launch Conductor to the SSBN.

- c.* Actual launch times for SSBN launches vary significantly and may occur at any time after the Range has passed a CLEAR-TO-LAUNCH and after the earliest submarine launch time. **NOTE:** For the launch to occur, both conditions must be

met.

the ACO at the WR for ships, aircraft, and

7.8.5 Critical Hold or Scrub Point

a. The Range User shall identify critical hold or scrub points for each launch, if they exist, and coordinate these times with the MFCO for the launch.

b. (ER only) The MFCO shall assume waiver authority for Range Safety mandatory items when the Range CLEAR-TO-LAUNCH is passed.

7.8.6 Launch Aborts

A launch abort (hangfire/misfire) is the termination of the launch sequence in an unplanned manner or the failure of the vehicle to liftoff for reasons not immediately known. It shall be presumed that the vehicle may liftoff without warning.

a. In the event of a launch abort, the RCO shall release no instrumentation until directed to do so by the MFCO.

b. (ER only) The OSM shall determine which event (hangfire or misfire) has occurred and report to the MFCO.

c. (WR only) The Range User shall determine which event (hangfire or misfire) has occurred and report to the MFCO.

d. All other activities shall be conducted in accordance with Chapter 6 of this document.

7.8.7 Mission Scrubs

a. In cases where the mission and/or launch operation is terminated under normal circumstances, the RCO shall not release instrumentation until after coordinating with the MFCO.

b. The Command Destruct receivers shall remain captured until the FTS is safed in accordance with the Range User provided and Range Safety approved recycle procedures.

7.9 LAUNCH AREA SURVEILLANCE

7.9.1 Launch Area Surveillance General Requirements

a. ER launch area surveillance includes those land, air, and sea areas designated as the FCA, FHA, and Launch Danger Zone (LDZ).

b. WR launch areas surveillance includes those land, air, and sea areas designated as the FHA and the FCA.

c. The determination of a Launch Area Surveillance GO FOR LAUNCH is provided by the Surveillance Control Officer (SCO) at the ER and by

trains to the MFCO who makes the final determination for CLEAR-TO-LAUNCH on the basis of information from the above sources and any other sources available during the final phases of launch countdown.

d. Designated clearance areas, warning areas, and restricted airspace areas shall be active and controlled according to this document, Safety Operating Instructions, 45 and 30 SW regulations, and Federal Aviation Administration (FAA) directives and regulations.

7.9.2 Hazardous Launch Area Clearance

a. Concurrence from the Chief of Safety must be obtained for all personnel required or requesting to be within a Hazardous Launch Area during a launch operation. **NOTE:** Mission-essential personnel may be permitted within the Impact Limit Lines (ILLs) and the FCA, but only within the FHA if located in blast-hardened structures with adequate breathing apparatus.

b. Wing-essential personnel located at required work areas and non-essential personnel may be permitted inside the ILLs with Wing Commander approval.

c. Requests for personnel to remain in these hazardous launch areas shall be submitted to Range Safety, with justification, in sufficient time to permit approval action prior to L-1 day.

d. The OSM shall confirm the on land portions of the FHA and FCA clear and report to the MFCO.

e. The FHA and FCA clear report shall occur at a designated time in the launch countdown.

f. (ER only) 45 SW/SES shall compile a list of personnel authorized to remain in hazardous launch areas, obtain 45 SW/SE approval, and provide the list to the RCO, MFCO, and OSM no later than L-1 day.

g. (WR only) 30th SW/SE shall compile a list of personnel authorized to remain in hazardous launch areas and provide the list to the security police and the LDCG.

7.9.3 Hazardous Area Surveillance and Control

7.9.3.1 Surveillance Aircraft

Surveillance aircraft support for surveillance control shall be required for all launches.

7.9.3.2 Radar Surveillance

The following radars are required to perform air and sea surveillance of the hazardous launch area:

7.9.3.2.1 ER RAPCON Radars and Miami Air Route Traffic Control Center Radar.

a. The Radar Approach Control (RAPCON) radars at Patrick Air Force Base (PAFB) and the Miami Air Route Traffic Control Center (ARTCC) radar are required to support pad and offshore launches.

b. RAPCON and ARTCC shall survey for intruding aircraft within a 50 nautical mile radius of the launch point beginning no later than L-30 min and continue until released by the SCO.

c. Contacts shall be reported using the following criteria:

1. Speed
2. Heading
3. Bearing from a known reference point such as PAFB or Kennedy Space Center (KSC) Tactical Air Control and Navigation (TACAN)
4. Estimated time to clear the warning areas

7.9.3.2.2 WR Air Route Surveillance Radar.

a. The Air Route Surveillance Radar (ARSR) shall survey the offshore area from T-90 min until operation completion.

b. The ARSR shall survey the restricted airspace from T-15 min until operation completion.

7.9.3.2.3. ER Lighthouse Sea Surveillance Radar.

a. The ER lighthouse sea surveillance radar (radar 1.60) is required to survey for surface craft during pad launches.

b. Radar 1.60 shall provide coverage from L-120 min; L-180 min for STS.

7.9.3.2.4 ER FURUNO Radar.

a. The FURUNO (CONDO 8 radar) is required for sea surveillance during pad launches.

b. The FURUNO radar shall be available for SCO use beginning at L-120 min; L-180 min for STS.

7.9.3.3 Small, Solid Propellant Rockets and Inert Body Drop Test Impact or Drop Area Surveillance

For small, solid propellant rocket launches or inert body drop tests, the impact or drop area surveil-

lance shall normally be within a few miles of shore. In such cases, surveillance requirements of the impact area shall be specified in the applicable RSOR.

7.9.3.4 ER Launch Danger Zone Warning Requirements

7.9.3.4.1 Warning Signals.

a. Warning signals shall be displayed when the LDZ is closed at L-60 min.

b. The warning signals are large red spheres and red rotating beacons located at the North end, South end, and tip of Cape Canaveral Air Station (CCAS).

c. The spheres shall be raised for daylight launches, and the beacons shall be illuminated for both day and night launches.

7.9.3.4.2 Warning Signs. To warn vessels leaving the port, illuminated warning signs shall be posted in the following Port Canaveral areas:

a. Channel Leading to the Ocean

1. A 12 x 12 ft warning sign is required along the channel leading to the ocean at Port Canaveral.

2. The sign shall be equipped with strobe lights activated 1 h before the zone is closed.

3. The sign shall have the following or similar wording: *Warning: Flashing Lights Indicate Offshore Launch Danger Zone Closed to all Vessels.*

b. Barrier Gates West of the Canaveral Harbor Locks and Public Boat Ramps at the Port Canaveral Harbor at Jetty Park

1. Two aluminum signs are required on the barrier gates West of the Canaveral Harbor locks, one sign for each set of locks.

2. Three metal signs are required at the public boat ramps at the Port Canaveral Harbor at Jetty Park.

3. The signs described in 1 and 2 above shall have the following or similar wording: *Warning: A sea launch danger zone extending 50 miles from Cape Canaveral is established during launch operations. A US Air Force helicopter shall patrol this area to warn mariners in or approaching the danger zone. All vessels are requested to remain clear of this area. A large red sphere is hoisted and red rotating beacons are activated to indicate danger periods. These signals are located 1/2 mile North of the*

Southeast corner of Cape Canaveral. Additional white flashing beacons are located atop warning signs on North side of harbor channel. Periodic broadcasts defining specific danger zones are made by the US Coast Guard on VHF channel 16 every hour on the hour beginning 4 hours prior to launch.

7.9.3.5 Marine Radio Broadcast Warnings

Marine radio broadcast warnings shall be made to inform vessels of the effective closure times for the sea LDZ.

7.9.3.6 Notice to Airmen and Mariners

a. (ER Only) Flight Analysis shall provide 45 RANS with the areas hazardous to ships and aircraft for all normally jettisoned and impacting stages by F-10 days. **NOTE:** 45 RANS is responsible for disseminating the Notice to Airmen and Mariners (NOTAM) to aircraft and shipping interests

b. (WR Only) Flight Analysis shall provide RANS with the areas hazardous to ships and aircraft for all normally jettisoned and impacting stages by F-30 days.

7.9.3.7 Special Designated Control Areas

a. (ER Only) Control of air traffic in FAA designated areas around the ER launch head shall be maintained and coordinated between the SCO, ACO, and Miami ARTCC to ensure that aircraft shall not be endangered by launches, nor launches delayed by the presence of aircraft **NOTE:** Miami ARTCC shall be advised by the RCO to close W-497A for all weather rocket launches from CCAS.

b. (WR Only) Control of air traffic in FAA designated areas around the WR launch head shall be maintained and coordinated between the ACO and FAA to ensure that aircraft shall not be endangered by launches, nor launches delayed by the presence of aircraft.

7.9.3.8 Surveillance Control

a. Specific surveillance control requirements shall be specified in the appropriate RSOR.

b. (WR only) The ACO shall ensure that a plot of all surface contacts is maintained and provided to the MFCO via closed circuit television (CCTV).

7.9.3.9 United States Coast Guard Support

In accordance with applicable MOAs, the USCG shall assist in clearing the hazardous areas for launches.

7.10 RANGE SAFETY DISPLAY SYSTEM

7.10.1 Range Safety Display System General Requirements

a. The RSD is required as the primary information display system used by the MFCO to evaluate launch vehicle flight.

b. Flight Analysis shall provide RSD requirements, instructions, and data necessary for display generation to RANS or the Range Technical Services Contractor.

7.10.2 Additional ER RSD Display System Requirements

a. Prior to L-2 h, the "A" background tape shall be displayed.

b. No later than L-2 h, Flight Analysis shall notify the RCO of the applicable autoloading tape to be used in support of the mission.

c. A final RSD verification using theoretical data shall be completed by the MFCO no later than L-90 min in the countdown.

d. Recordings of the launch displays shall be made for post-operation review. **NOTE:** The capability to print color hard copies of selected displays during operations and for post-operations analysis is required.

7.10.3 Video Display Systems

7.10.3.1 Video Display Systems General Requirements

a. Video monitors with channel switching capability are required at the MFCO and SMFCO positions.

b. Specific video coverage requirements peculiar to a mission shall be identified in the RSOR for the vehicle or OpsSup for the mission.

7.10.3.2 Flight Line and Program Cameras

a. Videotape recordings of flight line (Back Azimuth) and Program camera presentations are required for all launches.

b. When used to support a launch, flight line (Back Azimuth) and Program cameras shall be operated in accordance with requirements identified in this Chapter.

c. Flight line (Back Azimuth) and Program cameras shall be located according to the **Skyscreen Site Locations** section of this Chapter.

d. Videotapes shall be retained for 45 days unless directed otherwise by Range Safety.

e. (WR only) Video recordings of Program, Back Azimuth, LA-24, Santa Ynez, and pad view (when scheduled by the Range User) with the safety net audio recorded from the MFCO consoles and 30 SW public address net are required from T-90 seconds until loss of signal.

f. The IRIG-B timing signal display will be located in the upper right corner of the video frame.

7.10.3.3 ER Surveillance Radar 1.60 Camera

a. A camera shall be located at Surveillance Radar 1.60 for display of the radar scope to the MFCO and SCO.

b. A separate monitor is required in the SCO area for presentation of the radar scope display.

7.10.3.4 ER Weather Forecast Monitor

The ability to monitor range weather forecasts shall be provided at the MFCO consoles by L-60 min and the SCO area by L-60 min.

7.10.3.5 Telemetry Display

Specific telemetry display requirements shall be listed in the RSOR.

7.11 FLIGHT CONTROL COMMUNICATION CIRCUITS

7.11.1 Flight Control Communication Circuit General Requirements

The Flight Control communication circuits shall be specified in the applicable RSOR.

7.11.2 Checkout and Operation of Communication Networks

All communication networks required in an RSOR or OpsSup shall be checked out and operational prior to the scheduled time for FTS destruct checks or L-2 h, whichever is earliest in the countdown.

a. MFCO communications shall be recorded for all launches.

b. A voice operated relay may be used for recording voice data between the time the circuit checkout is completed and L-10 min.

c. A continuous recording shall be made from L-10 min to the termination of Flight Control operations.

d. Recordings shall be filed for a minimum of 45 days unless directed otherwise by Range Safety.

e. The appropriate security classification guide shall be followed prior to the release of information.

7.12 MISSION FLIGHT CONTROL TRAINING REQUIREMENTS

a. In accordance with applicable ER and WR directives, Mission Flight Control Training shall be conducted.

b. All displays used for training shall operate at full speed.

APPENDIX 7A

RANGE SAFETY LAUNCH COMMIT CRITERIA

7A.1 INTRODUCTION

Range Safety launch commit criteria (RSLCC) are those criteria associated with launch day parameters that must be met prior to final SE approval for launch. These criteria ensure public, launch site, and launch complex safety. They include launch vehicle, range, and environmental factors.

7A.1.1 Purpose

This appendix provides Range Users with general, and, where possible, specific information regarding RSLCC. Knowledge of this criteria may help Range Users to better understand and plan for potential Range Safety holds or scrubs as a result of related violations during the launch countdown.

7A.1.2 Content

Descriptions of each RSLCC are included in this appendix. Where possible, the exact criteria used during the countdown is provided. General criteria is provided for cases in which the criteria is too complex to address in this document and/or where the criteria is in a state of flux. Range Safety offices of primary responsibility (OPR) and referenced documents are provided as sources of additional information.

7A.1.3 Applicability

All RSLCC are not applicable to all launch vehicles. The applicability of each RSLCC is identified in the individual descriptions. Additional specific RSLCC may be provided as part of the RSOR for each individual mission.

7A.2 RANGE SAFETY LAUNCH COMMIT CRITERIA

7A.2.1 Range Safety Systems

Range Safety Systems are those ground and air-borne systems required to monitor, track, aid decision making, and, if necessary, destroy errant launch vehicles in flight.

7A.2.1.1 Ground Range Safety Systems

7A.2.1.1.1 General Description. Ground Range Safety Systems include such systems as the command destruct system (CDS), RTS, TDTS, RSD, real time processing (RTP) system, and all other

associated ground-based systems necessary to monitor, track, aid decision making, and destroy an errant launch vehicle.

7A.2.1.1.2 Applicability. All launch vehicle missions using a command FTS require certain ground range safety system assets to be operational prior to launch. The launch vehicle configuration, flight azimuth, and other factors drive the selection of necessary ground safety system assets.

7A.2.1.1.3 Ground Range Safety System Launch Commit Criteria.

a. Range tracking systems include radar, optics, telemetry inertial guidance downlink, S-Band tracking, and global positioning system based downlinks.

1. Two adequate and independent tracking sources shall be available throughout powered flight.

(a) *Adequate* is defined by error statistics for each source.

(b) *Independent* is defined as having no common components or systems between the vehicle and the front-end computers in the Range Operations Control Center (ROCC).

2. Tracking sources shall be tested prior to launch to ensure requirements for accuracy and data integrity such as good communication with the ROCC.

b. The CDS has dual transmitter sites connected to central command in the ROCC. The system is capable of operation in both secure and non-secure modes.

1. A dual command site (two transmitters connected by an automatic failover control system) and two command data links shall be available throughout powered flight.

2. Using test codes, closed loop testing shall be performed between command central and each site prior to launch to ensure proper performance of the system.

3. Using flight codes, closed loop testing shall be performed between command central and the Launch Area command site prior to launch to ensure code integrity.

4. Using test codes, open loop testing shall

APPENDIX 7A

RANGE SAFETY LAUNCH COMMIT CRITERIA

be performed between command central, via the Launch Area command site, to the launch vehicle performed prior to launch to ensure total system integrity.

5. System testing shall include the use of both the FTU and the Range Safety control and display (RASCAD) console.

6. Using test codes, open loop testing shall be performed between command central, via each command site, to the command destruct independent test sets (CDITS) prior to launch to quantitatively verify proper message, code, and radio frequency parameters.

c. Computer and data communications systems, including RTP and RSD, collect and process data from the tracking sources. They calculate vehicle state vector information and predict the vacuum impact point of a vehicle in real time. In addition, these systems are used to point command destruct antennas at the vehicle and provide the MFCO with graphic displays of vehicle position, velocity, and impact point overlaid on a geographic representation of the flight.

1. Using end-to-end playback of theoretical data, the proper function of all computer and data communication systems shall be verified prior to launch.

2. The data processing and display (RTP and RSD) systems and their associated peripheral support equipment are configured in two independent strings connected with an automatic failover system. Both strings shall function correctly prior to allowing a vehicle to launch.

7A.2.1.1.4 Offices of Primary Responsibility. 30 SW/SEO and 45 SW/SEO are the OPRs for determining ground safety systems launch commit criteria.

7A.2.1.1.5 Reference Documents. Vehicle specific ground safety systems launch commit criteria shall be documented in the RSOR. Mission specific modifications to the RSOR are published for each operation in the OpsSup.

7A.2.1.2 Airborne Range Safety Systems

7A.2.1.2.1 General Description. Airborne Range Safety Systems include the FTS and the airborne RTS.

7A.2.1.2.2 Applicability. An airborne FTS is required for all powered flight stages of a launch vehicle in accordance with Chapter 2 of this document. The need for an airborne FTS for all upper stages, payloads, and/or spacecraft capable of powered flight is determined as part of the flight plan approval process addressed in Chapter 2. An RTS is required for all launch vehicles per Chapter 2.

7A.2.1.2.3 Airborne Range Safety System Launch Commit Criteria.

a. The Operations Safety Console (OSC) (ER) and the Flight Safety Project Officer Console (FSPOC) (WR) shall be used to monitor the status of the airborne FTS prior to launch.

1. Final open-loop testing of the airborne FTS just prior to launch shall be satisfactory.

2. All components of the airborne FTS shall be operating within expected limits prior to launch.

3. The FTS shall be armed prior to launch.

b. The frequency control and analysis van and radar installations are used to monitor the status of the airborne RTS. The airborne RTS shall be operating within expected limits prior to launch.

c. A launch hold or launch scrub shall be implemented if the above criteria are not met.

7A.2.1.2.4 Offices of Primary Responsibility.

a. 30 SW/SES and 45 SW/SES are the OPRs for airborne FTS launch commit criteria.

b. 30 SW/SEO and 45 SW/SEO are the OPRs for airborne RTS launch commit criteria.

7A.2.1.2.5 Reference Documents.

a. Operating characteristics of the OSC and FSPOC are required as part of airborne Range Safety System Report (RSSR) in accordance with Appendix 4A of this document.

b. Vehicle specific airborne RTS launch commit criteria shall be documented in the RSOR. Mission-specific modifications to the RSOR shall be published in the OpsSup for each operation.

7A.2.2 Blast

7A.2.2.1 General Description

The Blast Damage Assessment model addresses intermediate hazardous range effects of a shock

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wave from an inadvertent detonation, such as from a launch vehicle malfunction, impact, or destruction. Near-in areas of overpressure above one pound per psi are evacuated of personnel and are not considered in the assessment. At far-out distances, with overpressures of less than 0.1 psi, there are relatively small hazards. It is the intermediate distance with overpressures of 0.1 to 0.5 psi that are of concern. The area encompassing overpressures in this range varies considerably with local meteorological conditions.

7A.2.2.2 Applicability

This launch commit criteria is generally applicable to large launch vehicles with large amounts of propellants, solid rocket motor launch vehicles with high energy propellants, and launch vehicles using launch complexes near the borders of general population.

7A.2.2.3 Blast Launch Commit Criteria

If the expected casualties of a potential blast overpressure exceed those limits defined in Chapter 1 of this document, a launch hold or launch scrub shall be implemented.

7A.2.2.4 Offices of Primary Responsibility

30 SW/SEY and 45 SW/SESE are the OPRs for launch commit criteria associated with the BlastC model; 45 SW/SESE is the OPR for launch commit criteria associated with the BlastX (tailored version of BlastC) model.

7A.2.2.5 Reference Documents

Mission-specific blast launch commit criteria shall be addressed in the RSOR.

7A.2.3 Collision Avoidance

7A.2.3.1 General Description

A collision avoidance (COLA) analysis is used in the minus count to protect manned orbiting objects from collision with a launch vehicle or its jettisoned components.

7A.2.3.2 Applicability

All launch vehicles with the potential to collide with manned orbiting objects shall meet the following criteria:

7A.2.3.3 Collision Avoidance Launch Commit Criteria

a. The COLA program computes the closest approach between the launch vehicle and an orbiting object based on a miss distance screening criteria of 200 km for manned objects.

b. A COLA (no launch) closure time period is calculated for the defined miss distance for any object approaching within distances less than the above criteria.

c. A COLA closure time period shall result in a launch hold for that time period. A launch scrub occurs only if the closure time period conflicts with any remaining T-0 for the mission launch window.

7A.2.3.4 Offices of Primary Responsibility

30 SW/SEY and 45 SW/SEO are the OPRs for determining COLA launch commit criteria.

7A.2.3.5 Reference Documents

a. Chapter 2 of this document provides more insight into the COLA process.

b. Mission-specific COLA criteria shall be documented in the COLA Requirements letter by 45 SW/SEO and 30 SW/SEY.

7A.2.4 Launch Winds and Debris Hazard

7A.2.4.1 Launch Winds (ER Only)

A Range Safety wind check (RSWC) program is used to compare forecasted T-0 winds and actual winds with statistical wind data and their effects on potential launch vehicle debris impacts.

7A.2.4.1.1 Applicability. All launch vehicles with potentially hazardous launch vehicle debris are subject to this launch commit criteria.

7A.2.4.1.2 Day of Launch Winds Commit Criteria. If forecasted T-0 winds cause potential launch vehicle debris dispersions to exceed acceptable statistical wind dispersion limits, a launch hold or launch scrub shall be implemented.

7A.2.4.1.3 Offices of Primary Responsibility. 30 SW/SEY and 45 SW/SEO are OPR for day of launch wind commit criteria.

7A.2.4.1.4 Reference Documents.

a. At the ER, the requirements shall be listed in the Range Safety Wind letter in accordance with

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Chapter 2, of this document.

b. At the WR, weather requirements and associated safety analyses shall be listed in the RSOR.

7A.2.4.2 Debris Hazard (WR Only)

At the WR, the Launch Risk Analysis (LARA) program is used to compute the estimate of casualty to personnel supporting the operation and to the general public due to debris from a vehicle destroyed during flight. The LARA program incorporates the latest available atmospheric data as well as vehicle breakup, malfunction turn, trajectory, and failure rate data.

7A.2.4.2.1 Applicability. In general, the launch commit criteria is applicable to all launch vehicles using an FTS and/or active guidance systems. Some larger rail-launched or unguided vehicles may also be affected.

7A.2.4.2.2 Debris Hazard Launch Commit Criteria. If the expected casualties exceed those limits defined in Chapter 1 of this document, a launch hold or launch scrub shall be implemented.

7A.2.4.2.3 Office of Primary Responsibility. 30 SW/SEY is OPR for debris hazard commit criteria.

7A.2.4.2.4 Reference Documents.

a. Data requirements are specified in Chapter 2 of this document.

b. Weather requirements are specified in the RSOR.

7A.2.5 Natural and Triggered Lightning

7A.2.5.1 General Description

Both natural and triggered lightning can cause launch vehicle malfunction and/or destruction. Triggered lightning is the phenomena associated with launch vehicles affecting the atmosphere during flight so that, under certain meteorological conditions, lightning is triggered and attracted to the launch vehicle.

7A.2.5.2 Definitions and Explanations

anvil - stratiform or fibrous cloud produced by the upper level outflow or blow-off from thunderstorms or convective clouds

cloud edge - the visible cloud edge is preferred. If this is not possible, then the 10 dBz radar cloud

edge is acceptable.

cloud layer - an array of clouds, not necessarily all of the same type, whose bases are approximately at the same level. Also, multiple arrays of clouds at different altitudes that are connected vertically by cloud elements; for example, turrets from one cloud array to another. Convective clouds (those clouds falling under **7A.2.5.4 b**) are excluded from this definition unless they are embedded with other cloud types.

cloud top - the visible cloud top is preferred. If this is not possible, then the 13 dBz radar cloud top is acceptable.

cumulonimbus cloud - any convective cloud with any part above the -20.0° temperature level.

debris cloud - any non-transparent cloud that has become detached from a parent cumulonimbus cloud or thunderstorm or results from the decay of a parent cumulonimbus cloud or thunderstorm.

documented - with respect to *EXCEPTION (2)* in paragraph **7A.2.5.4 c**, *documented* means sufficient data has been gathered on the benign phenomena to both understand it and to develop procedures to evaluate it; and the supporting data and evaluation have been reported in a technical report or equivalent publication. For launches at the ER, copies of documentation shall be maintained by the 45th Weather Squadron and the KSC Weather Projects Office. The procedures used to assess the phenomena during launch countdowns shall be documented and implemented by the 45th Weather Squadron.

electric fields (for surface-based electric field mill measurements) - the one minute arithmetic average of the vertical electric field (Ez) at the ground, such as measured by a ground-based field mill. The polarity of the electric field is the same as that of the charge overhead; that is, the polarity of the field at the ground is the same as that of the charge overhead.

flight path - the planned flight trajectory including its uncertainties (error bounds).

precipitating cloud - any cloud containing precipitation, producing virga, or having radar reflectivity.

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tivity greater than 13 dBz.

thunderstorm - any cloud that produces lightning.

transparent - synonymous with *visually transparent*. Sky cover through which higher clouds, blue sky, stars, and other items may be clearly observed from below. Also, sky cover through which terrain, buildings, and other items may be clearly observed from above. Sky cover through which forms are blurred, indistinct, or obscured is not transparent.

7A.2.5.3 Applicability

All launch vehicles are subject to this launch commit criteria, with exceptions as noted.

7A.2.5.4 Natural and Triggered Lightning Launch Commit Criteria

The constraints listed below are for the avoidance of natural or triggered lightning, based on known cloud types that can produce discharges and the distances to the charge regions. Even when constraints are not violated, if any other hazardous conditions exist, the Launch Weather Officer (LWO) will report the threat to the Launch Director (LD). The LD may initiate a launch hold at any time based on the instability of the weather. The LWO must have clear and convincing evidence the following constraints are not violated:

a. A launch shall not occur if any type of lightning is detected within 10 nautical miles (nm) of the flight path within 30 min prior to launch, unless the meteorological condition that produced the lightning has moved more than 10 nm away from the flight path.

b. A launch shall not occur if the flight path will carry the launch vehicle:

1. Through a cumulus cloud with its top between the $+5.0^{\circ}\text{C}$ and -5.0°C levels. **EXCEPTION:** *(a) The cloud is not producing precipitation*

and

(b) the horizontal distance from the furthest edge of the cloud top to at least one working field mill is less than the altitude of the -5.0°C level or 3 nm whichever is smaller;

and

(c) all field mill readings within 5 nm of the flight path are between -100 volts (V) per meter (m) and +1000V/m for the preceding 15 min.

2. Through cumulus clouds with tops higher than the -5.0°C level.

3. Through or within 5 nm (horizontal or vertical) of the nearest edge of cumulus clouds with tops higher than the -10.0°C level.

4. Through or within 10 nm (horizontal or vertical) of the nearest edge of any cumulonimbus or thunderstorm cloud, including non-transparent parts of its anvil.

5. Through or within 10 nm (horizontal or vertical) of the nearest edge of a non-transparent detached anvil for the first hour after detachment from the parent thunderstorm or cumulonimbus cloud. **NOTE:** Cumulus does not include altocumulus or stratocumulus.

c. A launch shall not occur if, for Ranges equipped with a working surface electric field mill network, at any time during the 15 min prior to launch time the one-minute average of the absolute electric field intensity at the ground is greater than 1000 V/m within 5 nm of the flight path. **EXCEPTION:** *(1) There are no clouds with-in 10 nm of the flight path except transparent clouds OR clouds with tops below the $+5.0^{\circ}\text{C}$ level that have not been associated with convective clouds with tops above the -10.0°C level within the last three hours;*

and

(2) a known source of electric field, such as ground fog, smoke, or sunrise effect that is occurring near the sensor, and that has been previously determined and documented to be benign, is clearly causing the elevated readings. NOTE: For confirmed failure of the surface field mill system, the countdown and launch may continue since other lightning launch commit criteria completely describe unsafe meteorological conditions.

d. A launch shall not occur if the flight path is through a vertically continuous layer of clouds with an overall depth of 4,500 ft or greater where any part of the clouds is located between the 0.0°C and -20°C levels.

e. A launch shall not occur if the flight path is through any clouds that extend to altitudes at or above the 0.0°C level and are associated with disturbed weather that is producing moderate (29 dBz) or greater precipitation within 5 nm of the flight path.

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f. A launch shall not occur if the flight path will carry the vehicle:

1. Through any non-transparent thunderstorm or cumulonimbus debris cloud during the first three hours after the debris cloud formed from the parent cloud.

2. Within 5 nm (horizontal or vertical) of the nearest edge of a non-transparent thunderstorm or cumulonimbus debris cloud during the first three hours after the debris cloud formed from a parent cloud. *EXCEPTION: (a) There is at least one working field mill within 5 nm of the debris cloud and*

(b) all electric field intensity measurements at the ground are between +1000 V/m and -1000 V/m within 5 nm of the flight path during 15 min preceding the launch time;

and

(c) the maximum radar return from the entire debris cloud is less than 10 dBz during the 15 min preceding launch time.

3. The start of the three-hour period is determined as follows:

a) *Detachment.* If the cloud detaches from the parent cloud, the three-hour period begins at the time when cloud detachment is observed or at any time of the last detected lightning discharge (if any) from the detached debris cloud, whichever is later.

b) *Decay Or Detachment Uncertain.* If it is not known whether the cloud is detached or the debris cloud forms from the decay of the parent cloud, the three-hour period begins at the time when the parent cloud top decays to below the altitude of the -10.0°C level, or at the time of the last detected lightning discharge (if any) from the parent cloud or debris cloud, whichever is later.

g. A launch vehicle that has not been treated for surface electrification shall not be launched if the planned flight path will go through clouds from the -10.0°C level, upward to the altitude at which the launch vehicle velocity exceeds 3000 ft/sec. **NOTE 1:** A launch vehicle is considered *treated* for surface electrification if all surfaces of the launch vehicle susceptible to precipitation particle

impact have been treated to ensure the surface resistivity is less than 10^9 ohms/square AND all conductors on surfaces, including dielectric surfaces that have been treated with conductive coatings, are bonded to the vehicle structure by a resistance that is less than 10^5 ohms. **NOTE 2:** The correct unit for surface resistivity is ohms/square. This means that any square area of any size measured in any units has the same resistance in ohms when the measurement is made from an electrode extending the length of one side of the square to an electrode extending the length of the opposite side of the square. The area-independence is literally valid only for squares; it is not true for other shapes such as rectangles and circles.

7A.2.5.5 Electrical Charge Regions

Electrical charge regions can occur in clouds with altitudes at or above the 0°C isotherm. These regions can produce lighting discharges triggered by the proximity of long electrical conductors (launch vehicle plus conductive port on the plume)

7A.2.5.6 Offices of Primary Responsibility

30 SW/SEY and 45 SW/SESE along with 30 WS and 45 WS are the OPRs for natural and triggered lightning launch commit criteria.

7A.2.5.7 Reference Documents

Additional or different mission specific natural and triggered lightning launch commit criteria shall be documented in the RSOR.

7A.2.6 Toxics

7A.2.6.1 General Description

A variety of predictive models and analytical techniques are used to ensure that the public and launch area personnel are not exposed to toxic chemicals in concentrations that exceed applicable threshold limits. Key considerations include, but are not limited to, the specific commodities loaded and their quantity; potential agents resulting from mixing and/or reactions; nature or mechanism of release; and weather parameters such as wind speed, wind direction, temperature, temperature gradient, inversion layer, surface re-

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flection coefficient, exposure response functions, and cloud cover as well as the uncertainty of these parameters.

7A.2.6.2 Applicability

All launch vehicles, including payloads, with potentially hazardous chemicals are subject to this toxic launch commit criteria.

7A.2.6.3 Toxic Launch Commit Criteria

The acceptable limits for various commodities are governed by a number of standards, statutes, and specifications. These standards, statutes, and specifications are subject to frequent revision based on controlled studies, real-world events, and other discoveries. Additionally, commodity loads also vary among launch vehicle classes and there are differences between variants within the same class. For these reasons and because of the evolving nature of predictive models used, a general toxic launch commit criteria cannot be stated. For guidance about a specific commodity or set of commodities in the case of a particular launch vehicle, contact the 45 SW Office of Safety, Missile Systems Division, Large Vehicles Section (45 SW/SESL). At the WR, the 30 SWI 91-106 defines the exposure criteria, unit support requirements, actions required for cold spill potential Hazard Zones as well as other requirements.

7A.2.6.4 Offices of Primary Responsibility

30 SW/SEY and 45 SW/SESL are the OPRs for toxic launch commit criteria.

7A.2.6.5 Reference Documents

Mission-specific toxic launch commit criteria shall be addressed in the RSOR.

7A.2.7 Safety Clearance Zones

Safety Clearance Zones are restricted areas designated for day-to-day prelaunch processing and launch operations to protect the public, launch area, and launch complex personnel. These zones are established for each launch vehicle and/or payload at specific processing facilities to include launch complexes. Safety Clearance Zones include Hazardous Clear Areas and Hazardous Launch Areas.

7A.2.7.1 Hazardous Clear Areas

7A.2.7.1.1 General Description. Hazardous Clear Areas are Safety Clearance Zones for ground processing that are defined in the Operations Safety Plan for each operating facility. Hazardous Clear Areas include Blast Danger Areas (BDA), Control Area Clears, and Toxic Hazard Corridor (THC) (ER) and Toxic Hazard Zone (WR).

7A.2.7.1.2 Applicability. All launch vehicles and, if necessary, associated payloads shall be evaluated and hazardous clear areas determined.

7A.2.7.1.3 Hazardous Clear Areas Launch Commit Criteria.

a. Blast Danger Area: Clearance prior to establishment of a major explosive hazard such as vehicle fuel/oxidizer load and pressurization. This is the area subject to fragment and direct overpressure resulting from the explosion of the booster/payload.

b. Control Area Clears: Clearance of defined areas to protect personnel from hazardous operations

c. Toxic Hazard Corridor/Zone: Clearance area of a sector in which toxic material may exceed predetermined concentration levels

7A.2.7.2 Hazardous Launch Areas

7A.2.7.2.1 General Description. Hazardous Launch Areas are Safety Clearance Zones used during launch operations and include the FCA, FHA, the Vessel Exclusion Area (VEA) and the Impact Limit Lines (ILLs).

7A.2.7.2.2 Applicability. All launch vehicles and, if necessary, associated payloads, shall be evaluated and hazardous launch areas determined.

7A.2.7.2.3 Hazardous Launch Area Launch Commit Criteria.

a. FHA. Only mission-essential personnel in approved blast-hardened structures with adequate breathing protection are permitted in this area during a launch.

b. FCA. Only mission-essential personnel

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with adequate breathing protection are permitted in this area during launch.

c. VEA. Ships and aircraft shall remain outside this area during launch.

d. ILL. Mission-essential and Wing-essential personnel are permitted within ILLs during a launch. Non-essential personnel, with Wing Commander approval, may be permitted in this area during a launch; however, the collective risk shall not exceed acceptable standards for non-essential personnel.

7A.2.8 LAUNCH AREA AIR AND SEA SURVEILLANCE

7A.2.8 Launch Area Air and Sea Surveillance

7A.2.8.1 General Description

Areas to be cleared of boats and ships are defined by Flight Analysis and based on probability contours and/or Toxic Hazard Zones, including known impact areas of jettisoned stages/bodies and destruct debris resulting from malfunction scenarios plus the areas and altitudes in which Toxic Hazards will exist. Areas defined by NOTAM are surveilled on launch day for intruder aircraft and are analyzed as a potential for risk to the launch vehicle or the aircraft.

7A.2.8.2 Applicability

These criteria are applicable to all CCAS/KSC pad launch vehicles and select offshore Navy launches and all 30 SW launch operations.

7A.2.8.3 Launch Area Air and Sea Surveillance Launch Commit Criteria

7A.2.8.3.1 Boat and Ship Traffic.

a. At the ER, if the sum total of the individual hit probabilities of all targets plotted within, or predicted to be within, the established probability contours exceed 10^{-5} , a launch hold or scrub may be initiated.

b. At the WR, if an individual vessel is exposed to a probability of impact greater than 10^{-5} , the vessel shall be moved or a launch hold or scrub may be initiated.

7A.2.8.3.2 Aircraft. For an aircraft posing a threat to itself or the launch vehicle by its expected position being within predetermined hazard corridors, launch hold or scrub may result until the aircraft clears the hazard corridor.

7A.2.8.4 Offices of Primary Responsibility

At the ER, 45 SW/SEO is the OPR for launch area air and sea surveillance. At the WR, the ACO is the OPR for launch area air and sea surveillance; however, 30 SW/SEY performs the analysis for the hazard areas and the boat box.

7A.2.9 JETTISONED BODIES IMPACTING LAND IN LAUNCH AREA

7A.2.9.1 General Description

EWB 127-1 prohibits the impact of jettisoned components on any land mass. For certain launch vehicles, the possibility exists for jettisoned bodies such as nozzle closures to impact in the launch area near occupied facilities or resources requiring protection. This is allowed in these cases when the risks associated are mitigated or minimized. Hit probability contours are created and used in conjunction with launch day impact prediction runs to determine possible threat near the predicted impact location.

7A.2.9.2 Applicability

All vehicles jettisoning components in the launch area with the potential to impact land.

7A.2.9.3 Jettisoned Bodies Launch Commit Criteria

Launch day impact prediction runs are made and the associated probability contours or impact dispersions are overlaid with the launch areas. A launch hazard may result in a launch hold or scrub condition.

7A.2.9.4 Offices of Primary Responsibility

30 SW/SEY and 45 SW/SEO are the OPRs for jettisoned bodies impacting land.

APPENDIX 3A

MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE

3A.1 INTRODUCTION

3A.1.1 Purpose

The Missile System Prelaunch Safety Package (MSPSP) provides a detailed description of hazardous and safety critical ground support and flight hardware equipment, systems, and materials and their interfaces used in the launch of launch vehicles and payloads. It is one of the media through which missile system prelaunch safety approval is obtained.

3A.1.2 Content

This Appendix contains the content preparation instructions for the data generated by the requirements specified in Chapter 3.

3A.1.3 Applicability

The requirements in this Appendix are applicable to all launch vehicle, payloads, and ground support equipment contracts and facilities contracts, as necessary.

3A.1.4 Submittal Process

An MSPSP shall be submitted to Range Safety by the Range User with overall responsibility for the launch vehicle, payload, or ground support equipment. However, for commercial payloads, the payload MSPSP is normally submitted to Range Safety through the launch vehicle contractor.

3A.1.5 Final Approval

A final MSPSP that satisfies all Range Safety concerns addressed at the CDR shall be submitted to Range Safety at least 45 calendar days prior to the intended shipment of hardware to the Range.

3A.2 PREPARATION INSTRUCTIONS

3A.2.1 Content

a. The MSPSP contains technical information concerning hazardous and safety critical equipment, systems, and materials and their interfaces used in the launch of launch vehicles and payloads. Where applicable, previously approved documentation shall be referenced throughout the package.

b. The MSPSP is a detailed description of the design, test, and inspection requirements for all ground support equipment and flight hardware and materials and their interfaces used in the launch of launch vehicles and payloads. **NOTE:** All sche-

matics, functional diagrams, and operational manuals shall have well defined, standard Institute of Electrical and Electronics Engineers (IEEE) or Military Specification (MIL-SPEC) terminology and symbols.

3A.2.2 Format

Range User format is acceptable provided the information described below is provided. Suggested formats are shown as applicable. The format presented in this Appendix provides two distinct sections: Flight Hardware Systems and Ground Support Equipment.

3A.2.2.1 Table of Contents and Glossary

The MSPSP shall contain a table of contents and a glossary.

3A.2.2.2 Introduction

The Introduction shall address the scope and purpose of the MSPSP.

3A.2.3 General Description

The General Description section provides an overview of the launch vehicle or payload as a prologue to the subsystem descriptions. The following information is included in this section:

- a.* Physical dimensions and weight
- b.* Nomenclature of major subsystems
- c.* Types of motors and propellants to be used
- d.* Sketches and/or photographs of the launch vehicle or payload
- e.* Synopsis of each hazardous and safety critical subsystem
- f.* A list of hazardous subsystems addressed in Chapter 3 of this Regulation that are not present in the launch vehicle or payload system

3A.2.4 Flight Hardware Subsystems

a. At a minimum, the Flight Hardware Subsystems Section shall include the following information and the specific data requirements listed in sections 3A.2.4.1 through 3A.2.4.13 below:

1. Subsystem overview
2. Nomenclature of major subsystems
3. Function of the subsystem
4. Types of motors and propellants to be used
5. Location of the subsystem
6. Operation of the subsystem
7. Subsystem design parameters

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8. Subsystem test requirements
9. Subsystem operating parameters
10. Summaries of any Range Safety required hazard analyses conducted
 - b.* Supporting data shall be included or summarized and referenced as appropriate with availability to Range Safety upon request.
 - c.* Tables, matrixes, and sketches are required for systems and component data. (See 3.A2.4.2.2 and 3.A.2.4.2.3 below for suggestions.)
 - d.* Required analyses, test plans, and test results may be included in the MSPSP as appendixes or submitted separately. At a minimum, analyses, test plans, and test reports shall be listed, referenced, and summarized in the MSPSP.

- e.* A list of all Range Safety approved noncompliances

3A.2.4.1 Flight Hardware Structures and Mechanisms

3A.2.4.1.1 Flight Hardware Structures and Mechanisms General Requirements. While there are no specific structure and mechanism design requirements for launch vehicles and payloads except for flight hardware used to lift critical loads in this Chapter, the following information concerning the main structures and mechanisms used on launch vehicles and payloads shall be included in the MSPSP:

- a.* Nomenclature of the structure or mechanism and deployables
- b.* Function of the structure or mechanism and deployables
- c.* Location of the structure or mechanism and deployables
- d.* Operation of the structure or mechanism and deployables
- e.* Structure or mechanism and deployables design parameters
- f.* Structure or mechanism and deployables test and operating parameters
- g.* Summaries of any Range Safety required hazard analyses conducted
- h.* Material properties of structures, mechanisms, and deployables.

3A.2.4.1.2 Flight Hardware Used in Lifting Critical Loads. At a minimum, the following documentation is required:

- a.* SFP analysis
- b.* NDE plan and test results for SFP components and SFP welds
- c.* Initial proof load test plan and test results
- d.* Stress analysis

3A.2.4.2 Flight Hardware Pressure, Propellant, and Propulsion Systems

3A.2.4.2.1 General Data. A detailed description of the pressure, propellant, and propulsion systems of the launch vehicle or payload shall be provided. The description shall include the following information:

- a.* Nomenclature of the system
- b.* Function of the system
- c.* Location of the system
- d.* Operation of the system
- e.* System design parameters
- f.* System test parameters
- g.* System operating parameters
- h.* Summaries of any Range Safety required hazard analyses conducted
 - i.* Material compatibility analysis
 - j.* Physical and chemical properties and general characteristics of the propellant, test fluid and gases
 - k.* For hazardous propellants, fluids and gases, the following shall be submitted:
 1. Specific health hazards such as toxicity and physiological effects
 2. TLV and MAC for 8-h day, five-day week of continuous exposure
 3. Emergency tolerance limits including length of time of exposure and authority for limits, (for example, Surgeon General, National Institute for Occupational Safety and Health (NIOSH), independent study)
 4. Maximum credible spill size including volume and surface area and supporting analyses
 5. Description of hazards other than toxicity such as flammability and reactivity
 6. Personal protective equipment to be used in handling and using the propellants when this equipment will be used during and operation, and the manufacturer, model number, and other identifying data

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7. Manufacturer, model number, specifications, operating limits, type of certification, and general description of vapor detecting equipment

8. Identification of material incompatibility problems in the event of a spill

9. Recommended methods and techniques for decontamination of areas affected by spills or vapor clouds and hazardous waste disposal procedures

3A.2.4.2.2 Flight Hardware Pressure, Propellant, and Propulsion System Data. The following information shall be submitted for all systems:

a. A schematic that presents the system in a clear and easily readable form with complete subsystems grouped and labeled accordingly. **NOTE:** Nomenclature of each element should be made adjacent to or in the vicinity of each element. The schematic or a corresponding data sheet shall provide the following information:

1. Identification (ID) of all pressure system components such as valves, regulator, tubes, hoses, vessels, and gauges using standard symbols. **NOTE:** A legend is recommended. The original mechanical drawings should be referenced.

2. Maximum operating pressure of all systems and subsystems at expected operating temperatures

3. Identification of expected source pressures and expected delivery pressures

4. All relief valve pressure settings and flow rates

5. System fluid and maximum expected temperature

6. Pressure ranges of all pressure transducers

7. Pressure settings of pressure regulators

8. Charging pressure of reservoirs and vessels, their nominal capacities, and wall thickness

9. Pressure setting of all pressure switches

10. The nominal outside diameter and wall thickness of all tubing and piping

11. Flow path through all components. **NOTE:** When the system is to be used in several operating modes, it is easier to provide a separate schematic that depicts flow paths for each operating mode.

12. Reference designations for each component so that a cross-reference between schematics and drawings and a pressure system component list or other documentation is possible

13. End-to-end electrical schematics of electrical and electronic components giving full functional data and current loads

14. Connections for testing or servicing

15. A narrative description of the system or subsystem and its operating modes, including a discussion of operational hazards and accessibility of components

16. A sketch or drawing of the system that shows physical layout and dimensions

17. System information shall be placed in tabular form. **NOTE:** Suggested format is shown below.

Systems

System ID Number	Number of Vessels
System Title	Recertification Date
Location	Recertification Period
MOP	Material(s)
Commodity	Inspection Results
Responsible Organization	ISI Requirements

3A.2.4.2.3 Flight Hardware Pressure, Propellant, and Propulsion Component Design Data. The following information shall be submitted for each component:

a. Identification of each component by a reference designation permitting cross reference with the system schematic

b. The MAWP for all pressure system components

c. The MOP component shall operate at when installed in the system

d. Safety factors or design burst pressure for all pressure system components

e. Actual burst pressures, if available

f. Pre-assembly hydrostatic test proof pressure for each system component

g. If applicable, the proof pressure the component will be tested to after installation in the system

h. Materials used in the fabrication of each element in the component, including soft goods and other internal elements

i. Cycle limits if fatigue is a factor of the component

j. Temperature limits of each system component

k. Component information shall be placed in tabular form. **NOTE:** Suggested format is shown below.

Vessels

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MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE

Vessel ID Number	Recertification MAWP
System ID Number	Recertification Date
Manufacturer Name	Recertification Period
Manufacturer Serial No.	Cyclic Limit
Manufacturer Drawing No.	Test Pressure
Commodity	Vessel Design
Orig. MAWP or Design Pressure	Material
Burst Pressure	Temperature Limits
Volume	Maximum Stress
Location	Inside Radius
DOT Specification	Thickness
Year of Manufacture	Dimensions
National Board No.	ISI Information
Code Stamps	ISI Results

Relief Devices

ID Number	Set or Burst Pressure
System Number	System MOP
Type	System Commodity
Manufacturer	Flow Capacity
Manufacturer Part No.	Material
Code Stamps	Temperature Limits
Inlet Size	Test Pressure
Manufacturer Date	ISI Requirements
Outlet Size	ISI Results

Pressure Gauges and Sensors

ID Number	System Commodity
System Number	MAWP
Manufacturer	Burst Pressure
Manufacturer Date	System MOP
Manufacturer Part No.	Inlet Size
Pressure Range	ISI Requirements
Material	ISI Results

Flex Hoses

ID Number	Size (diameter, length)
System Number	Burst Pressure
Manufacturer	Cyclic Limit
Manufacturer Part No.	Test Pressure
Manufacturer Date	Shelf Life
Materials	ISI Requirements
Temperature Limits	ISI Results
MAWP/Manufacturer Rated Working Pressure	

3A.2.4.2.4 Flight Hardware Pressure, Propellant, and Propulsion Initial Test Plans and Procedures. A list and summary of all initial test plans,

test procedures, and test results for all flight hardware pneumatic, hydraulic, hypergolic, and cryogenic systems, as applicable in accordance with section 3.12 of this Chapter

3A.2.4.3 Flight Hardware Electrical and Electronic Subsystems

3A.2.4.3.1 General Data. A detailed description of the electrical and electronic subsystems of the launch vehicle or payload shall be provided. The description shall include the following information:

- a. Nomenclature of the system
- b. Function of the system
- c. Location of the system
- d. Operation of the system
- e. System design parameters
- f. System test parameters
- g. System operating parameters
- h. Summaries of any Range Safety required

hazard analyses conducted

3A.2.4.3.2 Flight Hardware Battery Design Data. The following information shall be submitted for flight hardware batteries:

- a. Design versus actual operating parameters of cells and battery
- b. Cell chemistry and physical construction
- c. Cell vent parameters
- d. Toxic chemical emission of cells and evaluation of hazards
- e. EPA classification of battery
- f. DOT classification of battery
- g. Physical and electrical integration of cells to form the battery
- h. Description of safety devices
- i. Case design including vent operation and cell and battery case housing yield point
- j. A description of all operations to include packing, transportation, and storage configuration; activation; installation; checkout; charging; usage; removal; and disposal
- k. Identification of the hazards associated with each activity in *j* above and the safety controls that shall be in effect
- l. Manufacturing qualification and acceptance testing results that are considered safety critical
- m. Battery size and weight
- n. Specification of the system that uses the battery
- o. A description of the EGSE used for packing, transportation, and storage; activation; installation;

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checkout; charging; usage; removal; and disposal of the battery

p. A list and summary of test plans, test procedures, and test results in accordance with the **Test Requirements for Lithium Batteries** section of this Chapter.

3A.2.4.3.3 Flight Hardware Electrical and Electronic Subsystem Data. The following information shall be submitted for electrical and electronic subsystems operating in hazardous atmospheres:

a. A brief description of power sources and the power distribution network, including schematics and line drawings of the distribution network

b. A description of how faults in electrical circuitry are prevented from propagating into hazardous subsystems, including such information as dedicated power sources and buses, use of fuses, and wiring sizing

c. A description of how inadvertent commands that can cause a hazardous condition are prevented

d. Identification of potential shock hazards

e. A description of how the intent of hazard proofing is met for electrical and electronic systems

f. Complete grounding and bonding methodology

g. A bent pin analysis for all connectors for safety critical or hazardous systems that have spare pins

3A.2.4.4 Flight Hardware Ordnance Subsystems

3A.2.4.4.1 General Data. A detailed description of the ordnance subsystems of the launch vehicle or space craft shall be provided. The description shall include the following information:

a. Nomenclature of system

b. Function of the system

c. Location of the system

d. Operation of the system

e. System design parameters

f. System test parameters

g. System operating parameters

h. Summaries of any Range Safety required hazard analyses conducted

3A.2.4.4.2 Flight Hardware Ordnance Hazard Classifications and Categories. The following ordnance hazard classification data shall be submitted:

a. DOD/UN hazard classifications, including class, division, and compatibility group, in accordance with DOD-STD-6055.9.

b. DOT classification

c. The 45 Space Wing ordnance device and system hazard category for each ordnance item and system; test results and/or analysis used to classify the ordnance devices and systems as Category A or B

3A.2.4.4.3 Flight Hardware Ordnance System Data. The following ordnance system data shall be submitted:

a. A block diagram of the entire ordnance system

b. A complete line schematic of the entire ordnance system from the power source to the receptor ordnance, including telemetry pick-off points and ground (umbilical) interfaces

c. Diagrams showing the location of all ordnance components on the vehicle

d. A description of wiring, ETS, and FOC routing

e. A description of electrical, ETS, and optical connections and connectors

f. Detailed, complete schematics of the entire ordnance system showing component values such as resistance and capacitance, tolerances, shields, grounds, connectors, and pin outs. **NOTE 1:** The schematics shall include all other vehicle components and elements that interface or share common usage with the ordnance system. **NOTE 2:** All pin assignments shall be accounted for.

g. Detailed narrative description of the operation of the ordnance system, including all possible scenarios

h. The FMECA for each ordnance system

i. An operational flow of the ordnance system processing and checkout, including timelines and summaries of each procedure to be used

j. A sketch showing the accessibility of manual arming and safing devices

k. Specification drawings and documents for all airborne and ground ordnance systems

3A.2.4.4.4 Ordnance Component Design Data. The following ordnance component design data shall be submitted:

a. A complete and detailed description of each ordnance system component and how it functions

b. Specification drawings and documents for all airborne and ground ordnance components

c. Illustrated breakdown of all mechanically operated ordnance components

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- d.* Part number, manufacturer, and net explosive weight for each ordnance item
- e.* Temperature and humidity requirements for each ordnance item
- f.* Bridgewire resistance, maximum safe no-fire current, and minimum all-fire current for each low voltage EED
- g.* Maximum no-fire voltage and minimum all-fire voltage for each EBW
- h.* Maximum no-fire energy and minimum all-fire energy for each LID and PAD
- i.* A list and summary of test plans procedures, and results, as required

3A.2.4.5 Flight Hardware Non-Ionizing Radiation Sources

3A.2.4.5.1 General Data. A detailed description of the non-ionizing radiation sources shall be provided. The description shall include the following information:

- a.* Nomenclature of the system
- b.* Function of the system
- c.* Location of the system
- d.* Operation of the system
- e.* System design parameters
- f.* System test parameters
- g.* System operating parameters
- h.* Summaries of any Range Safety required hazard analyses conducted

3A.2.4.5.2 RF Emitter Data. The following information shall be submitted for RF emitters:

- a.* Site plans shall be submitted to Range Safety and the RPO for all RF generating equipment. The site plan shall include the following information:
 - 1.* Location of generating equipment
 - 2.* RF hazard areas
 - 3.* Description and use of nearby facilities and operating areas
- b.* At a minimum, the following RF emitter design and test data shall be submitted:
 - 1.* Emitter peak and average power
 - 2.* Pulse widths
 - 3.* Pulse repetition frequencies
 - 4.* Pulse codes
 - 5.* Maximum rated duty cycle
 - 6.* Type and size of antenna
 - 7.* Antenna gain and illumination
 - 8.* Beam width and beam skew
 - 9.* Operating frequency in MHz

10. Insertion loss between transmitter and antenna

11. Polarization of transmitted wave hardware

12. An analysis of the RF hazard area with and without antenna hats/dummy load, and results of any testing

13. A table that lists all of the RF emitters aboard a launch vehicle, payload, and ground support equipment and their hazard areas (distances)

14. A description of interlocks, inhibits, and other safety features that prevent inadvertent exposures

15. A copy of the RPO approved Radiation Protection Program RF Use Request Authorization (ER only)

16. A copy of the Range Safety and RPO approved site plan

3A.2.4.5.3 Laser System Data. At a minimum, the following laser system data shall be submitted:

a. A general description of the systems and its operation including how, where, why, and by whom the laser will be used. **NOTE:** The laser system also includes calibration equipment.

b. Drawings of the system that identify and show the location and operation of all components, interfaces, safety interlocks, and stops

c. For lasers that generate or use hazardous or corrosive materials, the data required for hazardous materials as described in **Hazardous Materials Data** section of this Appendix

d. For lasers that use cryogenic fluids for cooling or operational enhancement, the data required for cryogenic systems and hazardous materials as described in the **Flight Hardware Pressure Systems Data** and **Hazardous Materials Data** section of this Appendix

e. For laser systems using high voltages and/or high capacitance, the data required for electrical ground support equipment as described in **Electrical and Electronic Ground Support Equipment Data** section of this Appendix

f. Laser System Performance Data

1. Type, class, nomenclature, manufacturer model number, general identification, and other pertinent information

2. General description of the test, pertinent drawing of the operation site, and associated equipment

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3. Lasing material
4. Continuous wave (CW) or pulse identification
5. Wave length
6. Bandwidth
7. Average power and/or energy per pulse and/or maximum output energy
8. Pulse duration and pulse rate
9. Beamwidth at 1/e point for both axes
10. A Sketch of the beam pattern and location and energy density of hot spots and effects of weather and reflectivity
11. Beam divergence at 1/e point for both axes
12. Emergent beam diameter
13. Coolant
14. Amount of energy reflected back through the eyepiece or pointing device
15. Electrical voltage applied to the system
16. Any other pertinent laser parameter such as distribution of energy on beam and scan rate as determined by the Range User or Range Safety
17. Composition, color, and specularly or diffusely reflected surface characteristics of intended targets
18. Maximum incident energy on targets
19. Target characteristics including secondary hazards that may be affected by the laser, including fuels and other flammables, sensitive electronic components, flight termination systems, and others
20. Intended method (such as binoculars or spotter scope) (of viewing the beam and/or its reflections)
21. Safety devices such as interlocks, filters, shutters, and aiming devices
22. Azimuth and/or electrical and mechanical elevation stops
- g. Hazard Evaluation Data. Analysis and supporting data outlining possible laser system failures for all phases of laser system uses shall be submitted. Such data includes the following:
 1. All critical failure modes, failure mode effects, and failure probabilities including possible effects on secondary hazards and the subsequent results
 2. Routine occupational hazard exposure that has been experienced in the past with the system or similar systems along with recommended methods for reducing or eliminating the hazards

- h. Biophysiological Data
 1. Safe eye and skin distances based on permissible exposure limits
 2. Safety clearance and hazard zones
 3. Personal protective equipment required for personnel remaining inside clearance zones
 - i. A copy of the RPO approved Radiation Protection Plan Laser Use Request Authorization
 - j. A list and summary of test plans, test procedures, and test results in accordance with the **Laser System Test Requirements** section of this Chapter

3A.2.4.6 Flight Hardware Ionizing Radiation Sources

3A.2.4.6.1 General Data. A detailed description of the ionizing radiation sources shall be provided. The description shall include the following information:

- a. Nomenclature of the system
- b. Function of the system
- c. Location of the system
- d. Operation of the system
- e. System design parameters
- f. System test parameters
- g. System operating parameters
- h. Summaries of any Range Safety required hazard analyses conducted

3A.2.4.6.2 Flight Hardware Ionizing Radiation Subsystem Data. The following data shall be submitted:

- a. The final SAS as required by AFI 91-110 or equivalent document if non-Air Force Range User. **NOTE:** The SAS shall be referenced in the MSPSP and submitted as an accompanying document.
 1. Status reports on the SAS approval and copy of the TNSE
 2. Verification of approval for launch by separate correspondence in accordance with the requirements of AFI 91-110 or the equivalent
- b. Manufacturer of the source
- c. Date of source preparation
- d. Source identification number
- e. Cross-sectional sketch showing dimensions of the source
- f. Source container or holder construction material
- g. Physical source form such as powder or plate
- h. Chemical source form such as metal or oxide
- i. Strength in curies

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j. Type of protective cover material over the source

k. Date and result of last wipe test

l. Method of sealing against leakage

m. Radionuclide solubility in sea water

n. Description, including diagrams, showing exact placement of source in vehicle or payload

o. A brief description of intended use

p. Radiation levels in millirem per hour for all modes of operation and all radiation container surfaces accessible to personnel

q. Description of potential accidents that would cause release of radioactive material including potential personnel exposure and ground contamination

r. A summary of the possible consequences of a release of radioactive material at the Ranges including the maximum credible release and recommendations for methods to reduce or eliminate the resulting hazards

s. Description of recovery plans for land and sea launch abort scenarios

t. Location and name of responsible organization and licensed individual assigned to supervise handling of this material

u. Detailed nuclear system design

v. Normal and potentially abnormal environments and failure modes that can affect the processing, launch, and flight of a nuclear system

w. The predicted responses of the nuclear system to processing, launch, and flight environments and failures

x. The predicted resulting nuclear risk

y. Ground support equipment design data as required by the appropriate sections of this Regulation

z. Detailed ground processing flow

aa. A copy of the RPO approved 45 SWI 40-201 Radiation Protection Program (ER only)

ab. A copy of the AFI 91-110 30SW1 Radiation Protection Plan (WR only)

ac. A list and summary of test plans, test procedures, and test results in accordance with the **Radioactive Sources Carried on Launch Vehicles and Payload Test Requirements** section of this Chapter.

3A.2.4.6.3 Flight Hardware Ionizing Radiation Producing Equipment and Devices. The following data shall be submitted:

a. Manufacturer and model number

b. A description of the system and its operation

c. A description of the interlocks, inhibits and other safety features

d. If installed on a flight system, a diagram showing the location of the equipment or devices

e. A description of the radiation levels, in millirems per hour, accessible to personnel for all modes of operation and all surfaces accessible to personnel. Levels with doors and access panels removed shall be included.

f. A copy of the RPO approved 45 SWI 40-201 Radiation Protection Program Radiation Use Request Authorization to use these sources during ground processing (ER only).

g. A copy of the AFI 91-110 30SW1 Radiation Protection Plan (WR only)

3A.2.4.7 Flight Hardware Acoustical Subsystems

3A.2.4.7.1 General Data. A detailed description of acoustical hazard sources shall be provided. The description shall include the following information:

a. Nomenclature of the system

b. Function of the system

c. Location of the system

d. Operation of the system

e. System design parameters

f. System test parameters

g. System operating parameters

h. Summaries of any Range Safety required hazard analyses conducted

3A.2.4.7.2 Flight Hardware Acoustics Hazards Data. The following data requirements shall be submitted for acoustic hazards:

a. The location of all sources generating noise levels that may result in hazardous noise exposure for personnel and the sound level in decibels on the A scale (dBA) for that noise

b. The anticipated operating schedules of these noise sources

c. Methods of protection for personnel who may be exposed to sound pressure levels above 85dBA (8-hr time weighted average)

d. A copy of the Bioenvironmental Engineering approval stating the equipment and controls used are satisfactory

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3A.2.4.8 Flight Hardware Hazardous Materials Subsystems

3A.2.4.8.1 General Data. A detailed description of the ionizing radiation sources shall be provided. The description shall include the following information:

- a.* Nomenclature of the system
- b.* Function of the system
- c.* Location of the system
- d.* Operation of the system
- e.* System design parameters
- f.* System test parameters
- g.* System operating parameters
- h.* Summaries of any Range Safety required hazard analyses conducted

3A.2.4.8.2 Flight Hardware Hazardous Materials Data. At a minimum, the following hazardous materials data shall be submitted:

- a.* A list of all hazardous materials on the flight system and used in ground processing
- b.* A description of how each of these materials and liquids is used and in what quantity
- c.* A description of flammability and, if applicable, explosive characteristics
- d.* A description of toxicity including TLV and other exposure limits, if available
- e.* A description of compatibility including a list of all materials that may come in contact with a hazardous liquid or vapor with test results provided or referenced
- f.* A description of electrostatic characteristics with test results provided or referenced
- g.* A description of personal protective equipment to be used with the hazardous material and liquid
- h.* A summary of decontamination, neutralization, and disposal procedures
- i.* An MSDS for each hazardous material and liquid on flight hardware or used in ground processing. **NOTE:** The MSDS shall be available for review at each location in which the material is stored or used.
- j.* Description of any detection equipment, location, and proposed use
- k.* Additional data for plastic materials:
 - 1.* Identification of the cleaning methods to be used to maintain surface cleanliness and conductivity, if applicable

- 2.* Identification of the minimum acceptable voltage accumulation levels for the plastic materials or operations

- 3.* Identification of the method for ensuring conductivity between adjoining pieces of the plastic materials

- 4.* Assessment of the environmental effects on plastic materials such as humidity, ultraviolet light, and temperature that could cause degradation of conductivity flammability, or electrostatic properties

- l.* A list and summary of test plans, test procedures, and test results in accordance with the **Hazardous Materials Test Requirements** section of this Chapter.

3A.2.4.9 Computing Systems Data

The Range User shall provide the following information to Range Safety in the MSPSP:

- a.* Hardware description including layout of operator console and displays
- b.* Flow charts or diagrams showing hardware, data buses, hardware or software interfaces, data flow, power systems, and any redundancy
- c.* Logic flow charts
- d.* Operator user manuals and documentation
- e.* List and description of all SCCSFs including interfaces
- f.* Software hazard analyses
- g.* Configuration management plan and procedures
- h.* Software test plan, test procedures, and test results

3A.2.5 Ground Support Equipment

a. At a minimum, the Ground Support Equipment Section shall include the following information and the specific data requirements listed in sections 3A.2.5.1 through 3A.2.5.13 below:

- 1.* Subsystem overview
- 2.* Nomenclature of major subsystems
- 3.* Function of the subsystem
- 4.* Location of the subsystem
- 5.* Operation of the subsystem
- 6.* Subsystem design parameters
- 7.* Subsystem test requirements
- 8.* Subsystem operating parameters
- 9.* Summaries of any Range Safety required hazard analyses conducted

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b. Supporting data shall be included or summarized and referenced as appropriate with availability to Range Safety upon request.

c. Tables, matrixes, and sketches are required for systems and component data. (See 3.A2.4.2.2 and 3A.2.4.2.3 for suggestions.)

d. Required analyses, test plans, and test results may be included in the MSPSP as appendixes or submitted separately. At a minimum, analyses, test plans, and test reports shall be listed, referenced, and summarized in the MSPSP.

e. A list of all Range Safety approved noncompliances

3A.2.5.1 Ground Support Material Handling Equipment

Design and test plan data for the following government and Range User furnished ground support MHE shall be provided:

3A.2.5.1.1 General Data. A detailed description of MHE shall be provided. The description shall include the following information:

- a.* Nomenclature of the system
- b.* Function of the system
- c.* Location of the system
- d.* Operation of the system
- e.* System design parameters
- f.* System test parameters
- g.* System operating parameters
- h.* Summaries of any Range Safety required hazard analyses conducted

3A.2.5.1.2 Cranes and Hoists Used to Handle Critical Hardware. At a minimum, the following documentation is required:

- a.* SFP analysis
- b.* O&SHA
- c.* FMECA
- d.* NDE plan and test results for crane hooks and SFP components and SFP welds on crane support structures, overhead crane and hoist support structures, and 10 percent of non-SFP welds on overhead crane and hoist support structures
- e.* Software test plans and results if applicable
- f.* Initial crane and hoist test plans and test results
- g.* Stress analysis for crane and hoist support structures
- h.* Crane specifications
- i.* Certificate of conformance to specifications

j. CAD output data, if available

3A.2.5.1.3 Sling Assemblies Used to Handle Critical Hardware. At a minimum, the following data is required:

- a.* SFP analysis
- b.* NDE plan and test results for SFP components
- c.* Initial proof load test plan and test results
- d.* Stress analysis

3A.2.5.1.4 Hydrasets and Load Cells Used to Handle Critical Hardware. At a minimum, the following documentation is required:

- a.* SFP analysis
- b.* NDE plan and test results for SFP components and SFP welds
- c.* Initial proof load test plan and test results
- d.* Stress analysis

3A.2.5.1.5 Handling Structures Used to Handle Critical Hardware. At a minimum, the following documentation is required:

- a.* SFP analysis
- b.* NDE plan and test results for SFP and non-SFP components and SFP and non-SFP welds
- c.* Initial proof load test plan and test results
- d.* Stress analysis for structures
- e.* Safe-life analysis if Option 2 of Appendix 3B is chosen
- f.* O&SHA and FMECA analyses for structural mechanisms like spin tables, rotating structures, and portable launch support frames

3A.2.5.1.6 Removable, Extendible, and Hinged Personnel Work Platforms. At a minimum, the following documentation is required:

- a.* SFP analysis
- b.* NDE plan and test results for SFP and non-SFP components and SFP and non-SFP welds
- c.* Initial proof load test plan and test results
- d.* Stress analysis

3A.2.5.1.7 Cranes and Hoists Used to Handle Non-Critical Hardware. At a minimum, the following documentation is required:

- a.* NDE plan and test results for crane hooks
- b.* Initial crane and hoist test plans and test results
- c.* Crane specifications
- d.* Certification of conformance to specifications

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3A.2.5.1.8 Sling Assemblies Used to Handle Non-Critical Hardware. At a minimum, the initial proof load test plan and results shall be documented and be made available upon request.

3A.2.5.1.9 Handling Structures Used to Handle Non-Critical Hardware. At a minimum, the initial proof load test plan and results shall be documented and available upon request.

3A.2.5.2 Ground Support Pressure and Propellant Systems

3A.2.5.2.1 General Data. A detailed description of the pressure and propellant systems shall be provided. The description shall include the following information:

- a. Nomenclature of the system
- b. Function of the system
- c. Location of the system
- d. Operation of the system
- e. System design parameters
- f. System test parameters
- g. System operating parameters
- h. Summaries of any Range Safety required hazard analyses conducted
- i. A material compatibility analysis
- j. Inservice operating, maintenance, and ISI plan
- k. Physical and chemical properties and general characteristics of propellants, test fluids, and gases
- l. For hazardous propellants, fluids, and gases, the following shall be submitted:
 1. Specific health hazards such as toxicity and physiological effects
 2. TLV and maximum allowable concentration for 8-h day, 5-day week of continuous exposure
 3. Emergency tolerance limits including length of time of exposure and authority for limits, such as the Surgeon General, NIOSH, independent study
 4. Volume and surface area of a maximum credible spill and supporting hazard analyses
 5. Description of hazards other than toxicity, such as flammability and reactivity
 6. Material incompatibility problems in the event of a spill
 7. Recommended methods and techniques for decontamination of areas affected by spills or vapor clouds and hazardous waste disposal procedures

8. Personal protective equipment to be used in handling and using propellants when this equipment will be used during an operation, and manufacturer, model number, and other identifying data

9. Manufacturer, model number, specifications, operating limits, type of certification, and general description of vapor detecting equipment

3A.2.5.2.2 Ground Support Pressure and Propellant System Data. The following ground support pressure and propellant system data shall be submitted:

- a. A copy of any DOT approved exemptions for mobile and portable hazardous pressure systems
- b. A schematic presenting the system in a clear and easily readable form with complete subsystems grouped and labeled. The information listed below shall be provided on the schematic or on accompanying referenced data sheets. **NOTE:** Nomenclature of each element should be made adjacent to or in the vicinity of each element.
 1. Identification of all pressure system components such as valves, regulator, tubes, hoses, vessels, and gauges using standard symbols. **NOTE 1:** A legend is recommended. **NOTE 2:** The original schematic should be referenced.
 2. MOP of all systems and subsystems at expected operating temperatures
 3. Identification of expected source pressures and expected delivery pressures
 4. All relief valve pressure settings and flow rates
 5. System fluid and maximum expected temperature
 6. Pressure ranges of all pressure gauges
 7. Pressure settings of pressure regulators
 8. Charging pressure of reservoirs and vessels, their nominal capacities, and wall thickness
 9. Pressure setting of all pressure switches
 10. Nominal outside diameter and wall thickness of all tubing and piping
 11. Flowpath through all system components. **NOTE:** When the system is to be used in several operating modes, it is easier to provide a separate schematic that shows flowpaths for each operating mode.
 12. Identification of each component (reference designations) so that cross-referencing between schematics and drawings and a pressure sys-

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tem component list or other documentation is possible

13. End-to-end electrical schematics of electrical and electronic components giving full functional data and current loads

14. Connections for testing or servicing

15. A narrative describing the following information:

(a) System or subsystem and its operating modes

(b) Operational hazards

(c) Accessibility of components

16. A sketch or drawing of the system that shows physical layout and dimensions

17. System information shall be placed in tabular form. **NOTE:** See 3A.2.4.2.2 for suggested format.

3A.2.5.2.3 Ground Support Pressure and Propellant System Component Design Data. At a minimum, the following information shall be submitted for ground support pressure system components:

a. Identification of each component with a reference designation permitting cross-referencing with the system schematic described above

b. MAWP for all pressure system components

c. MOP the component shall operate at when installed in the system

d. Safety factors or design burst pressure for all pressure system components, identifying actual burst pressures if available.

e. Hydrostatic test pressure for each system component

f. As applicable, the test pressure the component will be tested to after installation in the system

g. Materials used in the fabrication of each element in the component, including soft goods and other internal elements

h. Cycle limits if fatigue is a factor

i. Temperature limits

j. Manufacturer name, model number, and part number

k. Component information shall be placed in tabular form. **NOTE:** See 3A.2.4.2.3 for suggested format.

3A.2.5.3 Ground Support Electrical and Electronic Subsystems

3A.2.5.3.1 General Data. A detailed description of electrical and electronic subsystems shall be provided.

The description shall include the following information:

a. Nomenclature of the system

b. Function of the system

c. Location of the system

d. Operation of the system

e. System design parameters

f. System test parameters

g. System operating parameters

h. Summaries of any Range Safety required hazard analyses conducted

3A.2.5.3.2 EGSE Battery Design Data. At a minimum, the following EGSE battery design data shall be provided:

a. Design versus actual operating parameters of cells and battery

b. Cell chemistry and physical construction

c. Cell vent parameters

d. Toxic chemical emission of cells and evaluation of hazards

e. EPA classification of battery

f. DOT classification of battery

g. Physical and electrical integration of cells to form the battery

h. Description of safety devices

i. Case design including vent operation and cell and battery case housing yield point

j. A description of all operations to include packing, transportation, and storage configuration; activation; installation; checkout; charging; usage; removal; and disposal

k. Identification of the hazards associated with each activity in j above and the safety controls that shall be in effect

l. Manufacturing qualification and acceptance testing results that are considered safety critical

m. Battery size and weight

n. Specification of the system that uses the battery

o. A description of the MHE and EGSE used for packing, transportation, and storage; activation; installation; checkout; charging; usage; removal; and disposal of the battery

p. A list and summary of test plans, test procedures, and test results in accordance with the **Test Requirements for Lithium Batteries** section of this Chapter.

3A.2.5.3.3 EGSE Design Data. The following EGSE design data is required:

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- a. Identification of EGSE and its use
- b. A description of how faults in the EGSE circuitry that can create a hazardous condition are prevented from propagating into the flight system
- c. A description of how inadvertent commands that can cause a hazardous condition are prevented
- d. Identification of potential shock hazards
- e. A description of how the intent of the NFPA is met with respect to hazardous atmospheres
- f. Identification of all non-explosion proof equipment powered up during and after propellant loading
- g. For explosion proof and intrinsically safe equipment approved by a nationally recognized testing laboratory, the following information shall be provided:
 1. Manufacturer
 2. Model number
 3. Hazardous location class and group
 4. Operating temperature
- h. For any explosion proof equipment or components not having a fixed label from a nationally recognized testing laboratory, the data and certification shall be available for inspection in the facility of use.
- i. Test data and certification on custom or modified equipment that can not be certified by a nationally recognized testing laboratory for explosion proof equipment
- j. Test results for all Range User designed, built, or modified intrinsically safe apparatus as required by a nationally recognized testing laboratory in accordance with UL 913
- k. A bent pin analysis for all connectors for safety critical or hazardous systems that have spare pins

3A.2.5.4 Ground Support Ordnance Subsystems

3A.2.5.4.1 General Data. A detailed description of ordnance subsystems shall be provided. The description shall include the following information:

- a. Nomenclature of the system
- b. Function of the system
- c. Location of the system
- d. Operation of the system
- e. System design parameters
- f. System test parameters
- g. System operating parameters
- h. Summaries of any Range Safety required hazard analyses conducted

3A.2.5.4.2 Ordnance Ground Systems Design Data. The following ordnance ground systems design data is required:

- a. A complete description of the ground test equipment that will be used in the checkout of ordnance devices and systems, including general specifications and schematics for all test equipment
- b. Specifications, schematics, and a complete functional description of the low voltage stray current monitor
- c. Schematics of all ordnance system monitor circuits from the ordnance component pick-off points to the OSC termination
- d. Calibration data for all monitor circuit terminations that will be provided to the OSC
- e. A complete and detailed description of the airborne and ground ordnance telemetry system and how it functions, including general specifications and schematics
- f. The following information is required for ordnance continuity and bridgewire resistance measurement devices:
 1. Maximum safe no-fire energy of the ordnance being tested
 2. A declaration of any certification currently in effect for the instrument along with the manufacturer specifications including:
 - (a) Range
 - (b) Accuracy
 - (c) Power supply and recharge capability
 - (d) Self-test features
 - (e) Schematics
 3. Failure Analysis including the outcome of the energy analysis (open circuit or maximum terminal voltage) and current limit analysis (short circuit or maximum output current)
 4. Instrument description including any modifications required for operational use and details of safety design features such as interlocks
 5. Description of intended operations
- g. A list and summary of test plans, test procedures, and test results, as required.

3A.2.5.6 Ground Support Non-Ionizing Radiation Source Data

3A.2.5.6.1 General Data. A detailed description of non-ionizing subsystems shall be provided. The description shall include the following information:

- a. Nomenclature of system
- b. Function of the system

APPENDIX 3A

MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE

- c.* Location of the system
- d.* Operation of the system
- e.* System design parameters
- f.* System test parameters
- g.* System operating parameters
- h.* Summaries of any Range Safety required hazard analyses conducted

3A.2.5.6.2 Ground Support RF Emitter Data.

a. Site plans shall be submitted to Range Safety and the RPO for all RF generating equipment. The site plan shall include the following information:

- 1. Location of generating equipment
- 2. RF hazard areas
- 3. Description and use of nearby facilities and operating areas
- b.* At a minimum, the following RF emitter design and test data shall be submitted:
 - 1. Emitter peak and average power
 - 2. Pulse widths
 - 3. Pulse repetition frequencies
 - 4. Pulse codes
 - 5. Maximum rated duty cycle
 - 6. Type and size of antenna
 - 7. Antenna gain and illumination
 - 8. Beam width and beam skew
 - 9. Operating Frequency (MHz)
 - 10. Insertion loss between transmitter and antenna
 - 11. Polarization of transmitted wave
 - 12. An analysis of the RF hazard area with and without antenna hats/dummy load
 - 13. A table that lists all of the RF emitters aboard a launch vehicle, payload, and ground support equipment and their hazard areas (distances)
 - 14. A description of interlocks, inhibits, and other safety features that prevent inadvertent exposures
 - 15. A copy of the RPO approved Radiation Protection Program RF Use Request Authorization
 - 16. A copy of the Range Safety and RPO approved site plan
 - 17. A list and summary of test plans, test procedures, and test results in accordance with the **RF Emitter Initial Test Requirements** section of this Chapter.

3A.2.5.6.3 Ground Support Laser Systems. At a minimum, the following laser system data requirements shall be submitted:

a. A general description of the systems and its operation including how, where, why, and by whom the laser will be used. **NOTE:** The laser system also includes calibration equipment.

b. Drawings of the system that identify and show the location and operation of all components, interfaces, safety interlocks, and stops

c. For lasers that generate or use hazardous or corrosive materials, the data required for hazardous materials as described in the **Hazardous Materials Data** section of this Appendix

d. For lasers that use cryogenic fluids for cooling or operational enhancement, the data required for cryogenic systems and hazardous materials as described in the **Ground Support Pressure and Propulsion Systems Data** and **Hazardous Materials Data** sections of this Appendix

e. For laser systems using high voltages and/or high capacitance, the data required for electrical ground support equipment as described in **Electrical and Electronic Ground Support Equipment Data** section of this Appendix

f. Laser System Performance Data

1. Type, class, nomenclature, manufacturer model number, general identification, and other pertinent information

2. General description of the test, pertinent drawing of the operation site, and associated equipment

3. Lasing material

4. CW or pulse identification

5. Wave length

6. Bandwidth

7. Average power and/or energy per pulse and/or maximum output energy

8. Pulse duration and pulse rate

9. Beamwidth at 1/e point for both axes

10. A Sketch of the beam pattern and location and energy density of hot spots and effects of weather and reflectivity

11. Beam divergence at 1/e point for both axes

12. Emergent beam diameter

13. Coolant

14. Amount of energy reflected back through the eyepiece or pointing device

15. Electrical voltage applied to the system

16. Any other pertinent laser parameter such as distribution of energy onbeam and scanrate as determined by the Range User or Range Safety

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17. Composition, color, and specularly or diffusely reflected surface characteristics of intended targets

18. Maximum incident energy on targets

19. Target characteristics including secondary hazards that may be affected by the laser, including fuels and other flammables, sensitive electronic components, flight termination systems, and others

20. Intended method (such as binoculars or spotter scope) of viewing the beam and/or its reflections

21. Safety devices such as interlocks, filters, shutters, and aiming devices

22. Azimuth and/or electrical and mechanical elevation stops

g. Hazard Evaluation Data. Analysis and supporting data outlining possible laser system failures for all phases of laser system uses shall be submitted. Such data includes the following:

1. All critical failure modes, failure mode effects, and failure probabilities including possible effects on secondary hazards and the subsequent results

2. Routine occupational hazard exposure that has been experienced in the past with the system or similar systems along with recommended methods for reducing or eliminating the hazards

h. Biophysiological Data

1. Safe eye and skin distances based on permissible exposure limits

2. Safety clearance and hazard zones

3. PPE required for personnel remaining inside clearance zones

i. A copy of the RPO approved Radiation Protection Plan Laser Use Request Authorization

j. A list and summary of test plans, test procedures, and test results in accordance with the **Laser System Test Requirements** section of this Chapter.

3A.2.5.7 Ground Support Ionizing Radiation Source Data

3A.2.5.7.1 General Data. A detailed description of ionizing subsystems shall be provided. The description shall include the following information:

a. Nomenclature of the system

b. Function of the system

c. Location of the system

d. Operation of the system

e. System design parameters

f. System test parameters

g. System operating parameters

h. Summaries of any Range Safety required hazard analyses conducted

3A.2.5.7.2 Ionizing Radiation Sources Data.

At a minimum, the following data shall be provided for all ground radiation producing sources:

a. Manufacturer and model number

b. A description of the system and its operation

c. A description of the interlocks, inhibits and other safety features

d. If installed on a flight system, a diagram showing the location

e. A description of the radiation levels, in millirems per hour, accessible to personnel for all modes of operation and all surfaces accessible to personnel. Levels with doors and access panels removed shall be included.

f. A copy of the RPO approved 45 SWI 40-201 Radiation Protection Program Radiation Use Request Authorization to use these sources during ground processing

g. A copy of the AFI 91-110 30SW1 Radiation Protection Plan (WR only)

3A.2.5.8 Ground Support Acoustic Hazards

3A.2.5.8.1 General Data. A detailed description of acoustical hazards and subsystems shall be provided. The description shall include the following information:

a. Nomenclature of the system

b. Function of the system

c. Location of the system

d. Operation of the system

e. System design parameters

f. System test parameters

g. System operating parameters

h. Summaries of any Range Safety required hazard analyses conducted

3A.2.5.8.2 Acoustic Hazards Data. The following data shall be submitted for acoustic hazards:

a. The location of all sources generating noise levels that may result in hazardous noise exposure for personnel and the sound level (in dBA) for that noise

b. The anticipated operating schedules of these noise sources

APPENDIX 3A

MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE

c. Methods of protection for personnel who may exposed to sound pressure levels above 85 dBA (8-h time weighted average)

d. A copy of the Bioenvironmental Engineering approval stating the equipment and controls used are satisfactory

3A.2.5.9 Ground Support Hazardous Materials

3A.2.5.9.1 General Data. A detailed description of hazardous materials and subsystems shall be provided. The description shall include the following information:

- a.* Nomenclature of the system
- b.* Function of the system
- c.* Location of the system
- d.* Operation of the system
- e.* System design parameters
- f.* System test parameters
- g.* System operating parameters
- h.* Summaries of any Range Safety required hazard analyses conducted

3A.2.5.9.2 Ground Support Hazardous Materials Data. The following hazardous materials data shall be submitted:

- a.* A list of all hazardous materials on the flight system and used in ground processing
- b.* A description of how each of these materials and liquids is used and in what quantity
- c.* A description of flammability and, if applicable, explosive characteristics
- d.* A description of toxicity including TLV and other exposure limits, if available
- e.* A description of compatibility including a list of all materials that may come in contact with a hazardous liquid or vapor with test results provided or referenced
- f.* A description of electrostatic characteristics with test results provided or referenced
- g.* A description of personal protective equipment to be used with the hazardous material and liquid
- h.* A summary of decontamination, neutralization, and disposal procedures
- i.* An MSDS for each hazardous material and liquid or used in ground processing. **NOTE:** The MSDS shall be available for review at each location in which the material is stored or used.
- j.* Description of any detection equipment, location, and proposed use
- k.* Additional data for plastic materials:

1. Identification of the cleaning methods to be used to maintain surface cleanliness and conductivity, if applicable

2. Identification of the minimum acceptable voltage accumulation levels for the plastic materials or operations

3. Identification of the method for ensuring conductivity between adjoining pieces of the plastic materials

4. Assessment of the environmental effects on plastic materials such as humidity, ultraviolet light, and temperature that could cause degradation of conductivity flammability, or electrostatic properties

l. A list and summary of test plans, test procedures, and test results in accordance with the **Hazardous Materials Test Requirements** section of this Chapter.

3A.2.5.10 Operations Safety Console

3A.2.5.10.1 General Data. A detailed description of the OSC shall be provided. The description shall include the following information:

- a.* Nomenclature of system
- b.* Function of the system
- c.* Location of the system
- d.* Operation of the system
- e.* System design parameters
- f.* System test parameters
- g.* System operating parameters
- h.* Summaries of any Range Safety required hazard analyses conducted

3A.2.5.10.2 OSC Data. The following data shall be submitted for the OSC:

- a.* An overall schematic of the OSC and outside interfaces
- b.* A narrative of each of the features of the OSC, including the following:
 - 1.* Function
 - 2.* Operation
 - 3.* Outside interface
 - 4.* Operating limits
- c.* A list and summary of test plans, test procedures, and test results in accordance with the **OSC Validation and Test Requirements** section of this Chapter.

3A.2.5.11 Vehicle Data

At a minimum, the following data shall be provided for vehicles:

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MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE

3A.2.5.11.1 General Vehicle Data.

a. Documentation certifying that vehicles used to transport bulk hazardous material on the Range comply with DOT requirements or are formally exempted by DOT

b. If DOT certification or exemption documentation is not available, the following information is required:

1. Design, test, inspection requirements
2. Stress analysis
3. SFP analysis
4. FMECA
5. Comparison analysis with similar DOT approved vehicle
6. "Equivalent safety" (meets DOT intent) analysis

3A.2.5.11.2 Critical Flight Hardware Trailer Data.

- a.* Stress analysis
- b.* SFP analysis
- c.* Initial proof load test plan and test results
- d.* Initial road test plan and test results
- e.* NDE plan and test results for SFPs

3A.2.5.11.3 Forklift Data.

a. Certification that the forklift has been designed and tested in accordance with applicable national standards such as ANSI/ASME B36.1, UL 538, and UL 583

- b.* For personnel platforms on forklifts:
1. Stress analysis
 2. SFP analysis
 3. NDE plan and test results for SFP components and SFP welds
 4. Proof load test plan and test results
- c.* For forklifts used to lift or move critical loads, maintenance plans shall be submitted for review and approval.

3A.2.5.12 Computing Systems Data

The Range User shall provide the following information to Range Safety in the MSPSP:

- a.* Hardware description including layout of operator console and displays
- b.* Flow charts or diagrams showing hardware, data buses, hardware or software interfaces, data flow, power systems, and any redundancy
- c.* Logic flow charts
- d.* Operator user manuals and documentation

e. List and description of all SCCSFs including interfaces

f. Software hazard analyses

g. Configuration management plan and procedures

h. Software test plan, test procedures, and test results

3A.2.5.13 WR Seismic Data Requirements

a. The Range User shall identify equipment that has the potential, directly or by propagation, to cause the following seismic hazards:

1. Severe personnel injury
2. A catastrophic event
3. Significant impact on space vehicle or missile processing and launch capability. **NOTE:** This criteria does not apply to commercial programs.
4. Damage to high value flight hardware.

NOTE: This criteria does not apply to commercial programs.

b. For equipment that can present a seismic hazard, the Range User shall identify the expected G forces, the level of G forces the equipment can withstand, the magnitude of potential damage, and the method of restraint used.

3A.3 COMPLIANCE CHECKLIST

A compliance checklist of all design, test, analysis, and data submittal requirements in this Chapter shall be provided. The checklist shall indicate

APPENDIX 3A

MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE

for each requirement if the proposed design is compliant, non-compliant but meets intent, non-compliant (waiver required) or non-applicable. An example of a compliance checklist can be found in Appendix E of the Ranger User Handbook. The following items are included in this section.

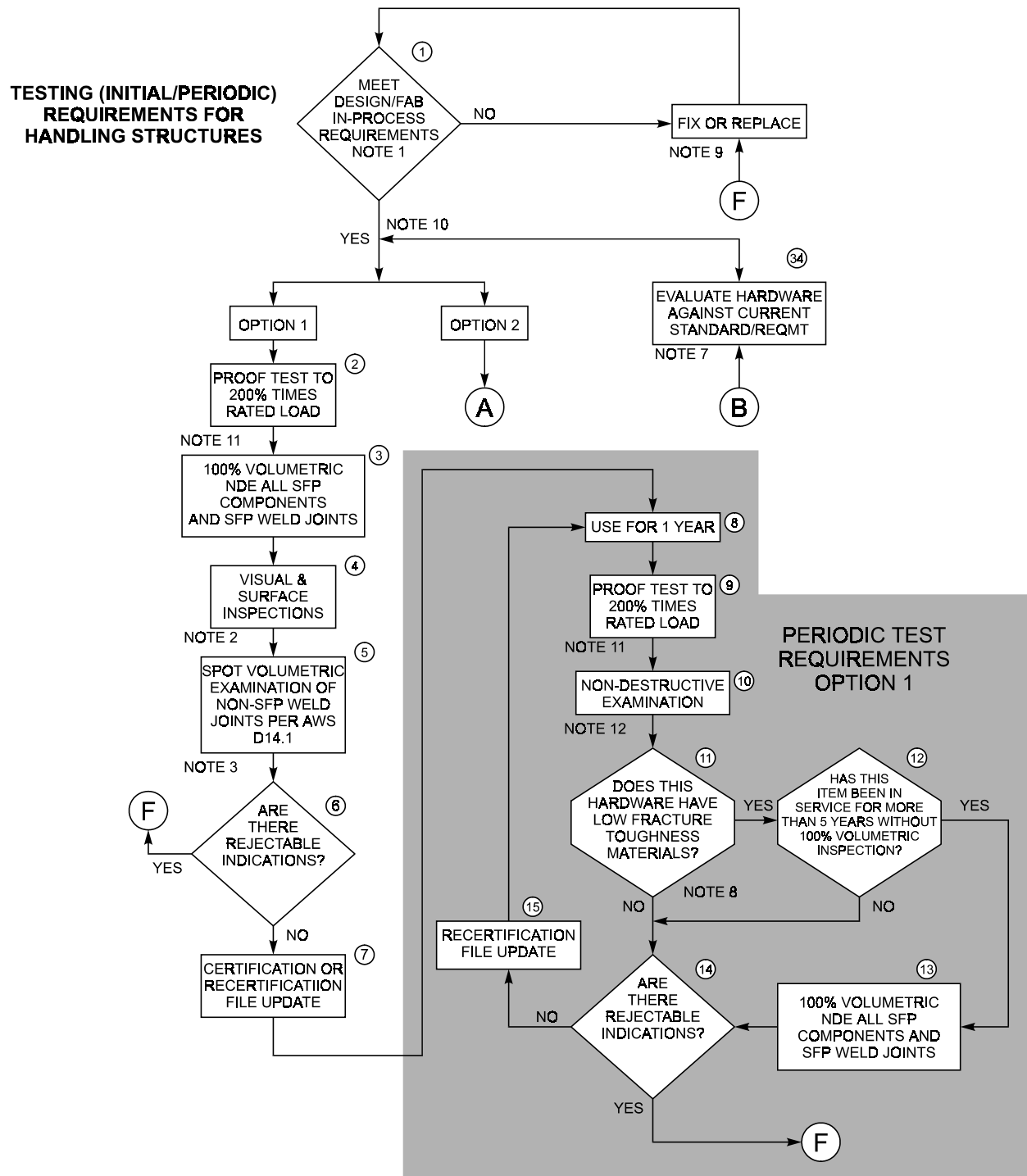
- a.* Criteria/requirement
- b.* System
- c.* Compliance
- d.* Noncompliance
- e.* Not applicable
- f.* Resolution
- g.* Reference
- h.* Copies of all Range Safety approved non-compliances including deviations, waivers, and formal meets intent certifications (MICs) shall be included.

3A.4 MODIFICATIONS TO THE MSPSP

The change section contains a summary of all changes to the last edition of the MSPSP. All changes shall be highlighted using change bars or similar means of identification.

APPENDIX 3B

HANDLING STRUCTURES INITIAL AND PERIODIC TEST REQUIREMENT FLOWPATH



APPENDIX 3B

HANDLING STRUCTURES INITIAL AND PERIODIC TEST REQUIREMENT FLOWPATH

NOTES

1. Design, Fabrication, and In-Process Requirements:
 - a. Meet EWR 127-1 design requirements for handling structures.
 - b. Identify SFP components and SFP welds
2. Perform 100 percent visual inspection of all components (including SFP) and weld joints (including SFP and non-SFP) and perform 100 percent surface NDE testing of all SFP components and SFP welds.
3. Perform volumetric NDE inspection on 4 in. or 10 percent (whichever is less) of every continuous non-SFP weld in accordance with AWS D14.1, paragraph 8.9.5.
4. Cycle count is required.
5. MHE and MHSE that has been in service for 10 years or 2500 cycles, whichever is less, shall be evaluated against current Range Safety standards and requirements.
6. Perform safe-life analysis assuming flaws to be in the worst location (transition areas, heat affected areas, weld joints, membrane sections, and highest stressed areas). Safe-life analysis shall be performed using fatigue crack growth computer programs such as NASA/FLAGRO (JSC-22267) or other Range Safety Approved computer programs or analysis methods.

NOTE: Fracture Mechanics Analysis used to established cyclic limits may assume “crack like defects.” This assumption does not imply that cracks or other rejectable indications are acceptable. The logic identified in this flow chart requires that cracks and rejectable indications be fixed.

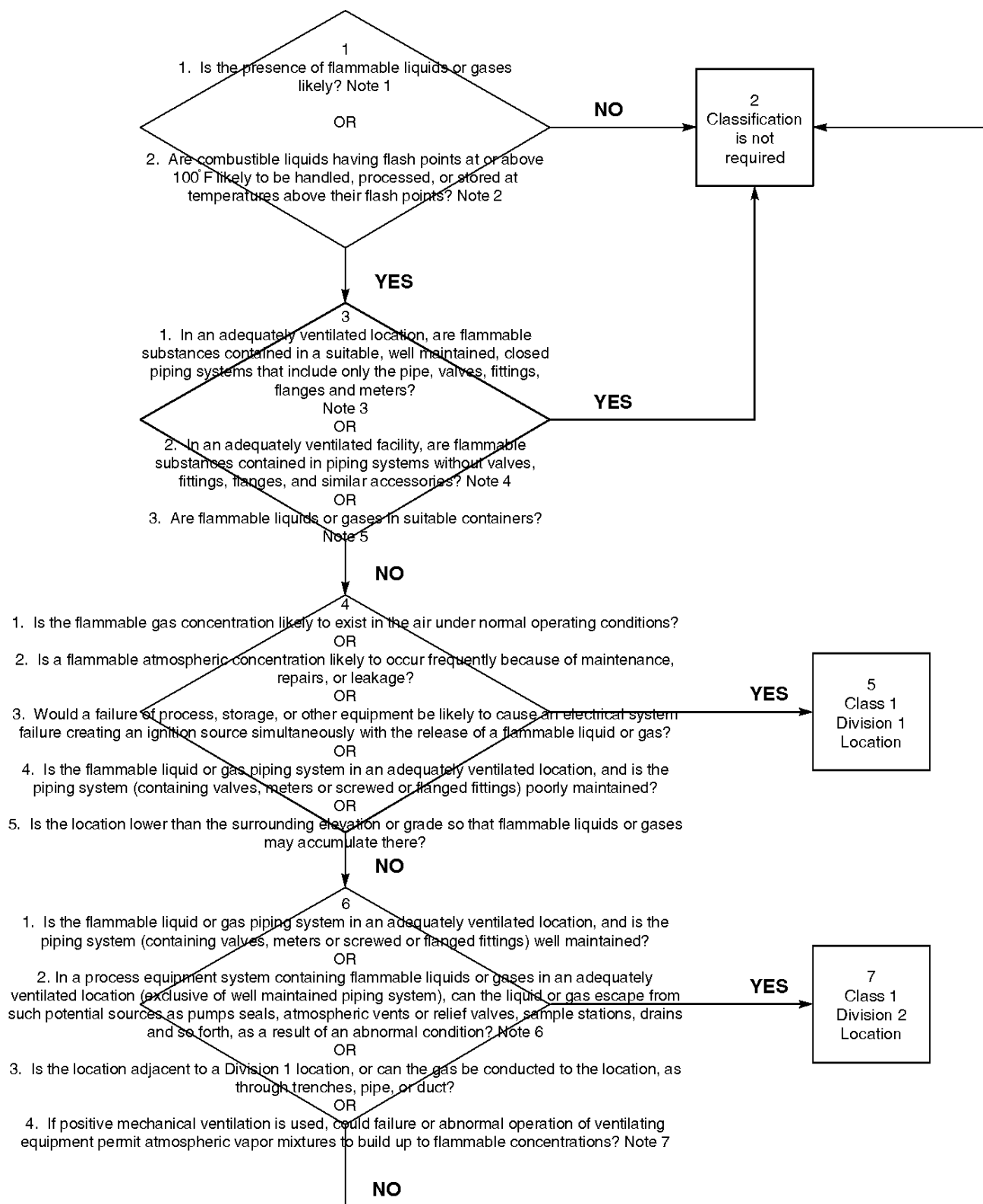
7. Provide noncompliance issues, if any, to Range Safety for disposition.
8. All parts shall be considered to have a low-fracture toughness with a material property ratio $K_{ic}/F_{ty} < 0.33 \text{ in}^{1/2}$. If the part is a steel bolt and the K_{ic} value is unknown, low fracture toughness shall be assumed when $F_{tu} > 180 \text{ ksi}$.

Where: K_{ic} = Plane strain fracture toughness.
 F_{ty} = Allowable tensile yield strength.
 F_{tu} = Allowable tensile ultimate strength.

Reference: NASA NBH 8071.1

9. Fix hardware. This means either repair or an analytical solution is required as approved by Range Safety.
10. Periodic test and inspection requirements are identified within the gray areas of the flow chart. All other processes identified within the figure are considered initial test requirements.
11. Proof test shall be performed on fully assembled handling structures, unless otherwise approved by Range Safety. Do not proof test greater than 85 percent of yield.
12. Perform NDE in accordance with Range Safety approved NDE plan.

APPENDIX 3C HAZARDOUS AREA CLASSIFICATION



APPENDIX 3C HAZARDOUS AREA CLASSIFICATION

NOTES

- 1: The following are considered flammable liquids/gasses:
 - a. Unsymmetrical dimethyl hydrazine (UDMH) - Flashpoint 34⁰F
 - b. Monomethyl hydrazine (MMH) - Flashpoint 62⁰F
- 2: Hydrazine (N₂H₄) - is considered a combustible liquid.
 - a. The surface temperature of potential spill areas must also be considered.
 - b. Temperature in the area must be single fault tolerant to remain below 100⁰F.
 - c. Below grade locations may still accumulate enough N₂H₄ to become flammable at lower temperatures.
- 3: Adequate ventilation is defined by NFPA 30, *Flammable and Combustible Liquids Code*, as that which is sufficient to prevent the accumulation of significant quantities of vapor-air mixtures in concentrations over 25 percent of the lower flammability limit.
 - a. An adequately ventilated location is one of the following:
 1. An outside location
 2. A building, room, or space that is substantially open and free of obstruction to the natural passage of air, either vertically or horizontally. Such locations may be roofed over with no walls, may be roofed over and closed on one side or may be provided with suitably designed wind breaks.
 3. An enclosed or partly enclosed space provided with mechanical ventilation equivalent to natural ventilation. The mechanical ventilation system must have adequate safeguards against failure.
 - b. Lower flammability limits of specific commodities are as follows:
 1. N₂H₄ - 4.7 percent
 2. MMH - 2.5 percent
 3. UDMH - 2.0 percent
 - c. Payload propellant systems cannot normally be considered closed piping systems that include only the pipe, valves, fittings, flanges, and meters; they normally also include a pressure vessel.
- 4: Payload propellant systems cannot normally be considered piping without valves, fitting, flanges, and similar accessories.
- 5: Payload propellant systems cannot be considered suitable containers unless they meet DOT or ASME requirements or meet EWR 127-1, section 3.12 and are also protected from outside damage.
- 6: A payload propellant system would normally be considered a process equipment system. In a dynamic mode, the answer to this question will almost always be *yes*; in a static mode, the answer may be *yes* or *no* depending on past history and adequacy of protection from outside damage.
- 7: An analysis must be provided. Consideration must be given to the size of the containment area, credible potential size of the spill, adequacy of the ventilation equipment and its potential failure modes, and the specific gravity of the commodity in question.

APPENDIX 4B

RSS QUALIFICATION, ACCEPTANCE, AND AGE SURVEILLANCE TEST APPENDIXES

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APPENDIX 4B

INTRODUCTION TO RSS COMPONENT QUALIFICATION, ACCEPTANCE, AND AGE SURVEILLANCE TEST APPENDIXES

4B.1 Introduction to the Appendix

This appendix provides applicable RSS component qualification, acceptance, and age surveillance test requirements.

4B.2 Organization

The test appendixes are organized into two separate sections with the exceptions of Appendix 4B1 and 4B11. The first section presents the environmental testing sequences. The second section presents the unique test requirements for the given component.

Where applicable, the purpose, conditions, procedure, and pass/fail criteria for the conduct of the unique tests are described to provide guidance to the Range User.

4B.3 Tailoring

The test requirements of Appendixes 4B1 through 4B14 may be tailored to fit the specific hardware design and application. The tests described in the appendixes are not intended to be fully applicable to every RSS system or component. Coordination with Range Safety will permit the application of sound, technically justified, tailoring criteria.

The rationale for all tailoring shall be ultimately submitted to Range Safety in writing for approval prior to requesting test plan and test procedure approval by Range Safety. Other additional tests not contained in these appendixes may be required for new technology and/or unique applications of existing technology.

In addition, non-operating environment tests are not required if it can be shown that the operating test environment includes the non-operating environment.

4B.4 Test Plan and Test Procedure Requirements

The Range User shall establish procedures for performing all required tests in accordance with detailed test plans approved by Range Safety.

The test plan shall indicate the test requirements, testing approach for each component, related special test equipment, facility and system interface requirements. Traceability shall be provided from the specified requirements to the test procedures.

The test procedures shall cover all operations in enough detail so that there is no doubt as to what is to be done. The pass/fail test criteria shall be determined prior to the start of every test.

4B.5 Testing Sequence

Unless otherwise agreed to by Range Safety, the testing sequences shall conform to those described in the test appendixes.

4B.6 Retest Requirements

In the case of a significant redesign of a component, all previous qualification tests, including acceptance tests, shall be repeated. Where the redesign or rework of the component is very minor, it may be acceptable to Range Safety to only repeat functional testing and the test in which the failure occurred.

4B.7 Failure to Meet Component Specifications

The failure of an RSS component to meet Range Safety approved specifications shall be reported to Range Safety verbally within 72 h and then in writing within 14 calendar days of the date the failure is noted. **NOTE:** Components whose test data reflect the unit is out-of-family when compared to other units shall be considered as out of specification.

A component that exhibits any sign that a part is stressed beyond its design limit (cracked circuit boards, loose connectors and/or screws, bent clamps and/or screws, worn parts) is considered a failure of the component even if the component passes the final functional test.

If a test discrepancy occurs, the test shall be interrupted, the discrepancy verified, and Range Safety

APPENDIX 4B

INTRODUCTION TO RSS COMPONENT QUALIFICATION, ACCEPTANCE, AND AGE SURVEILLANCE TEST APPENDIXES

shall be verbally notified within 24 h. If the discrepancy is dispositioned as a failure in the item under test, the preliminary failure analysis and appropriate corrective action plan shall be submitted to Range Safety before testing is resumed.

The failure analysis shall include the cause of the failure, the physics of the failure, and isolation of the failure to the smallest replaceable item(s). The degree of retest shall be determined for each case based upon the nature of the failure. The failure analysis plan shall be developed and approved by Range Safety before the test configuration can be

broken.

4B.8 Testing Prior to Qualification

Prior to the start of qualification testing, the component shall satisfactorily pass the acceptance test.

4B.9 Test Tolerances

The test tolerances allowed in Appendixes 4B1 through 4B14 shall be applied to the nominal test values specified. Unless otherwise specified, the maximum allowable tolerances shown in Table 4B-1 shall apply.

Table 4B-1
Test Tolerances

Temperature	±3°C
Pressure	
Above 1.3×10^2 Pascals (1 Torr)	
1.3×10^{-1} to 1.3×10^2 Pascals	±10%
(0.001 Torr to 1 Torr)	±25%
Less than 1.3×10^{-1} Pascals	
(0.001 Torr)	±80%
Relative Humidity	±5%
Acceleration	±10%
Vibration Frequency	±2%
Sinusoidal Vibration Amplitude	±10%
Random Vibration Power Spectral Density (G^2/Hz)	
20 to 100 Hz (5 Hz or narrower bands)	±1.5 dB
100 to 500 Hz (25 Hz or narrower bands)	±1.5 dB
500 to 2000 Hz (50 Hz or narrower bands)	±1.5 dB
Sound Pressure Level	
1/3 Octave Band	±3.0 dB
Overall	±1.5 dB
Shock Response Spectrum ($Q = 10$)	
1/6 Octave Band Center Frequency	+6 dB
Amplitude	- 3 dB
Static Load	±5%

APPENDIX 4B1

RSS COMPONENT COMMON TEST REQUIREMENTS

4B1.1 General Requirements

This appendix contains common test requirements for all RSS components. Some of the tests may not be applicable to all components. For example, the functional test prior to, during, and after environmental exposure is not applicable to the ordnance component. Pre- and post-environmental data shall be compared for any significant changes.

4B1.2 Product Examination

4B1.2.1 Visual Inspection

a. Purpose. To ensure that good workmanship has been employed and that the component is free of obvious physical defects.

b. Procedure. Visually inspect components before and after each manufacturing, handling, storage, and test operation.

1. With the unaided eye, inspect all accessible areas of the component.

2. Under 10X minimum magnification, inspect all critical surfaces and interfaces of the component.

c. Pass/Fail Criteria. Components shall be of good workmanship and free of obvious physical defects.

4B1.2.2 Weight

a. Purpose. To ensure that the weight of the component is within the weight limits that are specified in the component specification.

b. Procedure

1. Physically weigh the component.

2. Record weight reading in the component travel package.

c. Pass/Fail Criteria. Weight limits shall be in accordance with the component specification.

4B1.2.3 Dimension

a. Purpose. To ensure that the component configuration is within the dimensional limits that are specified in the applicable component specification.

b. Procedure

1. Physically measure the component.

2. Record dimensions in the component travel package.

c. Pass/Fail Criteria. The component configuration shall be in accordance with the dimensional limits that are specified in the component specification.

4B1.2.4 Identification

a. Purpose. To ensure that the component identification tag contains the applicable information as required by the component specification.

b. Procedure. As applicable, check identification tags to verify:

1. Component name

2. Manufacturer identification

3. Date of manufacture

4. Date of explosive loading for components containing explosives

5. Serial number

6. Part number

7. Shelf life

8. Service life

4B1.2.5 X-Ray

a. Purpose. To nondestructively inspect the internal parts of a component.

b. Procedure. Perform X-ray radiographic tests in accordance with MIL-STD-453 or the equivalent.

NOTE: The components shall be X-rayed to quality level 2-2T of MIL-STD-453 or the equivalent unless otherwise specified in the component specification.

c. Pass/Fail Criteria. The X-ray evaluation shall be in accordance with the accept/reject criteria that is established by the component specification.

4B1.2.6 N-Ray

a. Purpose. To nondestructively inspect the internal nonmetallic components of explosive components. **NOTE:** N-ray radiographic testing shall conform to the requirements of ASTM E 748.

b. Pass/Fail Criteria. N-ray inspection shall be in accordance with the accept/reject criteria established by the component specification.

4B1.2.7 Leakage

a. Purpose. To demonstrate the capability of a component to meet the component design leakage rate.

b. Procedure. Perform leak rate tests in accordance with the requirements of MIL-STD-202, Method 112, Procedure III or IV or the equivalent.

c. Pass/Fail Criteria. The leak rate shall not component specification.

APPENDIX 4B1

RSS COMPONENT COMMON TEST REQUIREMENTS

4B1.3 Non-Operating Environment

4B1.3.1 Storage Temperature

a. Purpose. To determine the ability of the test component to withstand high and low temperature conditions during all storage conditions without degradation in performance

b. Conditions

1. The minimum storage temperature range is -34°C to +71°C.

2. The test item shall be in its approved storage configuration.

c. Procedure

1. Expose the component to the high and low temperatures for a minimum of 7 cycles and a 12 h dwell at each temperature extreme.

2. Visually inspect the component for any signs of deterioration.

d. Pass/Fail Criteria. The component performance shall not degrade after it has been exposed to the test temperatures.

4B1.3.2 High Temperature Exposure

a. Purpose. To determine the ability of the device to withstand exposure to high temperature.

b. Condition. The item shall be placed in an oven preheated to 30° above the maximum predicted temperature during service life, but not less than 71°C for a period of 1 h.

c. Procedure. Dissect the item and visually inspect for any decomposition and/or degradation.

d. Pass/Fail Criteria. The item shall not autoignite or decompose as a result of this exposure.

4B1.3.3 Transport Shock/Bench Handling

To ensure that the test component can withstand the relatively infrequent, non-repetitive shocks encountered in handling, transportation, and service.

4B1.3.3.1 Transportation Shock Test

a. Conditions

1. The test component shall be packaged in the manner intended for shipment.

2. The test component shall be oriented so that, upon impact, a line from the impacting corner or edge to the center of gravity of the transportation case and the component is perpendicular to the impact surface.

3. Drops shall be made from a quick-release hook or drop tester.

b. Procedure. Drop each corner, each flat face,

and each edge of the component from a height of 48 in. onto a concrete surface.

c. Pass/Fail Criteria. The component shall not be damaged and shall be capable of meeting the performance requirements of its specification.

4B1.3.3.2 Bench Handling Shock

a. Condition. The test component shall be unpacked and in a ready-to-use configuration.

b. Procedure

1. Configure the item as it would be for servicing.

2. Position the item as it would be for servicing.

3. Using one edge as a pivot, lift the opposite edge of the chassis until one of the following conditions occurs:

(a) The chassis forms an angle of 45° with the horizontal bench top

(b) The lifted edge of the chassis has been raised 4 in. above the horizontal bench top

4. Let the item drop freely to the solid wood bench top.

5. Repeat, using other edges of the same horizontal face as pivot points, for a total of four drops.

6. Repeat 3 above with the test item resting on other faces until it has been dropped for a total of four times on each face on which the test item could be placed practically during servicing. **NOTE:** The test item shall not be operating.

7. Visually inspect the test item.

c. Pass/Fail Criteria. The component shall be capable of meeting the performance requirements of its specification.

4B1.3.4 Transportation Vibration

a. Purpose. To ensure that the component can withstand the transportation environment that may be encountered during logistic transportation conditions on the land, on the sea, and in the air.

b. Conditions

1. The component shall be packaged in the manner intended for shipment.

2. The test duration shall be 60 min minimum per axis.

c. Procedure. Expose each axis of the component to the levels listed below:

0.01500 g²/Hz at 10 Hz to 40 Hz

0.01500 g²/Hz at 40 Hz to 0.00015 g²/Hz at 500 Hz

NOTE: If the test component is resonant below 10 Hz, extend the curve to the lowest resonant fre-

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quency.

d. Pass/Fail Criteria. The component shall be capable of meeting the performance requirements of its specification.

4B1.3.5 Fungus Resistance

a. Purpose. To determine that the component will resist fungal growth or if fungal growth occurs, the growth will not affect the performance of the component.

b. Procedure. Perform the fungal resistance test in accordance with MIL-STD-810, Method 508.4 or the equivalent.

c. Pass/Fail Criteria. The component shall be inspected in accordance with criteria stated in the component specifications.

4B1.3.6 Salt Fog

a. Purpose. To determine the ability of the test component to resist the effects of a moist, salt-laden atmosphere. This test is applicable to any component that will be exposed to salt fog conditions while in service.

b. Condition. The component shall be completely unpacked and in a ready-to-use configuration.

c. Procedure

1. Perform a full functional test of the component and record the test results.

2. Place the test component in a test chamber and expose the component to 5 percent salt fog at 35°C for a period of 48 h.

3. At the end of the exposure period, inspect the component for corrosion.

4. Store the test component in ambient atmosphere for 48 h.

5. At the end of the ambient stage period, operate the test component again and compare the results with the data collected prior to the start of the test. **NOTE:** If required, the test component may be gently washed in running water not warmer than 38°C.

d. Pass/Fail Criteria

1. The component shall be capable of meeting the performance requirements of the component specification.

2. The component performance shall not vary from the data that was collected during the full functional test prior to the start of the test.

4B1.3.7 Fine Sand

a. Purpose. To determine the ability of the test

item to resist the effects of dust or fine sand particles that may penetrate into cracks, crevices, and bearings and joints causing degradation of the performance, effectiveness, and reliability of the component.

b. Conditions

1. The test item shall be in a configuration that would allow it to be exposed to dust and fine sand conditions (in a shipping or storage container, a transit case, ready to use).

2. Relative humidity shall not exceed 30 percent.

3. Silica sand, at least 95 percent by weight SiO_2 , shall be used as the test medium. The size distribution as determined by weight using the US Standard Sieve Series shall be as follows:

(a) 1 percent shall be retained by a 20 mesh screen

(b) 1.7 percent shall be retained by a 30 mesh screen

(c) 14.8 percent shall be retained by a 40 mesh screen

(d) 37.0 percent shall be retained by a 50 mesh screen

(e) 28.6 percent shall be retained by a 70 mesh screen

(f) 12.7 percent shall be retained by a 100 mesh screen

(g) 5.2 percent shall pass through a 100 mesh screen

c. Procedure

1. Expose each face of the test item to a sand dust having a velocity of 18 to 29 meters per second for a total of 90 min per face.

2. If operation of the test item is required, continuously operate the test item for a minimum of 10 min during the last period of the test.

3. Visually inspect the component for abrasion, clogging effects, and any evidence of sand penetration.

d. Pass/Fail Criteria

1. The performance of the test item shall not be degraded.

2. Abrasion of the test item shall not exceed the amount specified in its component specification.

4B1.3.8 Pull

The purpose of the following tests is to verify the capability of the components to withstand handling tensile loads without damage or degradation of

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performance.

4B1.3.8.1 Initiator

EED Initiator Pins and EBW initiator pins (terminals) shall be capable of withstanding an axial pull of at least 18 lb for not less than 1 min without damage or degradation in performance.

4B1.3.8.2 ETS, FOCA, LIDs Pigtail, and Optical Connector

a. Conditions

1. 100 lb tensile load for qualification test
2. 50 lb tensile load for acceptance test

b. Pass/Fail Criteria. The component and its associated fittings shall be capable of withstanding tensile loads, as stated in the Condition, for 1 min minimum without damage or degradation in performance.

4B1.3.8.3 Destruct Charge

a. Conditions

1. 50 lb for qualification test
2. 25 lb for acceptance test

b. Pass/Fail Criteria. The component and associated fittings shall be capable of withstanding tensile loads, as stated in the Condition, for 1 min minimum without damage or degradation in performance.

4B1.3.96-ft Drop

To demonstrate that the component will not initiate when dropped from a height of 6 ft and that it will perform to specification after impact.

4B1.3.9.1 Initiator

a. Conditions

1. The initiator shall be dropped onto a 1/2-in. thick steel plate from a height of 6 ft.
2. The initiator shall be dropped twice.

b. Procedure

1. Drop the initiator to cause it to impact on the output end. This is drop 1 of 2.
2. Drop the initiator to cause it to impact on its side. This is drop 2 of 2.

c. Pass/Fail Criteria. The detonator shall not fire, dud, or deteriorate in performance as a result of this test.

4B1.3.9.2 ETS

a. Procedure. Drop the component onto a 1/2-in. thick steel plate from a height of 6 ft.

b. Pass/Fail Criteria

1. The component shall not detonate and it shall remain safe to handle.

2. The component shall function after the test if the effects of the test are not detectable.

4B1.3.9.3 Destruct Charge

a. Procedure. Drop the component onto a 1/2-in. thick steel plate from a height of 6 ft.

b. Pass/Fail Criteria

1. The component shall not detonate and it shall remain safe to handle.

2. The component shall function after the test if the effects of the test are not detectable.

4B1.3.10 40-ft Drop

a. Purpose. To demonstrate that the components will not initiate when dropped from a height of 40 ft and will be safe to handle.

b. Procedure. Drop the component onto a 1/2-in. thick steel plate from a height of 40 ft.

c. Pass/Fail Criteria. The component shall not detonate and shall remain safe to handle. The component is not required to function after the test.

4B1.4 Operating Environment

4B1.4.1 Qualification

4B1.4.1.1 Sinusoidal Vibration

a. Purpose

1. To demonstrate the ability of the component to withstand or, if appropriate, to operate at the design levels of the sinusoidal or decaying sinusoidal type dynamic vibration environment that is specified for the component.

2. To determine any resonant conditions that could result in failure in flight or in subsequent vibration tests.

b. Conditions

1. A full functional test shall be conducted before and after the completion of the sinusoidal vibration test.

2. Critical parameters, as agreed to by Range Safety, shall be continuously monitored for failures or intermittents during the vibration test.

3. When monitoring during the vibration test is not practical, a limited functional test shall be performed after the vibration test for each axis.

4. The component shall be tested in each of 3 mutually perpendicular axes. Significant resonant frequencies in each of these axes shall be noted and recorded.

5. As applicable, the component shall be

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mounted, including dynamic isolator (if used), as in flight configuration with flight-type support structure, hardware, cable, and explosive transfer line (ETL).

6. The induced cross axis acceleration at the attach points should be limited to the maximum test levels specified for the cross axes.

7. Tests that are conducted to determine resonant conditions shall be conducted using test levels and duration that are sufficient to provide diagnostic capability.

8. Sinusoidal excitation may be applied as a dwell at discrete frequencies or as a frequency sweep with the frequency varying at a logarithmic rate.

9. The sweep rate for diagnostic tests shall be slow enough to allow identification of significant resonances.

10. Tests that are conducted to demonstrate the degree of ruggedness shall be a duration of 2 min per octave unless the sweep rates and dwell times can be based on the persistence of the environment in in-service use.

11. The vibration level shall be at 6 dB above the maximum predicted environment.

c. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation of performance.

4B1.4.1.2 Random Vibration

a. Purpose. To determine if the test component will continue to operate in an environment with a vibration level at 6 dB above the maximum predicted environment (MPE) and to ensure that the acceptance will not damage the flight unit.

4B1.4.1.2.1 Hard Mounted Components.

a. Conditions

1. A full functional test shall be conducted before and after the completion of the random vibration test.

2. During the random vibration test, electrical and electronic components, including redundant circuits, shall be electrically energized and functionally sequenced through various operational modes to the maximum extent possible.

3. Critical parameters, as agreed to by Range Safety, shall be continuously monitored for failures or intermittents during the random vibration test.

4. Where insufficient time is available at the full test level to test all functions and modes, extended testing at a level 6 dB lower shall be conducted as necessary to complete functional testing.

b. Procedure

1. Mount the component as in flight configuration with flight-type support structure, bracket, hardware, cable, and ETL, as applicable.

2. Vibrate the component in each of three orthogonal axes.

3. The vibration test duration in each of the three orthogonal axes shall be 3 times the expected flight exposure time to the MPE or 3 times the component random vibration acceptance test time if that time is greater, but not less than 3 min per axis.

4. The minimum vibration test level shall be 6 dB above the MPE; however, the power spectrum density shall not fall below that shown in Table 4B1-1.

Table 4B1-1
Minimum Power Spectral Density
For Qualification Random Vibration

Frequency Range	Minimum Power Spectral Density
20	0.021 g ² /Hz
20 - 150	3 dB/OCTAVE SLOPE
150 - 600	0.16 g ² /Hz
600 - 2000	-6 dB/OCTAVE SLOPE
2000	0.014 g ² /Hz
Overall GRMS = 12.2	

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c. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.1.2.2 Isolator Mounted Components.

a. Conditions

1. A full functional test shall be conducted before and after the completion of the random vibration test.

2. During the random vibration test, electrical and electronic components, including redundant circuits, shall be electrically energized and functionally sequenced through various operational modes to the maximum extent possible.

3. Critical parameters, as agreed to by Range Safety, shall be continuously monitored for failures or intermittents during the random vibration test.

4. Where insufficient time is available at the full test level to test all functions and modes, extended testing at a level 6 dB lower shall be conducted as necessary to complete functional testing.

5. The isolator shall have passed the acceptance test in accordance with the requirements in Appendix 4B11.

6. The component shall be qualification tested in both hard mounted and isolated mounted configuration. **NOTE:** The hard mounted test is to ensure that subsequent acceptance tests will not damage the hardware. The isolated mounted test is to qualify the interfaces in flight configuration.

b. Hard Mount Procedure

1. Mount the component as in flight configuration with flight-type support structure, bracket, hardware, cable, ETL (as applicable) and without the isolator.

2. Vibrate the component in each of three orthogonal axes.

3. The vibration test duration in each of the three orthogonal axes shall be 3 times the expected flight exposure time to the MPE or 3 times the component random vibration acceptance test time if that time is greater, but not less than 3 min per axis.

4. The random vibration power spectrum density (PSD) used for this test shall be obtained as follows: (See also Figure 4B1-1)

(a) Using either the mass simulator, development or flight unit with the isolator mounted in flight configuration with flight-type cable, ETL (as applicable), vibrate the unit at 3 orthogonal axes at the component maximum MPE for 1 min for each

axis.

(b) Obtain the unit response PSD and envelop all 3 axes into one composite curve A.

(c) Obtain a new PSD curve B by adding 1.5 dB to Curve A.

(d) Compare PSD curve B to the minimum PSD for acceptance as is shown in Table 4B1-2.

(e) Create a new curve by enveloping the most stringent value of both curves. **NOTE:** This new PSD curve (curve C) becomes the PSD for acceptance testing.

(f) Obtain a qualification PSD (curve D) by adding 6 dB to curve C.

c. Isolator Mount Procedure

1. Mount the component as in flight configuration with flight-type support structure, hardware, cable, ETL (as applicable), and brackets.

2. Vibrate the component in each of three orthogonal axes.

3. The vibration test duration in each of the three orthogonal axes shall be 3 times the expected flight exposure time to the MPE or 3 times the component random vibration acceptance test time if that time is greater, but not less than 3 min per axis.

4. The minimum vibration input test level at the isolator shall be 6 dB above the MPE; however, the PSD shall not fall below that shown in Table 4B1-1.

d. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specifications without any physical damage or degradation in performance.

4B1.4.1.3 Acoustic

a. Purpose. To determine if the test component will continue to operate in an environment with a sound pressure level at 6 dB above the MPE.

b. Conditions

1. A full functional test shall be conducted before and after the completion of the acoustic vibration test.

2. During the acoustic vibration test, electrical and electronic components, including redundant circuits, shall be electrically energized and functionally sequenced through various operational modes to the maximum extent possible.

3. Critical parameters as agreed to by Range Safety shall be continuously monitored for failures

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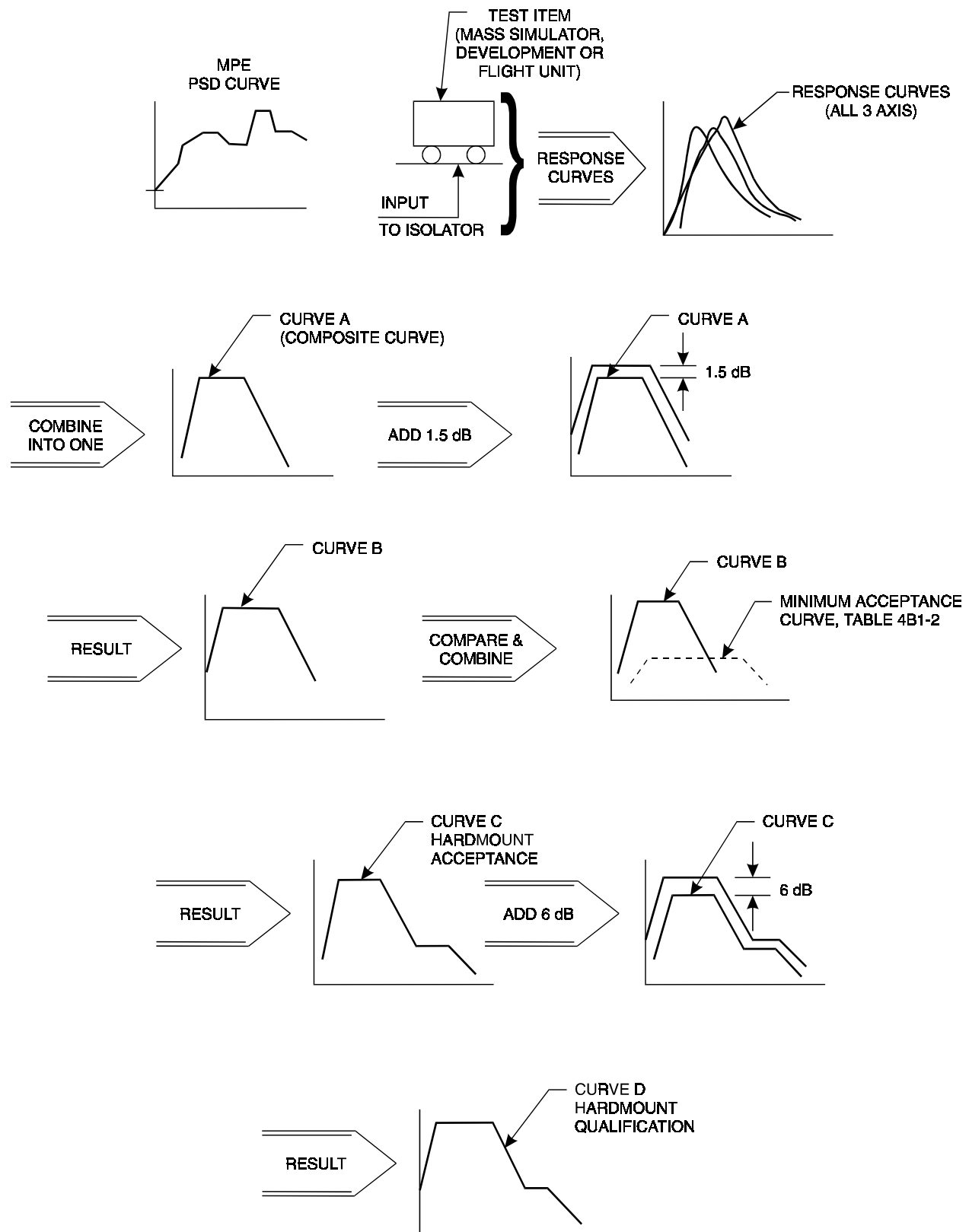


Figure 4B1-1
Obtaining Power Spectrum Density

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or intermittents during the acoustic vibration test.

4. The component shall be installed in a reverberant acoustic cell capable of generating desired sound pressure level.

5. As applicable, the component shall be mounted, including dynamic isolator (if used), as in flight configuration with flight-type support structure, hardware, cable, ETL, and brackets.

6. The sound pressure level shall be at the designed level (6 dB above the MPE), but not less than 144 dBA overall.

7. The test duration shall be 3 times the expected flight exposure time to the MPE or 3 times the acoustic acceptance test duration, whichever is greater, but not less than 3 min.

8. Where there is insufficient time at the full test level to test all functions and modes, extended testing at a level 6 dB lower shall be conducted as necessary to complete functional testing.

c. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.1.4 Shock

a. Purpose. To determine if the test component can withstand shock in each direction along each of the 3 orthogonal axes at the maximum predicted level plus 6 dB or a minimum of 1300 g.

b. Conditions

1. A full functional test shall be performed before and after all shock tests and several critical parameters continuously monitored during the shocks to evaluate performance and to detect any failures.

2. A visual inspection shall be made before and after the test.

3. The visual inspection shall not entail the removal of components covers nor any disassembly.

4. The proposed test method shall be validated prior to conducting tests on the flight component.

5. Any test technique that is used shall, as a minimum, provide the following:

(a) A transient with the prescribed shock spectrum can be generated within specified tolerances and

(b) The applied shock transient provides a simultaneous application of the frequency components as opposed to a serial application.

6. As applicable, the component shall be

mounted, including dynamic isolator (if used), as in flight configuration with flight-type support structure, hardware, cable, ETL, and brackets.

7. The shock spectrum in each direction along each of the 3 orthogonal axes shall be at least the maximum predicted level plus 6 dB or a minimum of 1300 G, whichever is greater, for that direction.

8. The minimum number of shocks shall be 3 times per axis for each direction, positive and negative, for a total of 18 shocks.

9. The duration shall simulate the actual event.

10. The minimum frequency range shall be from 100 to 10,000 Hz.

c. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.1.5 Acceleration

a. Purpose. To determine if the test component can withstand an acceleration level at least twice the maximum predicted levels or a minimum of 20 G in each direction for each of the 3 orthogonal axes.

b. Conditions. **NOTE:** If the peak acceleration is less than 3 times the square root of G (where G is the integrated area from 0 to 0.8 times the natural frequency response of a randomly vibrated system), then the random vibration test can usually be accepted in lieu of an acceleration test.

1. A full functional test shall be conducted before the acceleration test and after completion of the test.

2. Electrical components shall be powered during the test and critical parameters continuously monitored for failures or intermittents.

3. As applicable, the component shall be mounted, including dynamic isolator (if used), as in flight configuration with flight-type support structure, bracket, hardware, cable, and ETL.

4. The component shall be tested in each of 3 mutually perpendicular axes.

5. The specified accelerations apply to the geometric center of the test component.

6. If a centrifuge is used, the arm measured to the geometric center of the test component shall be at least 5 times the dimension of the test component measured along the arm.

7. The test acceleration level shall be at least twice the maximum predicted levels or 20 G, whichever is greater, in each direction for each of

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the 3 orthogonal axes.

8. The duration of the test shall be five min per each axis in each direction.

c. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.1.6 Humidity

a. Purpose. To determine if the test component is capable of surviving without excessive degradation when exposed to humidity during fabrication, test, shipment, storage, and launch operations.

b. Conditions

1. A full functional test shall be conducted before the humidity test and at the end of Cycle 3 and visually inspected for deterioration or damage.

2. The component shall also be functionally tested during the Cycle 4 periods of stability.

3. The component shall be placed in a chamber to simulate the normal installation.

4. Chamber temperature shall be at normal room ambient conditions with uncontrolled humidity.

5. The component shall be visually inspected for deterioration or damage after removal from the chamber.

c. Procedure

1. Cycle 1

(a) Increase the temperature to 35°C over a 1 h period.

(b) Increase the humidity to not less than 95 percent over a 1 h period with the temperature maintained at 35°C.

(c) Maintain temperature and humidity for 2 h.

(d) Reduce the temperature to 2°C over a 2-h period with the relative humidity stabilized at not less than 95 percent.

(e) Maintain these conditions for 2 h.

2. Cycle 2. Repeat cycle one with the following exception: *Increase the temperature from 2°C to 35°C over a 2 h period and do not add moisture to the chamber until 35°C is reached.*

3. Cycle 3

(a) Increase the chamber temperature to 35°C over a 2 h period without adding any moisture to the chamber.

(b) Dry the component with air at room temperature and 50 percent maximum relative

humidity (RH) by blowing air through the chamber for 6 h. The volume of air that is used per minute shall be equal to 1 to 3 times the test chamber volume. A suitable container may be used in place of the test chamber for drying the component.

(c) Visually inspect the component for physical damage or deterioration.

(d) Perform a full functional test.

4. Cycle 4

(a) Place the component in the test chamber and increase the temperature to 35°C and increase RH to 90 percent over a 1 h period.

(b) Maintain these conditions for at least 1 h.

(c) Perform a full functional test.

(d) Reduce the temperature to 2°C over a 1 h period with the RH stabilized at 90 percent.

(e) Maintain these conditions for at least 1 h.

(f) Perform a full functional test.

(g) Perform a drying cycle in accordance with cycle 3.

d. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.1.7 Thermal Cycle

a. Purpose. To demonstrate the ability of the component to operate over the design temperature range and to survive the thermal cycling screening test that is imposed upon the component during acceptance testing.

b. Conditions

1. Full Functional tests shall be conducted during the 1, 2, 12, 13, 23, and 24 thermal cycles at high and low temperatures and after return of the component to ambient.

(a) The functional test at the 1 and 23 cycle shall be performed at high voltage input.

(b) The functional test at the 2 and 24 cycle shall be performed at low voltage input.

(c) The functional test at the 12 and 13 cycle shall be performed at nominal voltage input.

2. During the remainder of the test, electrical components, including all redundant circuits, shall be cycled through various operational modes and critical parameters monitored for failures and intermittents. These tests shall be performed at the nominal voltage input.

3. Pressure

(a) Ambient pressure shall normally be used unless testing is performed to the requirements of

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paragraph 3(c) below.

(b) When unsealed components are being tested, the chamber may be flooded with dry air or nitrogen to preclude condensation on and within the component at low temperature.

(c) This test may be performed in a thermal vacuum and combined with the thermal vacuum tests, provided that the temperature limits, number of cycles, rate of temperature change, and dwell times conform to this test.

4. Temperature

(a) Non-Ordnance. The component temperatures shall be at the maximum flight predicted high temperature plus 10°C or 71°C, whichever is higher, during the hot cycle and at the maximum flight predicted low temperature minus 10°C or -34°C, whichever is lower, during the cold cycle.

(b) Ordnance. The component temperatures shall be at the maximum flight predicted high temperature plus 10°C or 71°C, whichever is higher during the hot cycle and at the maximum flight predicted low temperature minus 10°C or -54°C, whichever is lower during the cold cycle.

5. Duration

(a) Non-Ordnance. Three times the number of thermal cycles as used for acceptance testing but not less than 24 cycles total. Each cycle shall have a 1 h minimum dwell at the high and at the low temperature levels during which the unit shall be turned off until the temperature stabilizes and then turned on. The dwell time at the high and low levels shall be long enough to obtain internal thermal equilibrium. The test unit transitions between low and high temperatures shall be at an average rate of at least 1°C per min.

(b) Ordnance. The minimum number of thermal cycles testing shall not be less than 8 cycles. Each cycle shall have a 2 h minimum dwell at the high and at the low temperature levels. The transitions between low and high temperatures shall be at the maximum predicted thermal transient for the components, but not less than 3°C per min.

6. A thermal cycle begins with the components at ambient temperature.

c. Procedure. **NOTE:** Steps 1 through 9 represent one thermal cycle.

1. With the component operating (power ON) and while critical parameters are being continuously monitored, reduce the chamber temperature to the specified low temperature level as measured at a representative location on the component, such as

the mounting point on the baseplate for conduction-dominated internal designs or a representative location on the case for radiation-controlled designs.

2. After the component temperature has stabilized at less than 3°C per h rate of change, turn the unit off, permit the component to soak for one-half the specified dwell time, and then cold start it.

3. Continue the soak time for one-half the specified dwell time period.

4. Perform the functional test as specified in the *Conditions* section.

5. With the component operating, and while critical parameters are being continuously monitored, increase the chamber temperature to the upper temperature level.

6. After the component temperature has stabilized at the specified level, turn the component off, permit the component to soak for one-half the specified dwell time period, and then hot start it.

7. Continue the soak time for one-half the specified dwell time period.

8. Perform the functional test as specified in the *Conditions* section.

9. The temperature of the chamber shall then be reduced to ambient conditions.

d. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.1.8 Thermal Vacuum

a. Purpose. To demonstrate the ability of the component to perform in a thermal vacuum environment that simulates the design environment for the component.

b. Conditions

1. Full functional tests shall be conducted at the high and low temperature levels during the first and last cycle and after return of the component to ambient temperature.

2. During the remainder of the test, electrical and electronic components, including all redundant circuits and paths, shall be monitored for failures and intermittents to the maximum extent possible.

3. Monitoring of the RF output for corona shall be conducted using spectrum monitoring instrumentation during chamber pressure reduction.

4. The RF component shall be operated at maximum power and at design frequency.

5. The force or torque design margin shall be

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measured on moving mechanical assemblies at the environmental extremes.

6. The component shall be mounted in a vacuum chamber on a thermally controlled heat sink or in the actual flight configuration when installed in the launch vehicle.

7. A temperature sensor shall be attached to the component baseplate for conduction-dominated internal designs or to a representative case locations for a component cooled primarily by radiation. **NOTE:** This sensor shall be used to determine and control the test temperature.

8. Components shall be operating during the initial reduction of pressure to the specified lowest pressure levels.

9. Components shall be monitored for arcing and corona during the initial reduction of pressure to the specified lowest pressure levels. **NOTE:** These components may be turned off after the test pressure level has been reached. With the chamber at the test pressure level, RF equipment shall be monitored to assure that corona does not occur.

10. The time for reduction of chamber pressure from ambient to 20 Pascals (0.15 Torr) shall be at least 10 min to allow sufficient time in the region of critical pressure.

11. A minimum of 3 temperature cycles shall be used.

12. Each cycle shall have a 12 h or longer dwell at the high and at the low temperature levels during which time the unit is turned off until the temperature stabilizes and then is turned on.

13. The component temperature shall be at the maximum flight predicted high temperature plus 10°C or 71°C, whichever is higher during the hot cycle and at the maximum flight predicted low temperature minus 10°C or -34°C, whichever is lower during the cold cycle. **NOTE:** A temperature cycle begins with the chamber at ambient temperature.

c. Procedure

1. With the component in the thermal chamber, reduce the pressure from atmospheric to a critical pressure (pressure at which a corona or arcing is likely to occur). A function test shall be performed.

2. Reduce the pressure from critical pressure to a minimum of 0.0133 Pascals (0.0001 Torr) or actual flight altitude, whichever is less. **NOTE:** Steps 3 through 6 constitute one complete temperature cycle.

3. With the component operating, reduce and stabilize the component temperature to the specified low level.

4. After the component temperature has stabilized at the specified level and all electrical circuits have been discharged, turn the component off then cold-start it.

5. With the component operating, increase the component temperature to the upper temperature level.

6. After the component temperature has stabilized at the specified level and all electrical circuits have been discharged, turn the component off and then hot-start it. **NOTE:** Temperature stability has been achieved when the rate of change is no more than 3°C per h. The component heat transfer to the thermally controlled heat sink and the radiation heat transfer to the environment shall be controlled to the same proportions as calculated for the flight environment.

7. Reduce the temperature of the chamber to ambient conditions.

d. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.1.9 EMI/EMC

a. Purpose. To determine if the test component can continue to operate under an electromagnetic environment.

b. Procedure. Test the component to the requirements of MIL-STD-461 or equivalent. The RF level shall be at the maximum expected or the default level of MIL-STD-461, whichever is greater.

4B1.4.1.10 Explosive Atmosphere

a. Purpose. To determine the ability of the test component to operate in the presence of an explosive atmosphere without creating an explosion.

b. Condition. When being laboratory tested, the component shall operate in the presence of the optimum fuel vapor laden environment that requires the least amount of energy for ignition.

c. Procedure. A test method selected from an appropriate Military Standard or equivalent document is acceptable.

d. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or

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degradation in performance.

4B1.4.1.11 Disassembly

a. Purpose. To inspect the component internal parts for excessive wear and damage after exposure to qualification level environments

b. Conditions

1. Components that require disassembly shall be completely taken apart to the point at which all internal parts can be inspected.

2. All internal components and subassemblies such as circuit board traces, internal connectors, screws, clamps, electronic piece parts, and mechanical subassemblies shall be examined using an appropriate inspection method (magnifying lens, radiographic).

3. The type of inspection that is required and the pass/fail criteria shall be included in the qualification test plan.

4. Components such as antennas, potted units, and welded structures that cannot be disassembled due to manufacturing techniques will be required to meet special inspection criteria. This may include depotting units, cutting components into cross-sections or radiographic inspection.

c. Pass/Fail Criteria. A component that exhibits any sign that an internal part is stressed beyond its design limit (cracked circuit boards, loose connectors/screws, bent clamps/screws, worn parts) is considered a failure of the component under test even if the component passes the final functional test.

4B1.4.2 Acceptance Tests

4B1.4.2.1 Random Vibration

a. Purpose. To detect material and workman-ship defects prior to acceptance of the component for flight

b. Conditions

1. A full functional test shall be conducted before and after the completion of the random vibration test.

2. During the random vibration test, electrical and electronic components, including redundant circuits, shall be electrically energized and functionally sequenced through various operational modes to the maximum extent possible.

3. Critical parameters as agreed to by Range Safety shall be continuously monitored for failures or intermittents during the random vibration test.

4. Where insufficient time is available at the full test level to test all functions and modes, extended testing at a level 6 dB lower shall be conducted as necessary to complete functional testing.

c. Procedure

1. Vibrate the component in each of 3 orthogonal axes.

2. The vibration test duration in each of the 3 orthogonal axes shall equal or exceed the expected flight exposure time, but shall not be less than 1 min per axis.

3. For hard mounted components, the minimum vibration test level shall be the MPE; however, the PSD shall not fall below that shown in Table 4B1-2.

Table 4B1-2
Minimum Power Spectral Density
For Acceptance Random Vibration

Frequency Range	Minimum PSD
20	0.0053 g ² /Hz
20-150	3 dB/OCTAVE SLOPE
150-600	0.04 g ² /Hz
600-2000	-6 dB/OCTAVE SLOPE
2000	0.0036 g ² /Hz
Overall GRMS = 6.1	

4. For isolated mounted components, the component shall be vibrated in a hard mounted mode and the PSD used shall be Curve C as defined in the **Random Vibration Qualification** section of this Appendix.

d. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.2.2 Acoustic

a. Purpose. To detect material and workmanship defects prior to acceptance of the component for flight.

b. Conditions

1. A full functional test shall be conducted before and after the completion of the acoustic vibration test.

2. During the acoustic vibration test, electrical and electronic components, including redundant circuits, shall be electrically energized and functionally sequenced through various operational modes to the maximum extent possible.

3. Critical parameters as agreed to by Range Safety shall be continuously monitored for failures or intermittents during the acoustic vibration test.

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4. The component shall be installed in a reverberant acoustic cell capable of generating desired sound pressure level.

5. The acoustic spectrum shall represent the maximum predicted flight environment.

6. The overall sound pressure level for acceptance testing shall not be less than 138 dBA.

7. The exposure time at full acceptance test level shall be equal to or exceed the maximum expected flight exposure time, but shall not be less than 1 min.

8. Where sufficient time is not available at the full test level to test all functions and modes, extended testing at a level 6 dB lower shall be conducted as necessary to complete functional testing.

c. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.2.3 Acceleration

a. Purpose. To detect material and workmanship defects prior to acceptance of the component for flight.

b. Conditions

1. A full functional test shall be conducted before the acceleration test and after completion of the test.

2. Electrical components shall be powered during the test and critical parameters continuously monitored for failures or intermittents.

3. The test acceleration level shall be at the maximum predicted levels or 10 g, whichever is greater, in each direction for each of the 3 orthogonal axes.

4. The duration of the test shall be 3 min. per each axis in each direction.

c. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation of performance.

4B1.4.2.4 Thermal Cycle

a. Purpose. To detect material and workmanship defects prior to acceptance of the component for flight.

b. Conditions

1. Full functional tests shall be conducted during the 1, 2, 7, and 8 thermal cycles at high and low temperatures and after return of the component

to ambient.

(a) The functional test at the 1 and 7 cycle shall be performed at high voltage input.

(b) The functional test at the 2 and 8 cycle shall be performed at low voltage input.

2. During the remainder of the test, electrical components, including all redundant circuits, shall be cycled through various operational modes and critical parameters monitored for failures and intermittents. These tests shall be performed at the nominal voltage input.

3. Pressure

(a) Ambient pressure shall normally be used unless testing is performed to the requirements of paragraph 3(c) below.

(b) When unsealed components are being tested, the chamber may be flooded with dry air or nitrogen to preclude condensation on and within the component at low temperature.

(c) This test may be performed in a thermal vacuum and combined with the thermal vacuum tests, provided that the temperature limits, number of cycles, rate of temperature change, and dwell times conform to this test.

4. Duration

(a) A minimum of 8 cycles shall be performed.

(b) Each cycle shall have a 1 h minimum dwell at the high and at the low temperature levels during which the unit shall be turned off until the temperature stabilizes and then turned on. The dwell time at the high and low levels shall be long enough to obtain internal thermal equilibrium. The transitions between low and high temperatures shall be at an average rate of at least 1°C per min.

5. A thermal cycle begins with the component at ambient temperature.

6. The high temperature shall be the maximum predicted but not less than 61°C and the low temperature shall be the minimum predicted but not higher than -24°C.

c. Procedure. **NOTE:** Steps 1 through 9 represent one thermal cycle.

1. With the component operating (power ON) and while critical parameters are being continuously monitored, reduce the chamber temperature to the specified low temperature level as measured at a representative location on the component, such as the mounting point on the baseplate for conduction-dominated internal designs or a representative

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location on the case for radiation-controlled designs.

2. After the component temperature has stabilized at less than 3°C per h rate of change, turn the unit off, permit the component to soak for one-half the specified dwell time, and then cold start it.

3. Continue the soak time for one-half the specified dwell time period.

4. Perform the functional test as specified in the *CONDITIONS* section.

5. With the component operating, and while critical parameters are being continuously monitored, increase the chamber temperature to the upper temperature level.

6. After the component temperature has stabilized at the specified level, turn the component off, permit the component to soak for one-half the specified dwell time period, and then hot start it.

7. Continue the soak time for one-half the specified dwell time period.

8. Perform the functional test as specified in the *Conditions* section.

9. The temperature of the chamber shall then be reduced to ambient conditions.

d. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.2.5 Thermal Vacuum

a. Purpose. To detect material and workmanship defects prior to acceptance of the component for flight.

b. Conditions

1. Full functional tests shall be conducted at the high and low temperature levels and after return of the component to ambient temperature.

2. Monitoring of the RF output for corona shall be conducted using spectrum monitoring instrumentation during chamber pressure reduction.

3. The RF component shall be operated at maximum power and at design frequency.

4. The force or torque design margin shall be measured on moving mechanical assemblies at the environmental extremes.

5. The component shall be mounted in a vacuum chamber on a thermally controlled heat sink or in the actual flight configuration when installed in the launch vehicle.

6. A temperature sensor shall be attached to the component baseplate for conduction-dominated internal designs or to a representative case locations for a component cooled primarily by radiation. **NOTE:** This sensor shall be used to determine and control the test temperature.

7. Components shall be operating during the initial reduction of pressure to the specified lowest pressure levels.

8. Components shall be monitored for arcing and corona during the initial reduction of pressure to the specified lowest pressure levels. **NOTE:** These components may be turned off after the test pressure level has been reached. With the chamber at the test pressure level, RF equipment shall be monitored to assure that corona does not occur.

9. The time for reduction of chamber pressure from ambient to 20 Pascals (0.15 Torr) shall be at least 10 min to allow sufficient time in the region of critical pressure.

10. The component temperature shall be at the maximum flight predicted high temperature or 61°C, whichever is higher, during the hot cycle and at the maximum flight predicted low temperature or -24°C, whichever is lower, during the cold cycle.

11. A minimum of one temperature cycle shall be used.

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12. Each temperature cycle shall have a 12 h or longer dwell at the high and at the low temperature levels during which time the unit is turned off until the temperature stabilizes and then is turned on.

c. Procedure

1. With the component in the thermal chamber, reduce the pressure from atmospheric to a critical pressure (pressure at which a corona or arcing is likely to occur). A function test shall be performed.

2. Reduce the pressure from critical pressure to a minimum of 0.0133 Pascals (0.0001 Torr) or actual flight altitude, whichever is less. **NOTE:** Steps 3 through 6 constitute one complete temperature cycle.

3. With the component operating, reduce and stabilize the component temperature to the specified low level.

4. After the component temperature has stabilized at the specified level and all electrical circuits have been discharged, turn the component off and then cold-start it.

5. Increase the component temperature to the upper temperature level.

6. After the component temperature has stabilized at the specified level and all electrical circuits have been discharged, turn the component off and then hot-start it. **NOTE:** Temperature stability has been achieved when the rate of change is no more than 3°C per h. The component heat transfer to the thermally controlled heat sink and the radiation heat transfer to the environment shall be controlled to the same proportions as calculated for the flight environment.

6. Reduce the temperature of the chamber to ambient conditions.

d. Pass/Fail Criteria. The test component shall be capable of meeting the requirements of the applicable specification(s) without any physical damage or degradation in performance.

4B1.4.2.6 Burn-In

a. Purpose. To detect material and workmanship defects that occur early in component life.

b. Conditions

1. A modified thermal cycling test shall be used to accumulate the additional operational hours that are required for the burn-in test of electronic and electrical components.

2. The transitions between low and high temperatures shall be at an average rate greater than 1°C per min.

3. The high temperature shall be the maximum predicted but not less than +61°C, and the low temperature shall be the minimum predicted but not higher than -24°C.

4. The total operating time for component burn-in shall be 300 h including the operating time during thermal cycle.

5. The minimum number of temperature cycles shall be 18 including those conducted during the thermal cycling acceptance test.

6. Additional test time beyond the time that is required for thermal cycling shall be conducted at either the maximum or the minimum temperature.

c. Procedure

1. While the component is operating (power ON) and all of the critical parameters are being monitored, reduce the temperature of the component to the specified low temperature level.

2. Operate the component at the low temperature level for a minimum of 1 h.

3. Increase the component temperature to the specified high temperature level and continue to operate the component at this temperature for a minimum of 1 h.

4. To complete one cycle of the burn-in test, reduce the component temperature to ambient temperature.

APPENDIX 4B2 ANTENNA SYSTEM TEST REQUIREMENTS

Table 4B2-1
Antenna System Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Tests (a)		
Grounding	4B2.1	100%
Impedance/VSWR	4B2.2	100%
Insertion Loss	4B2.4	100%
RF Isolation	4B2.5	100%
Reference Functional Test (b)		
Impedance/VSWR	4B2.2	100%
Operating Environment Tests		
Acoustic	4B1.4.2.2	100%
Acceleration	4B1.4.2.3	100%
Thermal Cycling	4B1.4.2.4	100%
Thermal Vacuum	4B1.4.2.5	100%
Random Vibration	4B1.4.2.1	100%
Leakage (c)	4B1.2.7	100%

(a) These tests shall be performed prior to and after each environmental test.

(b) This test shall be performed during the operating environment tests.

(c) This test shall be performed after the last operating environment test.

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ANTENNA SYSTEM TEST REQUIREMENTS

Table 4B2-2
Antenna System Qualification Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Acceptance	ACCEPTANCE TEST MATRIX	X	X	X
Antenna Patterns (a)	4B2.6	X	X	X
Functional Tests (b)				
Grounding	4B2.1	X	X	X
Impedance/VSWR	4B2.2	X	X	X
Polarization	4B2.3	X	X	X
Insertion loss	4B2.4	X	X	X
RF Isolation	4B2.5	X	X	X
Reference Functional Test (c)				
Impedance/VSWR	4B2.2	X	X	X
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X	X	X
Transport Shock/Bench Handling	4B1.3.3	X	X	X
Transportation Vibration	4B1.3.4	X	X	X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6		X	
Fine Sand	4B1.3.7			X
Operating Environment Tests				
Sinusoidal Vibration	4B1.4.1.1	X	X	X
Acoustic	4B1.4.1.3	X	X	X
Shock	4B1.4.1.4	X	X	X
Acceleration	4B1.4.1.5	X	X	X
Humidity	4B1.4.1.6			X
Thermal Cycling	4B1.4.1.7	X	X	X
Thermal Vacuum	4B1.4.1.8	X	X	X
Random Vibration	4B1.4.1.2	X	X	X
EMI/EMC	4B1.4.1.9			X
Leakage (d)	4B1.2.7	X	X	X
Disassembly	4B1.4.1.11	X	X	X

(a) This test shall only be performed prior to environmental testing and after all environmental testing has been completed.

(b) These tests shall be performed prior to and after each environmental test.

(c) This test shall be performed during the operating environment tests.

(d) This test shall be performed after the last non-operating and the last operating environment tests.

APPENDIX 4B2

ANTENNA SYSTEM TEST REQUIREMENTS

4B2.1 Grounding

Measure all external conductive parts of the antenna system to verify that they are at ground potential in accordance with the component specification.

4B2.2 Impedance and VSWR

Measure the impedance and VSWR at the assigned operating frequency and at the maximum and the minimum frequencies of the operational bandwidth.

4B2.3 Polarization

Perform test to demonstrate the component compatibility with the on-axis, left-hand circular polarization.

4B2.4 Insertion Loss

Measure the antenna system insertion loss.

4B2.5 RF Isolation (Couplers only)

Measure the isolation between the RF junction ports.

4B2.6 Antenna Patterns

a. Perform antenna pattern measurements in accordance with RCC Document 253.

b. Compare the pre-qualification test pattern data to the post-qualification test pattern to determine if a significant change has occurred in the antenna radiation pattern. **NOTE:** A significant change is defined as more than 3 dB change over the 95 percent spherical coverage.

APPENDIX 4B3

COMMAND RECEIVER/DECODER TEST REQUIREMENTS

Table 4B3-1
Standard Command Receiver/Decoder Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Full Functional Tests (a)		
Resistances (b)	4B3.1	100%
DC Input Voltage	4B3.2	100%
Input Current	4B3.3	100%
Self-Test	4B3.4	100%
Leakage Current	4B3.6	100%
Input Impedance/VSWR	4B3.7	100%
RF Threshold Sensitivity	4B3.8	100%
Output Functions	4B3.9	100%
Maximum Usable RF Level	4B3.10	100%
RF Level Monitor (SSTO)	4B3.11	100%
CW Bandwidth	4B3.13	100%
Operational Bandwidth	4B3.15	100%
CW Peak-To-Valley Ratio	4B3.15	100%
Decoder Channel Bandwidth	4B3.16	100%
Decoder Channel Deviation	4B3.17	100%
Capture Ratio	4B3.21	100%
AM Rejection 50%	4B3.22	100%
Response Time	4B3.23	100%
Output Load Characteristic	4B3.25	100%
Decoder Logic	4B3.46	100%
Reference Functional Tests (c)		
Input Current Monitor	4B3.43	100%
Output Functions	4B3.9	100%
RF Level Monitor (SSTO)	4B3.11	100%
Operating Environment Tests		
Acoustic	4B1.4.2.2	100%
Acceleration	4B1.4.2.3	100%
Thermal Cycling (d)	4B1.4.2.4	100%
Thermal Vacuum (e)	4B1.4.2.5	100%
Random Vibration	4B1.4.2.1	100%
Burn-In	4B1.4.2.6	100%
Leakage (f)	4B1.2.7	100%

(a) These tests shall be performed prior to and after each environmental test.

(b) This test shall be performed prior to and after all environmental tests have been completed.

(c) These tests shall be performed during the operating environment tests.

(d) The full functional tests, except test 4B3.1, 2, 3, 4, 6, and 7, shall be performed at high voltage input on the 1 and 7 cycles, low voltage input on the 2 and 8 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(e) The full functional test, except test 4B3.1, 2, 3, 4, 6, and 7, shall be performed during the high and low temperature soak periods.

(f) This test shall be performed after the last operating environment test.

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COMMAND RECEIVER/DECODER TEST REQUIREMENTS

Table 4B3-2
Standard Command Receiver/Decoder Qualification Test Matrix
 (Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Acceptance	ACCEPTANCE TEST MATRIX	X	X	X
Circuit Protection Tests (a)				
Reverse Polarity Protection	4B3.5	X	X	X
Telemetry Short Circuit	4B3.32	X	X	X
Output Circuit Protection	4B3.33	X	X	X
Abnormal Voltage	4B3.34	X	X	X
Over Voltage Protection	4B3.45	X	X	X
Functional Tests (b)				
Resistances (c)	4B3.1	X	X	X
DC Input Voltage	4B3.2	X	X	X
Input Current	4B3.3	X	X	X
Self-Test	4B3.4	X	X	X
Leakage Current	4B3.6	X	X	X
Input Impedance/VSWR	4B3.7	X	X	X
RF Threshold Sensitivity	4B3.8	X	X	X
Output Functions	4B3.9	X	X	X
Maximum Usable RF Level	4B3.10	X	X	X
RF Level Monitor (SSTO)	4B3.11	X	X	X
CW Bandwidth	4B3.13	X	X	X
Operational Bandwidth	4B3.15	X	X	X
CW Peak-To-Valley Ratio	4B3.15	X	X	X
Decoder Channel Bandwidth	4B3.16	X	X	X
Decoder Channel Deviation	4B3.17	X	X	X
Adjacent Channel Rejection	4B3.19	X	X	X
Spurious Response Rejection	4B3.20	X	X	X
Capture Ratio	4B3.21	X	X	X
AM Rejection 50% & 100%	4B3.22	X	X	X
Response Time	4B3.23	X	X	X
Output Load Characteristics	4B3.25	X	X	X
Image Rejection	4B3.26	X	X	X
Warm-up Time	4B3.27	X	X	X
Dynamic Stability	4B3.28	X	X	X
Out-Of-Band Rejection	4B3.29	X	X	X
Noise Immunity	4B3.30	X	X	X
Decoder Logic	4B3.46	X	X	X

(a) One time test.

(b) These tests shall be performed prior to and after each environmental test.

(c) This test shall be performed prior to and after all environmental tests have been completed.

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COMMAND RECEIVER/DECODER TEST REQUIREMENTS

Table 4B3-2, Continued
Standard Command Receiver/Decoder Qualification Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Reference Functional Tests (<i>d</i>)				
Input Current Monitor	4B3.43	X	X	X
Output Functions	4B3.9	X	X	X
RF Level Monitor (SSTO)	4B3.11	X	X	X
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X	X	X
Transport Shock/Bench Handling	4B1.3.3	X	X	X
Transportation Vibration	4B1.3.4	X	X	X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6	X		
Fine Sand	4B1.3.7		X	
Operating Environment Tests				
Sinusoidal Vibration	4B1.4.1.1	X	X	X
Acoustic	4B1.4.1.3	X	X	X
Shock	4B1.4.1.4	X	X	X
Acceleration	4B1.4.1.5	X	X	X
Humidity	4B1.4.1.6			X
Thermal Cycling (<i>e</i>)	4B1.4.1.7	X	X	X
Thermal Vacuum (<i>f</i>)	4B1.4.1.8	X	X	X
Random Vibration	4B1.4.1.2	X	X	X
EMI/EMC	4B3.44		X	X
Explosive Atmosphere	4B1.4.1.10	X		
Leakage (<i>g</i>)	4B1.2.7	X	X	X
Disassembly	4B1.4.1.11	X	X	X

(*d*) These tests shall be performed during the operating environment tests.

(*e*) The full functional tests, except 4B3.1, 2, 3, 4, 6, 7, 36, 37, 38, and 42, shall be performed at high voltage input on the 1 and 23 cycles, nominal voltage on the 12 and 13 cycles, low voltage input on the 2 and 24 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(*f*) The full functional tests, except 4B3.1, 2, 3, 4, 6, 7, 36, 37, 38, and 42, shall be performed at high and low temperature soak period of first and last cycle.

(*g*) This test shall be performed after the last non-operating and the last operating environment tests.

APPENDIX 4B3 COMMAND RECEIVER/DECODER TEST REQUIREMENTS

Table 4B3-3
Secure Command Receiver/Decoder Acceptance Test Matrix
(Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Full Functional Tests (a)		
Resistances (b)	4B3.1	100%
DC Input Voltage	4B3.2	100%
Input Current	4B3.3	100%
Self-Test	4B3.4	100%
Leakage Current	4B3.6	100%
Input Impedance/VSWR	4B3.7	100%
RF Threshold Sensitivity	4B3.8	100%
Output Functions	4B3.9	100%
Maximum Usable RF Level	4B3.10	100%
RF Level Monitor (SSTO)	4B3.11	100%
CW Bandwidth	4B3.13	100%
Operational Bandwidth	4B3.15	100%
CW Peak-To-Valley Ratio	4B3.15	100%
Decoder Channel Bandwidth	4B3.16	100%
Decoder Channel Deviation	4B3.17	100%
Capture Ratio	4B3.21	100%
AM Rejection 50% (Pilot Tone)	4B3.22	100%
Response Time	4B3.23	100%
Output Load Characteristic	4B3.25	100%
Destruct Before Arm	4B3.39	100%
Reset	4B3.41	100%

(a) These tests shall be performed prior to and after each environmental test.

(b) This test shall be performed prior to and after all environmental tests have been completed.

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COMMAND RECEIVER/DECODER TEST REQUIREMENTS

Table 4B3-3, Continued
Secure Command Receiver/Decoder Acceptance Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED
Reference Functional Tests (c)		
Input Current Monitor	4B3.43	100%
Output Functions	4B3.9	100%
RF Level Monitor (SSTO)	4B3.11	100%
Operating Environment Tests		
Acoustic	4B1.4.2.2	100%
Acceleration	4B1.4.2.3	100%
Thermal Cycling (d)	4B1.4.2.4	100%
Thermal Vacuum (e)	4B1.4.2.5	100%
Random Vibration	4B1.4.2.1	100%
Burn-In	4B1.4.2.6	100%
Leakage (f)	4B1.2.7	100%

(c) These tests shall be performed during the operating environment tests.

(d) The full functional tests, except test 4B3.1, 2, 3, 4, 6, and 7, shall be performed at high voltage input on the 1 and 7 cycles, low voltage input on the 2 and 8 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(e) The full functional test, except test 4B3.1, 2, 3, 4, 6, and 7, shall be performed during the high and low temperature soak periods.

(f) This test shall be performed after the last operating environment test.

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COMMAND RECEIVER/DECODER TEST REQUIREMENTS

Table 4B3-4
Secure Command Receiver/Decoder Qualification Test Matrix
 (Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Acceptance	ACCEPTANCE TEST MATRIX	X	X	X
Circuit Protection Tests (a)				
Reverse Polarity Protection	4B3.5	X	X	X
Telemetry Short Circuit	4B3.32	X	X	X
Output Circuit Protection	4B3.33	X	X	X
Abnormal Voltage	4B3.34	X	X	X
Over Voltage Protection	4B3.45	X	X	X
Functional Tests (b)				
Resistances (c)	4B3.1	X	X	X
DC Input Voltage	4B3.2	X	X	X
Input Current	4B3.3	X	X	X
Self-Test	4B3.4	X	X	X
Leakage Current	4B3.6	X	X	X
Input Impedance/VSWR	4B3.7	X	X	X
RF Threshold Sensitivity	4B3.8	X	X	X
Output Functions	4B3.9	X	X	X
Maximum Usable RF Level	4B3.10	X	X	X
RF Level Monitor (SSTO)	4B3.11	X	X	X
CW Bandwidth	4B3.13	X	X	X
Operational Bandwidth	4B3.15	X	X	X
CW Peak-To-Valley Ratio	4B3.15	X	X	X
Decoder Channel Bandwidth	4B3.16	X	X	X
Decoder Channel Deviation	4B3.17	X	X	X
Spurious Response Rejection	4B3.20	X	X	X
Capture Ratio	4B3.21	X	X	X
AM Rejection 50% & 100% (Pilot Tone)	4B3.22	X	X	X
Response Time	4B3.23	X	X	X
Output Load Characteristics	4B3.25	X	X	X
Image Rejection	4B3.26	X	X	X
Warm-up Time	4B3.27	X	X	X
Dynamic Stability	4B3.28	X	X	X
Out-Of-Band Rejection	4B3.29	X	X	X

(a) One time test.

(b) These tests shall be performed prior to and after each environmental test.

(c) This test shall be performed prior to and after all environmental tests have been completed.

APPENDIX 4B3 COMMAND RECEIVER/DECODER TEST REQUIREMENTS

Table 4B3-4, Continued
Secure Command Receiver/Decoder Qualification Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Functional Tests (b) (continued):				
Tone Drop (a)	4B3.36	X	X	X
Tone Balance (a)	4B3.37	X	X	X
Message Timing (a)	4B3.38	X	X	X
Destruct Before Arm	4B3.39	X	X	X
Secure Logic	4B3.40	X	X	X
Reset	4B3.41	X	X	X
Memory (a)	4B3.42	X	X	X
Reference Functional Tests (d)				
Input Current Monitor	4B3.43	X	X	X
Output Functions	4B3.9	X	X	X
RF Level Monitor (SSTO)	4B3.11	X	X	X
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X	X	X
Transport Shock/Bench Handling	4B1.3.3	X	X	X
Transportation Vibration	4B1.3.4	X	X	X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6	X		
Fine Sand	4B1.3.7		X	
Operating Environment Tests				
Sinusoidal Vibration	4B1.4.1.1	X	X	X
Acoustic	4B1.4.1.3	X	X	X
Shock	4B1.4.1.4	X	X	X
Acceleration	4B1.4.1.5	X	X	X
Humidity	4B1.4.1.6			X
Thermal Cycling (e)	4B1.4.1.7	X	X	X
Thermal Vacuum (f)	4B1.4.1.8	X	X	X
Random Vibration	4B1.4.1.2	X	X	X
EMI/EMC	4B3.44		X	X
Explosive Atmosphere	4B1.4.1.10	X		
Leakage (g)	4B1.2.7	X	X	X
Disassembly	4B1.4.1.11	X	X	X

(a) One time test.

(b) These tests shall be performed prior to and after each environmental test.

(c) This test shall be performed prior to and after all environmental tests have been completed.

(d) These tests shall be performed during the operating environment tests.

(e) The full functional tests, except 4B3.1, 2, 3, 4, 6, 7, 36, 37, 38, and 42, shall be performed at high voltage input on the 1 and 23 cycles, nominal voltage on the 12 and 13 cycles, low voltage input on the 2 and 24 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(f) The full functional tests, except 4B3.1, 2, 3, 4, 6, 7, 36, 37, 38, and 42, shall be performed at high and low temperature soak period of first and last cycle.

(g) This test shall be performed after the last non-operating and the last operating environment tests.

APPENDIX 4B3

COMMAND RECEIVER/DECODER TEST REQUIREMENTS

NOTE: RCC 313 can be used to supplement test methodology.

4B3.1 Resistances

a. Verify that the CRD isolation and grounding resistance between the case ground and all power leads, signal outputs and command outputs, including returns, and between power leads and signal leads, including returns are within the requirements that are specified in the applicable component specification.

b. Measure all conductive external parts of the component to verify that they are at case ground potential.

4B3.2 DC Input Voltage

a. During this test, vary the DC power supply from the specified minimum to the maximum.

b. Verify that CRD power consumption is within the specified limits.

c. Verify that the CRD functions normally at all voltage requirements as specified by the applicable specification.

4B3.3 Input Current

a. Measure the maximum current in the standby mode at the low, nominal, and high supply voltage.

b. Measure the maximum current in the commanded mode (under loaded conditions) at the low, nominal, and high supply voltages.

4B3.4 Self-Test

a. Purpose. This test is applicable only to those CRDs that have microprocessors.

b. Procedure

1. Verify that the CRD microprocessor is capable of processing a test command routine and that it will issue a pass/fail output.

2. Verify that the CRD will not inhibit a command or cause a change state during a self-test routine.

4B3.5 Reverse Polarity Protection

Verify that the CRD will not be damaged, have a permanent deterioration of performance, or issue an outputting command when it is subjected to the reversal of the input voltage for a period of 5 min.

4B3.6 Leakage Current

Verify that the output leakage current (with no RF applied) does not exceed the value that is specified in the applicable specification.

4B3.7 Input Impedance and Voltage Standing Wave Ratio (VSWR)

Verify that the CRD input impedance is 50 ohms and that the VSWR is not greater than 2:1 across the specified bandwidth of the specified operating frequency.

4B3.8 RF Threshold Sensitivity

Verify the minimum RF signal input level at which the CRD correctly activates all command channels.

NOTE: The threshold sensitivity shall be as specified in the procurement specification but shall be between -107 dBm to -116 dBm.

4B3.9 Output Functions

Verify that the CRD responds to all input tone combinations at the minimum specified RF threshold level.

4B3.10 Maximum Usable RF Operating Level

Verify that the CRD will generate the correct output functions when it is subjected to variations of the RF signal input signal level up to a maximum of +13 dBm. **NOTE:** At a minimum, the following 5 RF input levels shall be used: +13 dBm (1 Vrms), -7 dBm (100,000 microvolts RMS [uVrms]), -27 dBm (10,000 uVrms), -67 dBm (100 uVrms) and the specified threshold sensitivity.

4B3.11 RF Level Monitor

Verify that the signal strength telemetry output monitor voltage meets the following requirements when operating into a 10 kilohm load. **NOTE:** This output is also called "Signal Strength Telemetry Output (SSTO)," or "Automatic Gain Control (AGC)".

a. The SSTO output level quiescent (no RF signal) condition shall be 0.5 ± 0.25 Vdc.

b. The SSTO measured command threshold sensitivity input condition shall be 0.1 Vdc minimum above the quiescent value.

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COMMAND RECEIVER/DECODER TEST REQUIREMENTS

c. The SSTO output level shall reach a maximum (4.75 ± 0.25 Vdc) with no less than 500 microvolts (-53 dBm) of RF input.

d. The shape of the transfer function shall not exceed approximately 1.0 Vdc change in voltage for each 13 dB change in RF input signal over the range between threshold and saturation.

e. The maximum SSTO voltage shall not exceed 5 Vdc under all conditions.

f. The slope of the SSTO voltage shall not change polarity from measured threshold to +13 dBm. **NOTE:** The slope of the SSTO voltage is monotonic.

4B3.12 Intentionally Left Blank

4B3.13 Continuous Wave Bandwidth

Verify that the continuous wave (CW) IF bandwidth of the receiver is 180.0 kHz minimum at 3 dB points and 360.0 kHz maximum at the 60 dB points.

4B3.14 Intentionally Left Blank

4B3.15 Operational Bandwidth/CW Peak-To-Valley Ratio

a. Verify that the CRD will properly function at all of the commands within the bandwidth of ± 45 kHz from the assigned RF center frequency with command input tone variations of plus and minus 27 kHz to plus and minus 33 kHz per tone. **NOTE:** The input RF level for this test shall be at the specified threshold sensitivity level.

b. Verify that the intermediate frequency (IF) filter is flat (within 3 dB) when it is subjected to an RF input signal (± 45 kHz) that is centered at the assigned frequency.

4B3.16 Decoder Channel Bandwidth

Verify that the CRD decoder channel bandwidth that is required to generate a tone is within the limits that are specified in the applicable component specification. **NOTE 1:** During this test the RF input signal shall be at -47 dBm (1000 microvolts). **NOTE 2:** For secure CRDs: Only the pilot tone is required to be measured during Acceptance testing.

4B3.17 Decoder Channel Deviation

a. Verify that the CRD decoder operates normally with a deviation of plus and minus 27 to 33 kHz per tone and at a two tone deviation of plus and minus 54 to 66 kHz.

b. Test the CRD decoder to ensure that it does not produce a decoder output at deviation levels of plus

or minus 9 kHz or less per tone.

c. Verify that the actual threshold deviation level at which the CRD first responds to commands is between plus and minus 9 kHz and plus and minus 18 kHz.

4B3.18 Intentionally Left Blank

4B3.19 Adjacent Tone Decoder Channel Rejection

Verify that the tone decoder channels do not respond to adjacent FM modulated tone channels when they are FM modulated with plus and minus 50 kHz per tone.

4B3.20 Spurious Response Rejection

Verify that any spurious response(s) that is within the frequency spectrum from 10 MHz to 1000 MHz (omitting the frequency band within the 60 dB bandwidth) is at least 60 dB minimum below the measured threshold sensitivity at center frequency.

4B3.21 Capture Ratio

Verify that the CRD will not be captured and/or interfered with when it is subjected to an unmodulated RF signal level up to 80 percent (-2 dB) of the desired modulated RF carrier signal at the same frequency.

4B3.22 AM Rejection 50 Percent and 100 Percent

Verify that the CRD can reject an AM modulated signal and that the CRD shall not produce an output from any decoder channel under the following conditions:

a. An RF input signal at the assigned center frequency of -90.1 dBm (7 microvolts) with 50 percent AM modulation by the assigned RCC tone frequencies

b. An RF input signal at the assigned frequency of -85.4 dBm (12 microvolts) signal with 50 percent AM modulation by the assigned RCC tone frequencies

c. An RF input signal at the assigned RF center frequency of -67 dBm (100 microvolts) with 100 percent peak AM noise modulation at Low Pass Filter (LPF) 3 dB frequencies of 3.5 kHz or 7.0 kHz.

4B3.23 Channel Response Time

Verify that the response time that is required for the CRD to activate the channel output when the tone(s)

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COMMAND RECEIVER/DECODER TEST REQUIREMENTS

is applied, is within the specified time that is indicated in the component specification. **NOTE 1:** The RF input level for this test shall be -67 dBm. **NOTE 2:** The minimum/maximum activation time is specified in applicable specification sheet but shall not be less than 4 millisecond nor greater than 25 millisecond when tested at the specified threshold sensitivity.

4B3.24 Intentionally Left Blank

4B3.25 Output Load Characteristics

Verify that the CRD is capable of outputting the specified power to the specified load on each output at any CRD input power supply voltage level between the minimum and the maximum specified.

4B3.26 Image Rejection

Verify that the CRD RF selectivity can reject frequencies other than the first harmonic and subharmonic of the assigned center frequency by 60 dB minimum.

4B3.27 Warm Up Time

Verify that time that is required by the CRD to properly respond to a command, after DC power is applied, is within the applicable component specification.

4B3.28 Dynamic Stability

Verify that the CRD will not produce false commands or spurious outputs when it is subjected to a change in the input of VSWR and/or open and short circuit conditions of the RF input sources.

4B3.29 Out-of-Band Rejection

Verify that the CRD will not respond to RF signals that are out-of-band as stated in the applicable component specification.

4B3.30 Noise Immunity

Verify that the CRD will not produce a command output when it is subjected to an RF signal of -95 dBm that is FM modulated with white noise at an amplitude of at least 12 dB higher than the measured deviation threshold of any individual audio tone. The white noise spectrum shall be at least 0 to 600 kHz.

4B3.31 Intentionally Left Blank

4B3.32 Telemetry Short Circuit

Verify that the CRD can process an Arm and Destruct command while the telemetry outputs are short circuited.

4B3.33 Output Circuit Protection

Verify that the CRD shall not be damaged by the application of up to 45 Vdc or the open circuit voltage (OCV) of the power source, whichever is greater, to any of the output monitor ports for up to 5 min.

a. When the ARM and OPTIONAL output channels are used for vehicle functions such as engine shutdown, they shall also meet the requirement stated above.

b. The CRD shall meet the requirement stated above in the ON and OFF mode.

4B3.34 Abnormal Voltage

Verify that the CRD can be subjected to low voltage and not suffer damage.

a. While a proper command is applied to the CRD, slowly adjust the voltage from zero to nominal voltage and back to zero.

b. Record the DC levels where the CRD first outputs the command and then ceases to output the command.

4B3.35 Intentionally Left Blank

4B3.36 Tone Drop

Verify that the CRD will reject an otherwise valid command when one tone in the sequence has been dropped.

4B3.37 Tone Balance

Verify that the amount of tone pair imbalances, with the CRD continuing to process the command, is within the component specification.

4B3.38 Message Timing

Verify that the CRD message timing tolerances are within the component specification.

4B3.39 DESTRICT Before ARM

Verify that the CRD will reject an otherwise valid DESTRICT command if not preceded by a valid ARM command.

4B3.40 Secure Logic

Verify that the CRD will reject a message that has been altered by one tone number from a valid command.

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4B3.41 Reset

Verify that the CRD will remove all outputs by DC power cycling (ON/OFF/ON) and by processing a valid secure reset command.

4B3.42 Memory

Verify that secure commands remain in memory for the specified time interval.

4B3.43 Input Current Monitor

Verify that the CRD current that is drawn during the standby and output command (ARM, DESTRUCT) mode is within the component specification.

4B3.44 EMI/EMC

a. Purpose. To determine if the test component can continue to operate under an electromagnetic environment.

b. Procedure. Test the component in accordance with the MIL-STD-462 procedure.

4B3.45 Overvoltage Protection

Verify that FTS components will meet the following overvoltage protection requirements:

a. FTS components shall not be damaged by the application of up to 45 Vdc or OCV of the power source, whichever is greater.

b. This voltage shall be applied in both normal and reverse polarity modes to the component power input ports for a period not less than 5 min.

c. The components shall not produce an output or be damaged.

4B3.46 Decoder Logic

At an RF level of -47 dBm, verify the CRD response to specified logics and ensure that it does not respond to abnormal logics per Table 4B3-5.

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COMMAND RECEIVER/DECODER TEST REQUIREMENTS

Table 4B3-5
Standard Logic Verification Test

TEST	SWITCH SEQUENCE	REQUIRED CRD OUTPUT	TONES ON
01	None	None	None
02	1 On	None	1
03	2 On	None	1, 2
04	5 On	ARM	1, 2, 5
05	5 Off	ARM and DESTRUCT	1, 2
06	2 Off	ARM	1
07	5 On	ARM	1, 5
08	2 On	ARM	1, 2, 5
09	2 Off	ARM	1, 5
10	5 Off	ARM	1
11	1 Off	None	None
12	2 On	None	2
13	1 On	None	1, 2
14	5 On	ARM	1, 2, 5
15	5 Off	ARM and DESTRUCT	1, 2
16	1 Off	None	2
17	5 Off	OPTIONAL	2, 5
18	1 On	ARM	1, 2, 5
19	1 Off	OPTIONAL	2, 5
20	5 Off	None	2
21	2 Off	None	None
22	5 On	None	5
23	1 On	ARM	1, 5
24	2 On	ARM	1, 2, 5
25	2 Off	ARM	1, 5
26	1 Off	None	5
27	2 On	OPTIONAL	2, 5
28	1 On	ARM	1, 2, 5
29	1 Off	OPTIONAL	2, 5
30	2 Off	None	5
31	5 Off	None	None
32	1 On	None	1
33	5 On	ARM	1, 5
34	2 On	ARM	1, 2, 5
35	5 Off	ARM and DESTRUCT	1, 2
36	2 Off	ARM	1
37	1 Off	None	None
38	1 On	None	1
39	5 On	ARM	1, 5
40	5 Off	ARM	1
41	2 On	ARM and DESTRUCT	1, 2
42	All Tones Off	None	None
43	4 On	CHECK CHANNEL	4
44	4 Off	None	None
45	4 On and repeat tests 01 through 44		

APPENDIX 4B4 BATTERY TEST REQUIREMENTS

Table 4B4-1
Silver Zinc Battery Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Inspection	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimensions	4B1.2.3	100%
Identification	4B1.2.4	100%
X-Ray	4B4.1.2	100%
Battery and Cell Venting	4B4.1.3	100%
Safety Devices	4B4.1.4	100% or Lot Sample (a)
Proof Pressure/Leak Test	4B4.1.5	100%
Electrolyte	4B4.1.6	100%
Electrical Tests		
Insulation Resistance	4B4.1.7	100%
Monitoring Devices	4B4.1.9	100%
Connector Pins Verification	4B4.1.10	100%
Heater Circuit Resistance	4B4.1.11	100%
Heater Circuit Operation	4B4.1.12	100%
Activation	4B4.1.13	100%
Leakage Current	4B4.1.14	100%
No-Load Voltage	4B4.1.15	100%
Load Test	4B4.1.16	100%
Verification Cell Acceptance Tests	4B4.1.1.5	1 Cell/Flight Battery
Discharge		
Cycling		

(a) If these tests can be performed on the actual article as a nondestructive test, they shall be tested on the article. If these tests are considered destructive in nature (such as burst disks), these tests shall be component tests of the same lot that will be used on flight articles. The lot sample shall be 10 percent of the lot but not less than 5 units, whichever is greater.

APPENDIX 4B4 BATTERY TEST REQUIREMENTS

Table 4B4-2
Silver Zinc Battery Qualification Test Matrix
(Page 1 of 2)

TEST	TEST REQUIREMENT	1	2	TEST GROUP
		3 (a)	12 (b)	QUANTITY
Product Examination				
Inspection	4B1.2.1	X	X	
Weight	4B1.2.2	X	X	
Dimensions	4B1.2.3	X	X	
Identification	4B1.2.4	X	X	
X-Ray	4B4.1.2	X	X	
Battery and Cell Venting	4B4.1.3	X	X	
Safety Devices (c)	4B4.1.4	X	X	
Proof Pressure/Leak Test	4B4.1.5	X	X	
Electrolyte	4B4.1.6	X	X	
Electrical Tests				
Insulation Resistance	4B4.1.7	X	X	
Monitoring Devices	4B4.1.9	X	X	
Connector Pins Verification	4B4.1.10	X	X	
Heater Circuit Resistance	4B4.1.11	X	X	
Heater Circuit Operation	4B4.1.12	X	X	
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X	X	
Transportation Shock/Bench Handling	4B1.3.3	X	X	
Transportation Vibration	4B1.3.4	X	X	
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6	X		
Fine Sand	4B1.3.7	X		
Activation	4B4.1.13	X	X	
Leakage Current	4B4.1.14	X	X	
No Load Voltage	4B4.1.15	X	X	
Qualification Load Test	4B4.1.17	X	X	
Reference Test				
Qualification Load Test (d)	4B4.1.16	X	X	

(a) Paragraph 4B4.1.1.4 Provides the additional testing units required for secondary silver zinc batteries.

(b) Test group 2 are cells only; also see paragraphs 4B4.1.1.3.

(c) If these tests can be performed on the actual article as a non-destructive test, they shall be tested on the article. If the tests are considered destructive in nature (such as burst disks), the article shall be from the lots that have successfully passed the lot acceptance test.

(d) This test is applicable to operating environment tests as described in paragraph 4B4.1.17. Actual load pulse (amperage and time) will be determined by manufacturer with Range Safety concurrence.

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BATTERY TEST REQUIREMENTS

Table 4B4-2
Silver Zinc Battery Qualification Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	1	2	TEST GROUP QUANTITY
		3 (a)	12 (b)	
Operating Environment Tests				
Wet Stand Time	4B4.1.19	X	X	
Overcharge	4B4.1.18	X		
Humidity	4B1.4.1.2	X		
Acoustic	4B1.4.1.3	X	X	
Shock	4B1.4.1.4	X	X	
Acceleration	4B1.4.1.5	X	X	
Sinusoidal Vibration	4B1.4.1.6	X	X	
Random Vibration	4B1.4.1.1	X	X	
Thermal Cycling (e)(f)	4B1.4.1.7	X	X	
Temperature, Altitude, Humidity	4B4.1.20	X	X	
EMI/EMC	4B1.4.1.9	X		
Discharge Design Capacity	4B4.1.21	X	X	
Leak Test	4B4.1.5	X	X	
Inspection(Destructive Physical Analysis) (g)	4B4.1.22	X	X	
Destructive Test				
Explosive Atmosphere (h)	4B1.4.1.10	X		

(e) Temperature limits shall be 10°C above maximum flight predicted high temperature and 10°C below maximum flight predicted low temperature. The minimum temperature margin of -10°C can be reduced to -10°F provided that a temperature sensor is within the battery and measurement tolerance of the sensor and telemetry system are less than 1.0°F.

(f) The number of thermal cycles shall be 8.

(g) To be performed after explosive atmosphere has been completed

(h) An electrical battery simulator/mockup can be use for this test.

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Table 4B4-3
Silver Zinc Battery Storage Life Verification Test Matrix

TEST	TEST REQUIREMENT	QUANTITY 2 CELLS/YEAR (a)
Product Examination		
Visual Inspection	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimensions	4B1.2.3	100%
Identification	4B1.2.4	100%
X-Ray	4B4.1.2	100%
Battery and Cell Venting	4B4.1.3	100%
Proof Pressure/Leak Test	4B4.1.5	100%
Electrolyte	4B4.1.6	100%
Electrical Tests		
Insulation Resistance	4B4.1.7	100%
Activation	4B4.1.13	100%
Leakage Current	4B4.1.14	100%
No-Load Voltage	4B4.1.15	100%
Qualification Load Test (b)	4B4.1.17	100%
Operating Environment Tests		
Acoustic	4B1.4.1.3	100%
Shock	4B1.4.1.4	100%
Acceleration	4B1.4.1.5	100%
Random Vibration	4B1.4.1.2	100%
Thermal Cycling (c)(d)	4B1.4.1.7	100%
Temperature, Altitude, Humidity	4B4.1.20	100%
Discharge Design Capacity	4B4.1.21	100%
Leak Test	4B4.1.5	100%
Inspection(Destructive Physical Analysis)	4B4.1.22	100%

(a) Reference paragraph 4B4.1.1.2.

(b) This test is applicable to operating environment tests as described in paragraph 4B4.1.17. Actual load pulse (amperage and time) will be determined by manufacturer with Range Safety concurrence.

(c) Temperature limits shall be 10°C above maximum flight predicted high temperature and 10°C below maximum flight predicted low temperature. The minimum temperature margin of -10°C can be reduced to -10°F provided that the combined temperature sensor and telemetry system tolerances are less than 1.0°F.

(d) The number of thermal cycles shall be 8.

APPENDIX 4B4

BATTERY TEST REQUIREMENTS

4B4.1 Silver Zinc Batteries

4B4.1.1 Scope

4B4.1.1.1 Silver Zinc Battery Failure Analysis

If a failure occurs or there is evidence of an internal cell failure or other similar damage that affects the performance testing of the battery, perform a full teardown analysis of the battery and affected cell.

4B4.1.1.2 Silver Zinc Battery Initial Production Buy and Storage Verification

a. Purpose. To ensure that dry and wet stand times have not affected the performance of a specific battery

b. Conditions

1. Initial procurement of flight production batteries shall include 2 additional cells per year of the manufacturer stated capability.

2. These cells shall be of the same lot when they are procured and electrically conditioned the same way as the other batteries and/or cells.

c. Procedure. At the end of each year, test 2 cells in accordance with the Storage Life Verification Test Matrix.

4B4.1.1.3 Silver Zinc Battery Qualification

a. Purpose

1. To verify that the chemical process is as predicted, that there are no additional chemical formations, and that the cell structure has not changed except for specifically predicted changes such as, enlargement of cell cases due to electrolyte soakage and slight electrode plate dimension change.

2. To develop baseline data for future investigations of any failure during production. **NOTE:** These tests are required of all the cells and/or battery systems that do not have specific development data of the cell construction to be tested.

3. To verify integrity of the mechanical properties of the battery and cells.

b. Conditions

1. Two test groups are required for qualification. Test Groups consist of full production-type batteries. Test Group 2 is composed of individual cells from the same lot used to form the qualification batteries.

2. A minimum of 12 cells is required for qualification testing (Test Group 2). **NOTE:** The quantity may be modified depending on the cell design

and the manufacturer capability to provide an internal investigation of the cells.

3. To verify integrity of the mechanical properties of the battery and cells.

c. Pass/Fail Criteria

1. The data shall show the chemical transformation that the cell processes through from the first activation through the qualification environments to the end of discharge.

2. The qualification test plan shall include the manufacturer expected results such as chemical formation, swelling of plates, and crystal salt growth for these tests.

3. The pass/fail criteria of **Silver Zinc Battery Discharge and Capacity** and **Silver Zinc Battery/Cell Inspection (Destructive Physical Analysis)** shall also be met.

4B4.1.1.4 Qualification of Secondary Cycle Batteries

a. Purpose. To provide the additional steps and quantities of batteries that are required for qualification of secondary batteries.

b. Procedure.

1. Operational environmental testing shall be conducted for each of the electrical cycles for all qualification batteries and cells. The batteries to be tested shall be at the end of each charge retention life for each cycle, with the final operational testing being accomplished at the end of the total specified wet stand time.

2. Alternative testing can include the use of additional batteries for testing for each electrical cycle. For example, if the specified number of electrical cycles is 2, three qualification batteries would be tested in the primary mode as outlined in the **Silver Zinc Battery Qualification Test Matrix** and an additional 3 batteries would be electrically cycled through the primary mode and then exposed to the **Silver Zinc Battery Qualification Test Matrix** on the second electrical cycle. The second set of three batteries will be tested at the end of the total specified wet stand time.

c. Pass/Fail Criteria

1. The data shall show the chemical transformation that the cell processes through from the first activation through the qualification environments to the end of discharge.

2. The qualification test plan shall include the manufacturer expected results such as chemical

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BATTERY TEST REQUIREMENTS

formation, swelling of plates, and crystal salt growth for these tests.

3. The pass/fail criteria of Silver Zinc Battery Discharge and Capacity and Silver Zinc Battery/Cell Inspection (Destructive Physical Analysis) shall also be met.

4B4.1.1.5 Verification Cell Acceptance Tests

a. Purpose. To verify that the flight battery cells were manufactured the same as the qualification battery cells and have not been exposed to environments exceeding the qualification parameters through cell testing

b. Conditions. 1 cell per flight battery, having the same lot date code shall be attached to the battery from manufacturing acceptance tests to just prior to installation of battery in launch vehicle.

c. Procedure

1. The cell shall be discharged at a moderate steady state rate to "end of voltage."

2. The cell shall be cycled through the specified number of electrical cycles utilizing the same discharge rate as step 1.

c. Pass/Fail Criteria. The cell shall demonstrate the amp hour capacity consistent with the qualification data. **NOTE:** This may exceed the specified value or warranted value.

4B4.1.2 Silver Zinc Battery X-Ray

a. Purpose. To non-destructively inspect structural welds of battery and cells

b. Procedure. Perform X-Ray and inspection on all welds of the cell and battery in accordance with MIL-STD-453.

c. Pass/Fail Criteria. The X-ray evaluation shall be in accordance with the accept/reject criteria that is established by the battery specification

4B4.1.3 Silver Zinc Battery and Cell Venting

a. Purpose. To verify cracking and reset pressure

b. Condition. Prior to using pressure relief devices incorporated into the battery and cell for qualification and acceptance testing, pressure relief devices shall be tested individually.

c. Procedure. Test the battery container vent pressure relief device in accordance with the manufacturer accepted test procedure.

d. Pass/Fail Criteria. The pressure relief device shall meet component specifications.

4B4.1.4 Silver Zinc Battery Safety Devices

a. Purpose. To demonstrate that safety devices are within design tolerance

b. Procedure

1. Lot acceptance test 100 percent of the safety devices that can be tested nondestructively.

2. Test a 10 percent lot sampling of each safety device such as burst discs, fuses, and diodes that acceptance testing would be considered destructive.

c. Pass/Fail Criteria. Safety devices shall meet design criteria.

4B4.1.5 Silver Zinc Battery Proof Pressure and Leak

a. Purpose. To verify that pressurized cells and batteries can withstand a proof pressure of 1.5 times the worst case operating pressure

b. Condition. The battery and/or cell shall be at room temperature.

c. Procedure

1. Pressurize the battery/cell with dry nitrogen or other appropriate gas to 1.5 times the component specified maximum operating pressure.

2. Monitor the pressure with a gauge or pressure transducer for a 1 h period at room temperature.

d. Pass/Fail Criteria.

1. The pressure drop shall not decay in 1 h after the pressure source has been removed.

2. There shall be no deformation of the battery or cell case or associated fitting, including electrical connectors and pressure port.

4B4.1.6 Silver Zinc Battery Electrolyte

a. Purpose. To verify electrolyte is within specifications to ensure consistent battery performance

b. Procedure. Test the chemical composition of the battery activation electrolyte stock solution in accordance with the supplier approved test procedure.

c. Pass/Fail Criteria. Electrolyte shall meet chemical purity defined in specification.

APPENDIX 4B4

BATTERY TEST REQUIREMENTS

4B4.1.7 Silver Zinc Battery Insulation Resistance

a. Purpose. To measure the resistance offered by the insulating material to an impressed direct voltage that could produce a leakage current. **NOTE:** This measurement should not be considered the equivalent of dielectric withstanding voltage tests.

b. Conditions

1. The insulation resistance test shall be performed prior to activation of the battery.

2. A second insulation resistance test shall be performed after activation of the battery.

c. Procedure. Measure the insulation resistance between the following mutually insulated components:

1. All battery connector pins and end of wire harness that would attach to cell terminals (pin-to-pin) at a potential of 500 ± 25 VDC.

2. Each connector pin and battery case (pin-to-case) at a potential of 500 ± 25 VDC.

d. Pass/Fail Criteria. The insulation resistance shall be 2 megohms or greater.

4B4.1.8 Intentionally Left Blank

4B4.1.9 Silver Zinc Battery Monitoring Devices

a. Purpose. To verify operation of temperature, voltage, and current monitoring devices prior to installation and after full battery assembly

b. Condition. The monitoring device test shall be performed at the piece part level and after the device has been installed.

c. Procedure. Test the measurement ranges of voltage, temperature, and current monitoring devices.

d. Pass/Fail Criteria. The voltage, temperature, and current monitoring devices shall be within the maximum and minimum range of the manufacturer specifications.

4B4.1.10 Silver Zinc Battery Connector Pins Verification

a. Purpose. To verify wires and associated connector pins are connected per the specification and drawing

b. Condition. Connector pin assignment shall be verified after installing the wiring but prior to activating the cell.

c. Procedure. Perform a continuity and isolation check to verify the proper pin assignments of all electrical connectors and pins. **NOTE:** Recommended isolation is 2 megohms and recommended continuity measurement is less than 0.05 ohms.

4B4.1.11 Silver Zinc Battery Heater Circuit Resistance

a. Purpose. To verify that thermistors used in heater circuits have not been damaged during installation

b. Procedure. Measure the heater circuit resistance, after installation in the battery case.

c. Pass/Fail Criteria. The heater circuit resistance shall meet the requirements of the applicable specification.

4B4.1.12 Silver Zinc Battery Heater Circuit Operations

a. Purpose. To verify complete heater circuit response at the proper external temperature

b. Procedure. Test the heater circuit operation at the low and high settings.

c. Pass/Fail Criteria. Heater circuit operation shall meet the requirements of the applicable specification.

4B4.1.13 Silver Zinc Battery/Cell Activation

a. Purpose. Activate batteries and cells.

b. Procedure. The activation shall be per manufacturer's procedure.

c. Pass/Fail Criteria. Deviations to the activation procedure will result in rejection of the battery or cell.

4B4.1.14 Silver Zinc Battery Leakage Current

a. Purpose. To verify no current leakage path due to spilled or leaked electrolyte

b. Conditions

1. This shall be performed after the no load and acceptance load test.

2. Voltage measurements shall be made using a digital voltmeter with a 100 kilohm resistor across the input.

c. Procedure. Perform voltage measurements from each connector pin (or cell terminal) to case for all connectors.

d. Pass/Fail Criteria. There shall be no voltages greater than 0.0 millivolts.

4B4.1.15 Silver Zinc Battery No Load Voltage

APPENDIX 4B4

BATTERY TEST REQUIREMENTS

a. Conditions

1. Open circuit voltage shall be verified without any load applied, immediately after activation and 48 h after soak.

2. Open circuit voltage measurements shall be made with a high impedance digital voltmeter having a current of 1.0 mA or less.

b. Procedure. Measure the open circuit voltage of the battery and each individual cell.

c. Pass/Fail Criteria. The open circuit voltage of the battery and individual cells shall meet the requirements of the applicable specification.

4B4.1.16 Silver Zinc Battery Acceptance Load

a. Conditions

1. The load shall be applied immediately after no load voltage measurements.

2. There shall not be a "no-load" interruption between application of loads.

b. Procedure

1. Subject the battery to a constant current load (equal to the load that is required when the RSS is on "internal") for 1 min.

2. Subject the battery to a pulse load that is equal to the maximum load that is required to support the RSS, (commonly the issuance of a DESTRUCT command) for 10 sec.

c. Pass/Fail Criteria. At no time shall the battery voltage fall below the minimum qualified voltage of the receiver and other RSS electrical components.

4B4.1.17 Silver Zinc Battery Qualification Load

a. Purpose. To ensure a qualification load application during actual environmental stresses do not reduce the battery voltage below the qualified voltage of the electronic components.

b. Conditions

1. The test equipment shall be set up to measure the resulting battery and/or cell characteristics. **NOTE:** The resolution of these measurements shall be 0.01 volts, 0.001 amps, and 0.0001 sec.

2. The battery and/or cell characteristics shall be graphed according to the following criteria:

(a) Y axis = voltage

(b) X axis = time

(c) A clearly marked horizontal line on the X axis shall show the minimum acceptable voltage.

(d) When and what magnitude loads are applied or removed shall be clearly indicated.

3. There shall not be a no-load interruption between the application of loads.

c. Procedures

1. Apply a steady state load to the battery for the duration of the test and include all loads the battery will be required to sustain during flight with the exception of the actual commanding of ARM and DESTRUCT.

2. Apply a current pulse after the steady state load test. The current pulse shall be based on two times the pulse width or 100 msec, whichever is greater, and two times the required pulse amperage that is used in the system for sending ARM and DESTRUCT commands and firing the initiator.

3. Thermal Cycling. During the first, middle, and last cycles of the thermal cycling test, perform the steady state load test and the current pulse test at the high and low temperature extremes soak time.

4. Temperature, Altitude, and Humidity. During the all three cycles of the temperature, altitude, and humidity operating environment test, perform the steady state load and the current pulse test at the high and low temperature extremes soak times.

5. Random Vibration. Perform the steady state and the current pulse test during each axis of random vibration.

6. Shock.

(a) Perform the steady state test during each shock test.

(b) Perform the steady state test for a minimum of 180 sec and the current pulse test after each axis shock.

d. Pass/Fail Criteria. The battery voltage shall not fall below the minimum qualified voltage of the electronic components.

4B4.1.18 Silver Zinc Battery/Cell Overcharge

a. Purpose. To demonstrate the capability of the battery and test cells to accept on overcharge condition.

b. Procedure. Apply an overcharge to the battery or cell using a nominal charging rate up to the specified limit.

c. Pass/Fail Criteria. The battery (or cell) shall pass all qualification tests after the overcharge has been applied.

4B4.1.19 Silver Zinc Battery Wet Stand Time

a. Purpose. To verify the battery performance is not degraded after a 60 day wet stand time.

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BATTERY TEST REQUIREMENTS

b. Conditions. The battery shall be stored in the same manner that actual flight batteries will be handled. Storage conditions shall take into account battery laboratory and launch vehicle stand environments.

c. Procedure

1. Activate the battery and let it stand for 60 days or whatever time the manufacturer's specified wet stand allows, whichever is greater, prior to operating environment tests.

2. Perform OCV tests on a periodic basis to document self-discharge characteristics.

3. Perform a load test after the initial OCV measurement to verify the chemical state of the battery.

d. Pass/Fail Criteria. Successfully complete operational testing and capacity requirement after a 60 day or the manufacturer's wet stand time.

4B4.1.20 Silver Zinc Battery Temperature, Altitude, and Humidity

NOTE 1: If this test is performed in its entirety, the Humidity Test and 3 cycles of the Thermal Cycling Test required in the Qualification Text Matrix will not have to be performed. **NOTE 2:** Refer to testing appendix for the required temperature margin.

a. Purpose

1. To ensure proper battery voltage regulation and mechanical stability of the battery and cells during varying temperatures, humidities, and altitude.

2. To ensure that the generation of gas does not force electrolyte from cells.

b. Procedure

1. High Temperature Step

(a) Place the battery in a test chamber that is maintained at sea level pressure with the temperature maintained at the maximum expected temperature plus 10°, and with the relative humidity maintained at 95 percent.

(b) Maintain these conditions for 4 h.

2. Low Temperature Step

(a) Reduce the temperature to the minimum expected temperature minus 10° with no humidity control.

(b) When the temperature of the battery has stabilized, perform a qualification load test.

3. Altitude Step

(a) In a period of 5 to 10 min, reduce the chamber pressure to 0.0001 Torr or less with no

temperature or humidity control.

(b) When the chamber pressure reaches 0.0001 Torr, perform another qualification load test.

4. High Temperature Step 2

(a) Return the chamber to standard atmospheric conditions and the battery to the maximum expected temperature plus 10°.

(b) When the chamber and battery stabilize, perform another qualification load test.

5. 0°F Step

(a) Maintain the chamber pressure at standard atmospheric conditions and reduce the chamber temperature to 0°F.

(b) If temperature is maintained with heaters, the following steps shall be performed at 0°F:

(1) Cycle the battery heaters through a heater cycle for minimum battery and temperature stabilization.

(2) Disconnect the heater power.

(3) After the battery has cooled down to the temperature that the heater would just turn on (thermostat setting), repeat the qualification load test.

6. Standard Atmospheric Condition Step

(a) When the temperature of the chamber has stabilized, bring the battery to standard atmospheric conditions (temperature and humidity).

(b) Perform another qualification load test.

7. Repeat the temperature, altitude, and humidity test described in steps 1 through 6 for two additional cycles for a total of three cycles.

4B4.1.21 Silver Zinc Battery Discharge and Capacity

a. Purpose

1. To verify sufficient battery capacity is equal to or greater than 150 percent of the mission time for which Range Safety has flight safety responsibility or 30-min hang-fire hold time plus mission time. The mission time includes the minus count time starting when the FTS has switched to the final internal power configuration (battery) through normal flight, with two ARM and DESTRUCT commands at the end of the time period. **NOTE:** The 30-min, hang-fire hold time applies only to vehicles using solid propellants and vehicles using solid propellant ignition systems.

2. To verify battery capacity is equal to or greater than the manufacturer warranted capacity.

b. Conditions

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BATTERY TEST REQUIREMENTS

1. The capacity evaluation shall be performed after all operational environment tests.

2. The capacity evaluation shall be performed at room temperature.

c. Procedure

1. Discharge each battery.

2. Use a C/2 discharge rate to the cutoff voltage.

NOTE: This cutoff depends on the lowest specified voltage of the electronic components or the manufacturer cutoff voltage, whichever is greater. For example, receivers are tested to a minimum of 24 VDC.

3. Monitor the battery and/or cell voltage and current.

4. Graph the results on a voltage versus time plot in accordance with the following criteria:

(a) Y axis = voltage

(b) X axis = time

(c) A clearly marked horizontal line on the X axis shall show the minimum acceptable voltage.

(d) When and what magnitude loads are applied or removed shall be clearly indicated.

d. Pass/Fail Criteria. At a minimum, the capacity demonstrated during this test and the amp-hour drawn during the operational environmental tests shall be the manufacturer warranted rating and be equal to, or greater than, 150 percent of the capacity that is required for actual use.

4B4.1.22 Silver Zinc Battery/Cell Inspection (Destructive Physical Analyses)

a. Purpose. To verify the proper chemical state and the actual physical construction of the cell

b. Conditions

1. Inspection shall be performed after completion of all environmental tests.

2. All cells shall be used for internal investigation.

3. The battery shall be disassembled and its cells removed for physical inspection.

c. Procedure

1. Record the open circuit voltage (OCV) of each cell in both Test Groups.

2. Internally inspect all battery wiring and cell interconnects and potting/shimming materials.

3. Discharge the batteries and individual cells at a C/2 rate to the manufacturer cutoff voltage.

4. Disassemble the batteries to gain access to all cells. The cell disassembly procedure shall be coordinated with Range Safety.

5. Leak check each cell.

6. Upon completion of discharge for capacity, all cells shall be discharged and subject to tear down and inspection.

7. Destructive physical analysis shall be performed on six cells minimum (one from each corner and two from the middle of each battery). At a minimum, the inspection shall include the following visual examinations with photography, when possible and observations recorded.

Plate Tabs - connection integrity

Plates - plate color, plate shape (size)

Separator - condition, silver migration, oxalate crystals.

d. Pass/Fail Criteria

1. The capacity shall meet the requirements of the **Silver Zinc Battery Discharge and Capacity** section of this Appendix.

2. The inspection shall verify the chemical state of the battery and the physical construction of the battery and cells.

3. A component that exhibits any sign that an internal part is stressed beyond its design is considered a failure of the component under test even if the component passes the final functional test.

APPENDIX 4B5 MISCELLANEOUS COMPONENT TEST REQUIREMENTS

Table 4B5-1
Miscellaneous Component Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Test (a)		
TBD		100%
Reference Functional Test (b)		
TBD		100%
Operating Environment Tests		
Acoustic	4B1.4.2.2	100%
Acceleration	4B1.4.2.3	100%
Thermal Cycling (c)	4B1.4.2.4	100%
Thermal Vacuum (d)	4B1.4.2.5	100%
Random Vibration	4B1.4.2.1	100%
Burn-In	4B1.4.2.6	100%
Leakage (e)	4B1.2.7	100%

(a) These tests shall be performed prior to and after each environmental test.

(b) This test shall be performed during the operating environment tests.

(c) The full functional tests shall be performed at high voltage input on the 1 and 7 cycles, low voltage input on the 2 and 8 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(d) The full functional test shall be performed during the high and low temperature soak period.

(e) This test shall be performed after the last operating environment test.

APPENDIX 4B5 MISCELLANEOUS COMPONENT TEST REQUIREMENTS

Table 4B5-2
Miscellaneous Component Qualification Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Acceptance	ACCEPTANCE TEST MATRIX	X	X	X
Functional Test (a) TBD	TBD	X	X	X
Reference Functional Test TBD (b) TBD (c)	TBD TBD	X X	X X	X X
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X	X	X
Transport Shock/Bench Hand- ling	4B1.3.3	X	X	X
Transportation Vibration	4B1.3.4	X	X	X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6		X	
Fine Sand	4B1.3.7			X
Operating Environment Tests				
Sinusoidal Vibration	4B1.4.1.1	X	X	X
Acoustic	4B1.4.1.3	X	X	X
Shock	4B1.4.1.4	X	X	X
Acceleration	4B1.4.1.5	X	X	X
Humidity	4B1.4.1.6			X
Thermal Cycling (d)	4B1.4.1.7	X	X	X
Thermal Vacuum (e)	4B1.4.1.8	X	X	X
Random Vibration	4B1.4.1.2	X	X	X
EMI/EMC	4B1.4.1.9		X	X
Explosive Atmosphere	4B1.4.1.10	X		
Leakage (f)	4B1.2.7	X	X	X
Disassembly	4B1.4.1.11	X	X	X

(a) This test shall be performed after all non-operating environment tests have been completed. This test shall also be performed after all operating environment tests have been completed.

(b) These tests shall be performed prior to and after each environmental test.

(c) This test shall be performed during the operating environment tests.

(d) The full functional tests shall be performed at high voltage input on the 1 and 23 cycles, nominal voltage on the 12 and 13 cycles, low voltage input on the 2 and 24 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(e) TBD tests shall be performed during the high and low temperature soak periods.

(f) This test shall be performed after the last non-operating and the last operating environment tests.

APPENDIX 4B6

S&A AND EED TEST REQUIREMENTS

Table 4B6-1
S&A Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Test (a)		
Full Bench Test	4B6.1	100%
Reference Functional Test (b)		
Limited Bench Test	4B6.2	100%
Operating Environment Tests		
Thermal Cycling (c)(d)	4B1.4.2.4	100%
Random Vibration (e)	4B1.4.2.1	100%
X-Ray	4B1.2.5	100%
N-Ray	4B1.2.6	100%
Leakage (f)	4B1.2.7	100%

(a) These tests shall be performed prior to and after all environmental tests.

(b) This test shall be performed prior to the random vibration test.

(c) Bridgewire resistance shall be measured at high and low temperature on the first, middle, and last cycles.

(d) The number of thermal cycles shall be 8 with dwell time of 1 h at each temperature extreme (-24°C to +61°C) or the MPE, whichever is more severe.

(e) During random vibration testing, the S&A ARM/SAFE telemetry circuits and firing line circuits shall be continuously monitored for status and chatter respectively.

(f) This test shall be performed after the last operating environment test.

APPENDIX 4B6 S&A AND EED TEST REQUIREMENTS

Table 4B6-2
S&A Qualification Test Matrix
(Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED			
		1	1	6	3
Acceptance	ACCEPTANCE TEST MATRIX	X	X	X	
Functional Test (a)					
Full Bench Test	4B6.1	X		X	
Reference Functional Test (b)					
Limited Bench Test	4B6.2	X		X	
Non-Operating Environment Tests					
Storage Temperature	4B1.3.1	X		X	
Transport Shock/Bench Handling	4B1.3.3	X		X	
Transportation Vibration	4B1.3.4	X		X	
Fungus Resistance	4B1.3.5	X			
Salt Fog	4B1.3.6	X			
Fine Sand	4B1.3.7	X			
Operating Environment Tests					
Stall, 5 min	4B6.4.1	X		X	
Sinusoidal Vibration (c)	4B1.4.1.1	X		X	
Shock (c)	4B1.4.1.4	X		X	
Acceleration (c)	4B1.4.1.5	X		X	
Humidity	4B1.4.1.6	X		X	
Thermal Cycling (d)(e)	4B1.4.1.7	X		X	
Random Vibration (c)	4B1.4.1.2	X		X	
Explosive Atmosphere	4B1.4.1.10	X			
Leakage (f)	4B1.2.7	X		X	
Disassembly	4B1.4.1.11			2	
Firing Test at Operating Current (g)					
At High Temperature (h)	4B6.7			2	
At Low Temperature (i)	4B6.7			2	

- (a) These tests shall be performed after all non-operating environment tests have been completed and after all operating environment tests have been completed.
- (b) These tests shall be performed after each environmental test (operating and non-operating) excluding leakage, explosive atmosphere, and disassembly.
- (c) During these tests, the S&A ARM/SAFE telemetry circuits and firing line circuits shall be continuously monitored for status and chatter respectively.
- (d) Bridgewire resistance shall be measured at high and low temperature on the first, middle, and last cycles.
- (e) The number of thermal cycles shall be 24 with dwell time of 2 h at each temperature extreme (-54EC to +71EC) or the MPE, whichever is more severe.
- (f) This test shall be performed after the last non-operating and the last operating environment test.
- (g) In the event that operating current cannot be predicted, the test current shall be 2 times the Bruceton All-Fire Current.
- (h) Fire at designed high temperature or +71°C whichever is higher.
- (i) Fire at designed low temperature or -54°C whichever is lower.

APPENDIX 4B6 S&A AND EED TEST REQUIREMENTS

Table 4B6-2
S&A Qualification Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED			
		1	1	6	3
Safety Test					
Cycle Life (<i>j</i>)	4B6.3	X			
Stall, 60 min (<i>j</i>)	4B6.4.2	X			
6-ft Drop Test (<i>k</i>)	4B6.5.1		X		
20-ft Drop Test (<i>j</i>)	4B6.5.2	X			
Visual Inspection (<i>l</i>)	---	X			
Barrier Test (<i>m</i>)	4B6.6				X

(*j*) The S&A exposed to these tests shall not be fired.

(*k*) The limited bench test shall be performed after this test. Also, the S&A shall be fired at ambient temperature after the limited bench test.

(*l*) The S&A shall be inspected for hazardous conditions prior to disposal.

(*m*) Test units that duplicate all dimensions shall be used, including gaps between explosive components, free volume, and diaphragm thickness (if used) of the operational S&A. The explosive transfer assemblies that are normally mated to the S&A in flight shall be used.

APPENDIX 4B6

S&A AND EED TEST REQUIREMENTS

Table 4B6-3
EED Lot Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Non-Destructive Tests		
Visual Inspection	4B1.2.1	100%
Dimension	4B1.2.3	100%
Leakage	4B1.2.7	100%
Static Discharge	4B6.8	100%
Pull Test (a)	4B1.3.8	100%
Bridgewire Resistance	4B6.9	100%
Insulation Resistance	4B6.10	100%
X-Ray	4B1.2.5	100%
N-Ray	4B1.2.6	100%
Destructive Tests		
Shock (b)	4B1.4.1.4	Lot Sample (c)
Thermal Cycling (b)(d)	4B1.4.1.7	Lot Sample
High Temp Storage (e)	4B6.18	Lot Sample
Random Vibration (b)	4B1.4.1.2	Lot Sample
X-Ray	4B1.2.5	Lot Sample
N-Ray	4B1.2.6	Lot Sample
Bridgewire Resistance	4B6.9	Lot Sample
Insulation Resistance	4B6.10	Lot Sample
Leakage	4B1.2.7	Lot Sample
No Fire Verification	4B6.11	Lot Sample
Firing Tests		
Ambient Temperature		
All-Fire Current (f)	4B6.16	1/6 Lot Sample
Operating Current (g)	4B6.16	1/6 Lot Sample
High Temperature (h)		
All-Fire Current (f)	4B6.16	1/6 Lot Sample
Operating Current (g)	4B6.16	1/6 Lot Sample
Low Temperature (i)		
All-Fire Current (f)	4B6.16	1/6 Lot Sample
Operating Current (g)	4B6.16	1/6 Lot Sample

(a) This test may be performed as in manufacture process.

(b) Environmental tests shall be performed at qualification levels.

(c) Lot sample is 10 percent of lot but not less than 30 units.

(d) The number of thermal cycles shall be 24 with dwell time of 2 h at each temperature extreme.

(e) This test is optional. If performed, the lot has initial service life of 3 yr.

(f) All-Fire current is specified All-Fire current vs Bruceton All-Fire current.

(g) In the event that operating current cannot be predicted, the test current shall be 2 times the Bruceton All-Fire Current.

(h) Fire at designed high temperature or +71°C whichever is higher.

(i) Fire at designed low temperature or -54°C whichever is lower.

APPENDIX 4B6

S&A AND EED TEST REQUIREMENTS

Table 4B6-4
EED Qualification Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED									
		120 (a)	230 (b)	45	45	5	5 (c)	6	5	5	105
Acceptance (Non-Destructive Test)	ACCEPTANCE TEST MATRIX	X	X	X	X	X	X	X	X	X	X
RF Impedance	4B6.12		10								
RF Sensitivity	4B6.13		<u>X</u> (d)								
RF Dudding	4B6.14	<u>X</u>									
No Fire Bruceton	4B6.15			<u>X</u>							
All-Fire Bruceton	4B6.15				<u>X</u>						
High Temp. Exposure	4B1.3.2					<u>X</u>					
Shock	4B1.4.1.4									X	X
Thermal Cycling (e)	4B1.4.1.7								X	X	X
High Temp. Storage (f)	4B6.18										30
Random Vibration	4B1.4.1.2										X
Drop Test (6 Foot)	4B1.3.9									X	X
Drop Test (40 Foot)	4B1.3.10						<u>X</u>				
Bridgewire Res.	4B6.9								X	X	X
Insulation Res.	4B6.10								X	X	X
Leakage	4B1.2.7								X	X	X
X-Ray	4B1.2.5								X	X	X
N-Ray	4B1.2.6								X	X	X
No Fire Verification	4B6.11							X	X	X	X
Firing Tests:											
Ambient Temperature											
All-Fire Current (g)	4B6.16							<u>X</u>	<u>X</u>	<u>X</u>	
Ambient Temp.											
All-Fire Current (g)	4B6.16										<u>15</u>
Oper. Current (h)	4B6.16										<u>15</u>
22 Amps Current	4B6.16										<u>5</u>
High Temp. (i)											
All-Fire Current (g)	4B6.16										<u>15</u>
Oper. Current (h)	4B6.16										<u>15</u>
22 Amps Current	4B6.16										<u>5</u>
Low Temp. (j)											
All-Fire Current (g)	4B6.16										<u>15</u>
Oper. Current (h)	4B6.16										<u>15</u>
22 Amps Current	4B6.16										<u>5</u>

(a) These tests are not required if the EEDs will not be exposed to RF levels greater than the RF no-fire level, as determined by the RF sensitivity testing. The maximum RF exposure level is that maximum level determined by a worst case electromagnetic hazard analysis approved by Range Safety.

(b) Number indicated is for single Bridgewire. For dual Bridgewire, increase number to 370.

(c) This test is not required if EED contained inside the S&A body.

(d) Underlining indicates units are considered destroyed.

(e) The number of thermal cycles shall be 24 with dwell time of 2 h at each temperature level.

(f) This test is optional. If performed, the lot has initial service life of three years.

(g) All-Fire current is specified All-Fire current vs Bruceton All-Fire current.

(h) In the event that operating current cannot be predicted, the test current shall be 2 times Bruceton All-Fire Current.

(i) Fire at designed high temperature or +71 degrees C whichever is higher.

(j) Fire at designed low temperature or -54 degrees C whichever is lower.

APPENDIX 4B6 S&A AND EED TEST REQUIREMENTS

**Table 4B6-5
EED Age Surveillance Test Matrix**

TEST	TEST REQUIREMENT	QUANTITY TESTED	
		5 (a)	10 (b)
Non-Destructive Tests			
Visual Inspection	4B1.2.1	X	X
Dimension	4B1.2.3	X	X
Bridgewire Resistance	4B6.9	X	X
Leakage	4B1.2.7	X	X
Static Discharge	4B6.8	X	X
Bridgewire Resistance	4B6.9	X	X
Insulation Resistance	4B6.10	X	X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Destructive Tests			
Shock (c)	4B1.4.1.4	X	X
Thermal Cycling (c) (d)	4B1.4.1.7	X	X
High Temperature Storage	4B6.18		X
Random Vibration (c)	4B1.4.1.2	X	X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Bridgewire Resistance	4B6.9	X	X
Insulation Resistance	4B6.10	X	X
Leakage	4B1.2.7	X	X
No Fire Verification	4B6.11	X	X
Firing Tests			
Ambient Temperature All-Fire Current (e)	4B6.16	1	4
High Temperature All-Fire Current (e)(f)	4B6.16	2	3
Low Temperature All-Fire Current (e)(g)	4B6.16	2	3

(a) Testing can be conducted to extend service life for one year

(b) Testing that can be conducted to extend service life for three years.

(c) Environmental tests shall be performed at qualification levels.

(d) The number of thermal cycles shall be 24 with dwell time of 2 h at each temperature cycle.

(e) All-Fire current is specified All-Fire current vs. Bruceton All-Fire current.

(f) Fire at design high temperature or +71°C whichever is higher.

(g) Fire at design low temperature or -54°C whichever is lower.

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S&A AND EED TEST REQUIREMENTS

Table 4B6-6
S&A Rotor Lead/Booster Charge Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Non-Destructive Tests		
Visual Inspection	4B1.2.1	100%
Dimension	4B1.2.3	100%
Leakage	4B1.2.7	100%
X-Ray	4B1.2.5	100%
N-Ray	4B1.2.6	100%
Destructive Tests		
Thermal Cycling (a) (b)	4B1.4.1.7	Lot Sample (c)
High Temp Storage (d)	4B6.18	Lot Sample
Random Vibration (a)	4B1.4.1.2	Lot Sample
Leakage	4B1.2.7	Lot Sample
X-Ray	4B1.2.5	Lot Sample
N-Ray	4B1.2.6	Lot Sample
Firing Tests		
High Temperature (e)	4B6.17	1/2 Lot Sample
Low Temperature (f)	4B6.17	1/2 Lot Sample

(a) Environmental tests shall be performed at qualification levels.

(b) Number of thermal cycles shall be 24 with dwell time of 2 h at each temperature cycle.

(c) The sample size is 10 percent of the lot, but not less than 10 units.

(d) This test is optional. If performed, the lot has initial service life of 3 yr.

(e) Fire at designed high temperature or +71°C whichever is higher.

(f) Fire at designed low temperature or -54°C whichever is lower

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S&A AND EED TEST REQUIREMENTS

Table 4B6-7
S&A Rotor Lead/Booster Charge Qualification Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED	
		6	21
Acceptance (Non-Dest. Test)	ACCEPTANCE TEST MATRIX	X	X
Destructive Tests			
Shock	4B1.4.1.4		X
Thermal Cycling (a)	4B1.4.1.7	X	X
High Temp Storage (b)	4B6.18		10
Random Vibration	4B1.4.1.2		X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Leakage	4B1.2.7	X	X
Firing Tests			
Ambient Temperature	4B6.17	2	7
High Temperature (c)	4B6.17	2	7
Low Temperature (d)	4B6.17	2	7

(a) Number of thermal cycles shall be 24 with dwell time of 2 h at each temperature cycle.

(b) This test is optional. If performed, the lot has initial service life of 3 yr.

(c) Fire at designed high temperature or +71°C whichever is higher.

(d) Fire at designed low temperature or -54°C whichever is lower.

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S&A AND EED TEST REQUIREMENTS

Table 4B6-8
S&A Rotor Lead/Booster Charge Age Surveillance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED	
		5 (a)	10 (b)
Non-Destructive Tests			
Visual Inspection	4B1.2.1	X	X
Dimension	4B1.2.3	X	X
Leak	4B1.2.7	X	X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Destructive Tests			
Thermal Cycling (c) (d)	4B1.4.1.7	X	X
High Temperature Storage	4B6.18		X
Random Vibration (c)	4B1.4.1.2	X	X
Leakage	4B1.2.7	X	X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Firing Tests			
High Temperature (e)	4B6.17	2	5
Low Temperature (f)	4B6.17	3	5

(a) Testing that can be conducted to extend service life for one year.

(b) Testing that can be conducted to extend service life for three years.

(c) Environmental tests shall be performed at qualification level.

(d) Number of thermal cycles shall be 24 with dwell time of 2 h at each temperature cycle.

(e) Fire at designed high temperature or +71°C whichever is higher.

(f) Fire at designed low temperature or -54°C whichever is lower.

APPENDIX 4B6

S&A AND EED TEST REQUIREMENTS

4B6.1 Full Bench Test

a. Purpose

1. To verify that the component is capable of cycling within its specified operating time
2. To verify the insulation resistances and firing circuit resistances in each operating mode
3. To verify the capability to manually safe the component
4. To confirm the effort that is needed to remove the safing pin and to determine the safing pin retention capability

b. Procedure

1. Remove the safing pin and measure the force/torque that is required to remove the pin.
2. Remotely arm the component and measure the cycle time.
3. Using the **Bridgewire Resistance and Insulation Resistance** tests, measure the component bridgewire resistance and insulation resistance.
4. Remotely safe the component.
5. Using the **Bridgewire Resistance and Insulation Resistance** tests, measure the component bridgewire resistance and insulation resistance.
6. Cycle the component (SAFE to ARM and ARM to SAFE) 25 more times and measure each cycle time.
7. Remotely return the component to its safe configuration.
8. Using the **Bridgewire Resistance and Insulation Resistance** tests, measure the component bridgewire resistance and insulation resistance.
9. Remotely arm the component and measure the cycle time.
10. Using the **Bridgewire Resistance and Insulation Resistance** tests, measure the component bridgewire resistance and insulation resistance.
11. Manually safe the component and measure the angular or the sliding displacement of safe rotation/travel if possible.
12. Verify that the S&A safing pin can be inserted and removed without binding.
13. Install the safing pin.
14. With the component in the SAFE position and the arming current applied, measure the retention capability of the safing pin.

c. Pass/Fail Criteria.

1. The component shall be capable of operating within the requirements of the component specification.

2. The resistances shall be within the component specification.

4B6.2 Limited Bench Test

a. Purpose

1. To verify that the device is capable of cycling within its specified operating time
2. To verify insulation resistances and firing circuit resistance in each operating mode
3. To verify the capability to manually safe the component

b. Procedure

1. Remotely arm the component and measure the cycle time.
2. Using the **Bridgewire Resistance and Insulation Resistance** tests, measure the component bridgewire resistance and insulation resistance.
3. Remotely safe the component.
4. Using the **Bridgewire Resistance and Insulation Resistance** tests, measure the component bridgewire resistance and insulation resistance.
5. Cycle the component (SAFE to ARM and ARM to SAFE) 5 more times and measure each cycle time.
6. Install the safing pin.

c. Pass/Fail Criteria

1. The component shall be capable of operating within the requirements of the component specifications.
2. The resistances shall be within the component specification.

4B6.3 Cycle Life

- a. Purpose.* To verify that the unit can withstand repeated cycling from the armed to the disarmed position for at least 1000 cycles without any malfunction, failure, or deterioration in electromechanical performance.

b. Procedure

1. Cycle the component 1000 times using nominal operational arming voltage.
2. Perform a limited bench test in accordance with the **Limited Bench Test** section of this Appendix at every 1/3 interval of cycle life.

- c. Pass/Fail Criteria.* The component shall be capable of operating within the requirements of the component specifications.

4B6.4 Stall Test

4B6.4.15-Min Stall

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S&A AND EED TEST REQUIREMENTS

a. Purpose. To verify that electrically actuated S&As will meet the specified electromechanical performance requirements after the application of maximum operational arming voltages continuously for up to 5 min with the safing pin installed.

b. Procedure

1. With the safing pin installed, apply a maximum value arming voltage for 5 min.

2. Verify the performance by performing a limited bench test in accordance with the **Limited Bench Test** section of this Appendix.

c. Pass/Fail Criteria. The component shall be capable of operating within the requirements of the component specification.

4B6.4.260-Min Stall

a. Purpose. To verify that the explosive that is in the S&A will not detonate after the application of maximum operational arming voltages continuously for up to 60 min with the safing pin installed

b. Procedure. With the safing pin installed, apply a maximum value arming voltage for 60 min.

c. Pass/Fail Criteria. The detonator/explosive in the S&A shall not detonate.

4B6.5 Drop Test

4B6.5.16-ft Drop

a. Purpose. To demonstrate that the explosive in the S&A device will not initiate when dropped from a height of 6 ft and will perform to specification after impact if the effects of the drop are not detectable

b. Condition. The S&A device shall be dropped onto a 1/2 in. thick steel plate from a height of 6 ft. (one drop)

c. Pass/Fail Criteria

1. The explosive in the device shall not initiate as a result of the impact and will be safe to handle.

2. If the effects of the drop are not detectable, the S&A device shall fire and properly propagate.

4B6.5.220-ft Drop

a. Purpose. To demonstrate that the explosive in the S&A device will not initiate when dropped from a height of 20 ft and will be safe to handle for subsequent disposal.

b. Condition. The S&A device shall be dropped onto a 1/2 in. thick steel plate from a height of 20 ft. (one drop).

c. Pass/Fail Criteria

1. The explosive in the device shall not initiate as a result of the impact and will be safe to handle.

2. The device shall be safe to handle for subsequent disposal.

3. The device need not be functional following this test.

4B6.6 Barrier Test

a. Purpose. To verify that the S&A barrier will prevent the initiation of subsequent explosive charges in the event of an inadvertent firing of the detonator when the device is in the safe condition

b. Conditions

1. A test unit can be used that duplicates all nominal dimensions (including gaps between explosive components, free volume, and diaphragm thickness) of the operational S&A.

2. The explosive transfer line shall be mated to the test unit for this test.

c. Procedure

1. For Rotating Barriers. Position the test unit rotor 50 degrees or greater from the full safe position.

2. For Sliding Barriers. Position the test unit barrier midway between the safe and the arm position.

3. Temperatures

(a) Fire one test unit at least 10°C above the maximum predicted temperature or +71°C whichever is greater.

(b) Fire one test unit at ambient (approximately 25°C) temperature.

(c) Fire one test unit at least 10°C below the minimum temperature or -54°C whichever is lower.

(d) Temperature conditioning of at least 4 h is required.

d. Pass/Fail Criteria.

1. S&As that use rotor leads shall not have their rotor leads undergo a low or a high order detonation as the result of the test unit firing.

2. S&As that couple the detonator directly to an external ordnance train shall not have that external ordnance train undergo a low or a high order detonation as the result of the test unit firing.

4B6.7 S&A Firing Test

a. Purpose. To verify that the explosives will fire upon application of a specified current and that the output of the device will initiate a specified explosive train after being subjected to a specified

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preconditioning

b. Conditions

1. The S&A device shall be fired at ambient, high, and low temperatures.

2. The predicted operating current shall be used.

NOTE: If the operating current is unknown, the test current of 2 times Bruceton All-Fire of the EED shall be used.

3. With both detonators receiving current simultaneously, test half of the test sample.

4. With the detonators receiving current sequentially to demonstrate complete redundancy, test the remaining half of the test sample. **NOTE:** A minimum of 1 min shall be provided between the sequenced detonators firings.

5. A witness target shall be used to verify successful initiation.

c. Pass/Fail Criteria

1. The S&A explosives shall fire upon application of a specified current.

2. The output of the S&A device shall initiate a specified explosive train after being subjected to a specified preconditioning.

4B6.8 Static Discharge Sensitivity

a. Purpose. To verify the EED can withstand electrostatic discharge without being fired, dudged, or deteriorating in performance

b. Procedure

1. Use the static discharge test shown in Figure 4B6-1.

2. Discharge 25 kV from a 500 pf capacitor applied without series resistor at the test points for a pin-to-case mode. **NOTE:** Pins shall be shorted during testing.

3. Discharge 25 kV from a 500 pf capacitor applied through a 5k ohm resistor at the test points for a pin-to-pin mode. **NOTE:** The method used for steps 2 and 3 shall preclude external arcing.

c. Pass/Fail Criteria. The EED shall not fire, dud, or deteriorate in performance as a result of this test.

4B6.9 Bridgewire Resistance

a. Purpose. To verify the Bridgewire resistance of the component

b. Conditions

1. An accuracy of 2 percent of the true value or better is required.

2. The open circuit voltage of the test equipment shall not exceed one volt.

b. Procedure. Apply a maximum current of 10 milliamps or 10 percent of the no-fire current (as determined by the Bruceton test) whichever is less, and measure the Bridgewire resistance.

c. Pass/Fail Criteria. The Bridgewire resistance shall be in accordance with the applicable specification.

4B6.10 Insulation Resistance

a. Purpose. To determine the extent to which the insulating properties are affected by deterioration influences, heat, moisture, dirt, oxidation, or the loss of volatile materials

b. Conditions

1. Insulation resistance measurements shall be made on an apparatus that is suitable for the characteristics of the component to be measured. Such apparatus include: a megohm bridge, megohm meter, insulation resistance test set, or other suitable apparatus.

2. When special preparations or conditions such as special test fixtures, reconnections, grounding, isolation, low atmospheric pressure, humidity, or immersion in water are required, they shall be specified.

3. The applied test voltage shall be a minimum of 500 Vdc. **NOTE:** For the NASA Standard Initiator (NSI), the potential shall not exceed 250 Vdc and only one 250 Vdc test shall be permitted. All subsequent NSI testing shall be at 50 Vdc.

4. All current carrying components and conductors shall be electrically insulated from each other and system grounded.

5. Unless otherwise specified, the measurement error at the required insulation resistance value shall not exceed 10 percent.

c. Procedure. Perform insulation resistance measurements between the mutually insulated

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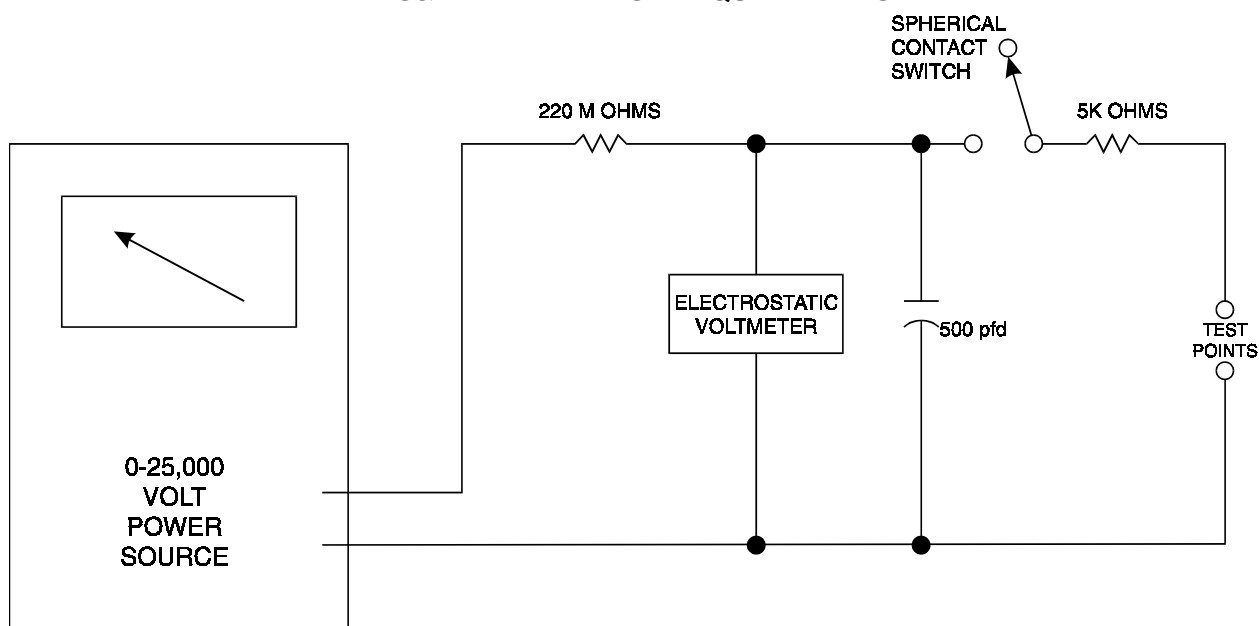


Figure 4B6-1
Static Discharge Test

points or between insulated points and ground immediately after a 2-min period of uninterrupted test voltage application.

d. Pass/Fail Criteria. The insulation resistance between all insulated parts shall be greater than 2 megohms after exposure to the environment specified herein.

4B6.11 No-Fire Verification

a. Purpose. To verify that the EED will not fire or degrade when subjected to a no-fire current

b. Conditions. No external heat sinks shall be used for this test.

c. Procedure. Subject the EED to the specified no-fire DC current, +5 percent/-0 percent for 5 min at ambient condition.

d. Pass/Fail Criteria. The EED shall not fire or degrade as a result of this test.

4B6.12 RF Impedance

a. Purpose. To determine the RF impedance of an explosive device. **NOTE:** During a worst-case analysis of the susceptibility of the system to its electromagnetic environment, a worst-case parameter such as the DC resistance is used for the impedance. If this worst-case resistance parameter causes a rejection of the worst-case analysis results, RF impedance can be used to reduce predicted

analytical results.

b. Conditions

1. All tests shall be performed at room temperature (approximately 25°C).

2. A minimum of 10 EEDs shall be used in the impedance measurements. These items may be reused in the RF sensitivity or RF dudding testing.

3. Apparatus. The impedance measuring equipment shall be able to function at extremely low RF power levels so that the EEDs are not subjected to heating effects. Automatic equipment is preferred. It is suggested that no more than 1 milliwatt be applied to the EED in any firing mode during the measurements. The mounting apparatus used to connect the EED to the impedance measuring apparatus will be constructed so that the impedance measurements refer to a point as close to the base of the EED (exterior surface of the EED header) as is possible.

d. Procedure

1. Measure impedance for each potential firing mode of the EED. **NOTE 1:** For 2 pin conventional hot wire EEDs, pin-to-pin and pin-to-case impedances shall be measured. **NOTE 2:** For dual Bridgewire EEDs, pin-to-pin, pin-to-case, and bridge-to-bridge firing modes shall be measured.

2. Measure impedances at 10 frequencies between 1 and 1200 MHz inclusive. **NOTE:** The

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individual measurement frequencies should be selected so that neighboring frequencies differ from each other by an approximately equal logarithmic increment.

4B6.13 RF Sensitivity

a. Purpose. To determine the radio frequency sensitivity of the EED and to provide an RF no-fire level usable for RF hazard analyses

b. Conditions

1. Number of EEDs Required

(a) Single Bridgewire type: 230 minimum

(b) Dual Bridgewire type: 370 minimum

2. At each radio frequency to be used in the test, the radio frequency power to be applied to the EEDs is determined from the mean DC firing current measured in the Bruceton test and DC Bridgewire resistance. This level shall be applied to the devices in each mode (pin-to-pin, pin-to-case, bridgewire-to-bridgewire).

3. The equipment used in the tests shall provide a means to account for loss in the power supplying system. Applied powers shall be demonstrated to be those that are actually delivered to the input of the EED.

4. Mounting hardware for the EED shall be constructed to allow measurement of power as close to the EED base (exterior surface of the EED header) as possible.

5. The environmental conditions of the Bruceton test shall be complied with.

6. At least 10 frequencies shall be used in the probing tests. These frequencies should be chosen to cover the frequency range from 1 MHz to 32 GHz and should include any frequency corresponding to a known high power density in the EEDs operational environment.

7. Special consideration should be given to the frequencies that correspond to the transmitters that are associated with the overall system of which the EED is a part.

8. If there are no specific requirements, the approximate frequency and modulation stimuli shown in Table 4B6-9 shall be used.

c. Procedure: Probing Test

1. At each test frequency, test 10 EEDs for 5 min in the pin-to-pin mode and 10 EEDs in the pin-

Frequency (MHz)	Modulation
1.5	CW ^a
27.0	CW
154.0	CW
250.0	CW
900.0	CW
2,700.0	P ^b
5,400.0	P
8,900.0	P
15,000.0	CW
32,000.0	P

^a Continuous Wave

^b Pulsed modulation with pulse width of 1 microsecond and pulse repetition rate of 1 kHz

to-case mode. If the EED has dual bridgewires, test 10 more in the bridgewire-to-bridgewire mode.

2. Up to 5 EEDs that did not fire in the pin-to-pin test can be reused in the pin-to-case test. Thus, RF probing tests require 15 items at each frequency for a two-pin single bridge device and 25 items for a dual bridge device.

d. Analysis

1. Count the number of firings at each frequency. At any particular frequency, if two or less fire, it can be stated with very small risk that the EEDs are less sensitive to the test condition than they are to direct current and the direct current sensitivity level can be used for subsequent analysis. If from 3 to 7 EEDs fire, they can be considered to be of the same order of sensitivity to the test condition as to the direct current susceptibility level and the direct current level can be used in subsequent calculations with a risk of approximately 11 percent. If 8 or more fire, there is little doubt that the EED is more sensitive to the test conditions than to the direct current level.

2. From the data that was obtained in the probing tests, determine the most sensitive frequency/modulation stimulus for each firing mode.

e. Procedure: Determining Statistical RF No-Fire Level

1. Perform a 5-min, 40 item, No-Fire Bruceton test at the most sensitive frequency/modulation stimulus for each mode. The same equipment shall be used in the probing tests.

2. Forty items are required for each firing mode of the device being tested. Thus, 80 items are required for a two-pin single bridge device and 120 items for a dual bridge device.

Table 4B6-9

Default Test Frequencies and Modulation

4B6.14 RF Dudding

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NOTE: These tests are not required if the EEDs will not be exposed to RF levels greater than the RF no-fire level, as determined by the RF sensitivity testing. The maximum RF exposure level is that maximum level determined by a worst case electromagnetic hazard analysis approved by Range Safety.

a. Purpose. To evaluate the RF dudding susceptibility of the EED in the pin-to-pin firing mode. **NOTE:** Essentially, this evaluation compares DC pulse Bruceton test results for virgin items and for EEDs that are exposed to the 10 percent pin-to-pin firing level (1.2816 Sigma below the mean) as determined in RF sensitivity test.

b. Condition. A total of 120 devices are required if the results of the Bruceton test are available; if not, 165 devices are required. **NOTE:** Since dudding effects can vary with the firing pulse time, this evaluation requires comparison of the Bruceton Data on RF exposed and non-RF exposed groups for two DC pulse times of 5 min and 1 millisc. These are chosen to be long and short, respectively, in relation to the thermal time constant of the EED bridgewire.

c. Procedure

1. Bruceton Tests

(a) Perform the Bruceton test on 40 units using a 5-min DC pulse.

(b) Perform the Bruceton test on a second group of 40 units using a 1 millisc DC pulse.

(c) Expose a third group of 80 virgin EEDs pin-to-pin using the equipment of RF sensitivity test to the 10 percent firing level (probability) as calculated from the pin-to-pin RF Bruceton test. This exposure shall be for 5 min. It is expected that several items will fire.

(d) Divide the items remaining from the RF exposure into two approximately equal groups. One group shall be used to rerun the 1 millisc Bruceton described in paragraph *(b)* above; the other group shall be used to rerun the 5 min Bruceton, paragraph *(a)* above.

2. Compare thermal density parameters for virgin and exposed items for both the 1 millisc and 5 min tests. Any large differences in the mean indicate a propensity for RF dudding or possibly RF sensitization.

3. To determine if the RF exposure of the EEDs has altered the DC firing characteristics for either the 5 min or 1 millisc exposure, computes:

$$t_t = \frac{|\overline{LX_C} - \overline{LX_E}|}{(N_C S_C^2 + N_E S_E^2)^{\frac{1}{2}}} \times \left(\frac{N_C N_E (N_C + N_E - 2)}{N_C + N_E} \right)^{\frac{1}{2}}$$

and

$$DF = N_C + N_E - 2$$

WHERE:

$\overline{LX_C}$ 1= \log_{10} (mean of the control test (amps))

$\overline{LX_E}$ 2= \log_{10} (mean of the post-exposure test (amps))

N_C 3= $\frac{1}{2}$ the number of items used in the control test, rounded to the lowest integer

N_E 4= $\frac{1}{2}$ the number of items used in the post-exposure test, rounded to the lowest integer

S_C^2 5= sigma squared for the control test

S_E^2 6= sigma squared of the post-exposure test

t_t = tested two tailed value of t for 5 percent probability

DF = degrees of freedom

NOTE: If $N_C = N_E = N$

$$t_t = \frac{|\overline{LX_C} - \overline{LX_E}|}{(S_C^2 + S_E^2)^{\frac{1}{2}}} \times (N - 1)^{\frac{1}{2}}$$

4. Consult Table 4B6-10 and determine the value of t_c (critical two tailed value of t for 5 percent probability) associated with the DF (as computed in paragraph 3, above). If t_t is less than or equal to t_c , one can assume with 95 percent confidence, that the RF exposure has not altered the DC firing characteristics of the devices. The above test is based on a comparison of the mean firing level of the devices as determined by the two Bruceton tests.

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Table 4B6-10
RF Dudding Test Table
Two Tailed Value of T for 5 Percent Probability

DEGREES OF FREEDOM	t_c	DEGREES OF FREEDOM	t_c	DEGREES OF FREEDOM	t_c	DEGREES OF FREEDOM	t_c
1	12.7060	14	2.1450	27	2.0520	39	2.0232
2	4.3030	15	2.1310	28	2.0480	40	2.0211
3	3.1820	16	2.1200	29	2.0450	41	2.0200
4	3.1320	17	2.1100	30	2.0423	42	2.0190
5	2.5760	18	2.1010	31	2.0402	43	2.0179
6	2.4470	19	2.0930	32	2.0381	44	2.0169
7	2.3650	20	2.0860	33	2.0359	45	2.0158
8	2.3060	21	2.0800	34	2.0338	46	2.0148
9	2.2620	22	2.0740	35	2.0317	47	2.0137
10	2.2281	23	2.0690	36	2.0296	48	2.0127
11	2.2010	24	2.0600	37	2.0275	49	2.0116
12	2.1790	25	2.0560	38	2.0253	50	2.0106
13	2.1600	26	2.0540				

4B6.15 All-Fire and No-Fire Bruceton Direct Current Sensitivity

a. Purpose. To determine the pin-to-pin direct current characteristics of EEDs based on an assumed current log normal density function.

b. Conditions

1. A 5-min constant current pulse stimulus is required for determining the maximum no-fire level.

2. A 30-millisecond constant current pulse is required for determining the all-fire level.

3. Forty-five EEDs are required for each test.

4. Test Temperature. The test should be performed under ambient (approximately 25°C) temperature conditions, or operational temperatures if conditions include exposure of the EED to potentially hazardous pin-to-pin stimuli at elevated temperatures. The EED and heat sink intended to simulate actual installation shall be allowed to come to thermal equilibrium at the test temperature before the stimulus is applied to the EED.

5. Heat Sink (as applicable). The heat sink environment of the EED shall approximate the predicted operational thermal environment. If the thermal environments for the EED usage are multiple or unknown, the minimum heat sink should be used during the test. If hazards related to "hand held" environments are to be evaluated, the EED should be mounted in a fixture that effectively insulates the EED against heat transfer to the environment.

6. During testing, each exposure shall be moni-

tored to provide a permanent record (an oscilloscope picture, digital recording on floppy disk, etc.) of the voltage and current of the bridgewire during the five minute pulse. These records shall be retained by the facility performing the test.

7. Test equipment shall be checked for calibration before any data is taken and an estimate made of maximum errors that are possible in pulse amplitudes and durations.

4B6.15.1 No-Fire Procedure

a. Expose 5 units to a constant current pulse for 5 min to determine the mean and Standard Deviation of the firing current assumed log normal density function.

b. Expose 40 units to a constant current pulse for 5 min. **NOTE:** The current pulse amplitudes used for this test are to be chosen so that neighboring tests vary by a logarithmic increment approximately equal (0.5 to 1.25) to the Standard Deviation attained in paragraph *a* above. Improper selection of the mean and standard deviation will cause a failure of the Bruceton test and will require another forty items.

c. In the event of a no-fire, do not disconnect the EED from the system.

1. Apply a current pulse large enough to ensure firing of the EED.

2. If the EED still fails to fire, omit the no-fire data point from the test, determine the reason for the no-fire, and report in the EED test report. **NOTE:**

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Any deviation exceeding 10 percent between the fire (X) determined sigma and the no fire (0) determined sigma will be sufficient to void the test and be cause for rerun of the test. The difference is computed by the ratio of the larger sigma to the smaller sigma, and a ratio greater than 110 percent will void the test. Tests showing less than four or greater than seven levels shall also be considered void and the test shall be rerun.

d. Compute the results of the Bruceton test on both X and 0 data. **NOTE:** The actual computations of the Bruceton results should be performed by a computer program that is capable of demonstrating its accuracy by calculating log normal density function parameters from simulated Bruceton procedure test results. These simulated results shall be consistent with an assumed log normal density function. This verification, that consists of simulated test results, the assumed distribution parameters, and the Bruceton calculation should be included with the test results.

e. Calculate the confidence levels using the average of the Standard deviations and the average of the means (log) as determined by the X and 0 data.

f. Compute the 0.001 (0.1 percent) firing level of the EED, in amperes with 95 percent confidence, from the Bruceton test results.

4B6.15.2 All-Fire Procedure

The all-fire test shall be conducted following the steps described in the **No-Fire Procedure** section above with the following conditions:

a. Substitute a 30-millisecond constant current pulse in lieu of the 5-min requirement.

b. Compute the 0.999 (99.9 percent) firing level of the EED, in amperes with a 95 percent confidence level from the Bruceton test results.

4B6.16 Firing Test

a. Purpose. To verify that the EED will fire upon application of a specified current after being subjected to a specified preconditioning and to verify

that the output of the electroexplosive device meets the requirements of the component specifications.

b. Conditions

1. Gas-producing EEDs shall be fired in a closed bomb. The following parameters shall be measured:

(a) Time from application of current to bridgewire burn out.

(b) Time from application of current to first indication of pressure.

(c) Time from first indication of pressure to peak pressure.

(d) Peak pressure.

2. Detonating explosives shall be tested using a metal witness plate to record output through a dent depth measurement technique.

c. Pass/Fail Criteria. The device shall meet the requirements of the component qualification.

4B6.17 S&A Rotor Lead and Booster Charge Firing Test

a. Purpose

1. To verify that the rotor leads or booster charges will fire when they are subjected to the detonating output of the specified initiating component.

2. To verify that the output of the rotor leads/booster charges meet the requirement of the component specification.

b. Conditions

1. Rotor leads/booster charges shall be stabilized and tested at the test temperatures.

2. A metal witness plate shall be used to record the output by using a dent depth measurement technique to test the rotor lead/booster charge output.

c. Pass/Fail Criteria. The S&A device shall meet the requirements that are specified in the component specification.

4B6.18 High Temperature Storage

a. Purpose. To verify that long term storage at high temperatures will not shorten the service life of an explosive component

b. Condition. The storage conditions shall be +71°C and 40 to 60 percent relative humidity for 30 days.

APPENDIX 4B7 EBW FIRING UNIT AND EBW TEST REQUIREMENTS

Table 4B7-1
EBW Firing Unit Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Test (a)		
Performance Tests:		
Resistances	4B7.1	100%
Power-on Duty Cycle	4B7.4	100%
Destruct (Fire ⁺) Command	4B7.5	100%
Arm Command	4B7.6	100%
Monitor Functions	4B7.7	100%
Output Pulse	4B7.8	100%
Function Time	4B7.9	100%
H.V. Charge Voltage	4B7.10	100%
Safety Tests:		
H.V. Cap. Discharge Time	4B7.11	100%
Inhibit (Fire ⁰) Command (b)	4B7.12	100%
Output Pulse	4B7.8	100%
Reference Functional Tests (c)		
Fire ⁺ Nominal. Voltage	4B7.13	100%
Fire ⁺ Max. Voltage	4B7.14	100%
Fire ⁺ Min. Voltage	4B7.15	100%
Output Pulse	4B7.8	100%
Function Time	4B7.9	100%
H.V. Charge Voltage	4B7.10	100%
Fire ⁰ Command (b)	4B7.12	100%
Operating Environment Tests		
Acoustic (d)	4B1.4.2.2	100%
Acceleration	4B1.4.2.3	100%
Thermal Cycling (e)	4B1.4.2.4	100%
Thermal Vacuum (d)	4B1.4.2.5	100%
Random Vibration (d)	4B1.4.2.1	100%
Burn-in	4B1.4.2.6	100%
Leakage (f)	4B1.2.7	100%

(a) These tests shall be performed prior to and after all environmental tests.

(b) These tests shall be performed if applicable.

(c) These tests shall be performed after each environmental test.

(d) The EBW FU shall be functionally tested and critical parameters monitored during these environmental tests.

(e) Full functional tests shall be performed at high voltage input on the 1 and 7 cycles, low voltage input on the 2 and 8 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(f) This test shall be performed after the last operating environment test.

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EBW FIRING UNIT AND EBW TEST REQUIREMENTS

Table 4B7-2
EBW Firing Unit Qualification Test Matrix
 (Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Acceptance	ACCEPTANCE TEST MATRIX	X	X	X
Cycle Life	4B7.16	X	X	X
Functional Tests (a)				
Performance Tests				
Resistances	4B7.1	X	X	X
Reverse Polarity (b)	4B7.2	X	X	X
Overvoltage (b)	4B7.3	X	X	X
Power-on Duty Cycle	4B7.4	X	X	X
Destruct (Fire ⁺) Command	4B7.5	X	X	X
Arm Command	4B7.6	X	X	X
Monitor Functions	4B7.7	X	X	X
Output Pulse	4B7.8	X	X	X
Function Time	4B7.9	X	X	X
H.V. Charge Voltage	4B7.10	X	X	X
Safety Tests				
H.V. Cap. Discharge Time	4B7.11	X	X	X
Inhibit (Fire ⁰) Command (c)	4B7.12	X	X	X
Output Pulse	4B7.8	X	X	X
Reference Functional Tests (d)				
Fire ⁺ Nominal. Voltage	4B7.13	X	X	X
Fire ⁺ Max. Voltage	4B7.14	X	X	X
Fire ⁺ Min. Voltage	4B7.15	X	X	X
Output Pulse	4B7.8	X	X	X
Function Time	4B7.9	X	X	X
H.V. Charge Voltage	4B7.10	X	X	X
Fire ⁰ Command (c)	4B7.12	X	X	X
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X	X	X
Transport Shock/Bench Handling	4B1.3.3	X	X	X
Transportation Vibration	4B1.3.4	X	X	X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6		X	
Fine Sand	4B1.3.7			X

(a) These tests shall be performed after all non-operating environment tests have been completed; they shall also be performed after all operating environment tests have been completed.

(b) One time test.

(c) These tests shall be performed if applicable.

(d) These tests shall be performed after each environmental test.

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EBW FIRING UNIT AND EBW TEST REQUIREMENTS

Table 4B7-2
EBW Firing Unit Qualification Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Operating Environment Tests				
Sinusoidal Vibration (e)	4B1.4.1.1	X	X	X
Acoustic (e)	4B1.4.1.3	X	X	X
Shock	4B1.4.1.4	X	X	X
Acceleration	4B1.4.1.5	X	X	X
Humidity (e)	4B1.4.1.6			X
Thermal Cycling (f)	4B1.4.1.7	X	X	X
Thermal Vacuum (e)	4B1.4.1.8	X	X	X
Random Vibration (e)	4B1.4.1.2	X	X	X
EMI/EMC (e)	4B1.4.1.9		X	X
Explosive Atmosphere (e)	4B1.4.1.10	X		
Leakage (g)	4B1.2.7	X	X	X
Disassembly	4B1.4.1.11	X	X	X

(e) The EBW Firing Unit shall be operated and critical parameters monitored during these environmental tests.

(f) Full functional tests shall be performed at high voltage input on the 1 and 23 cycles, nominal voltage on the 12 and 13 cycles, low voltage input on the 2 and 24 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(g) This test shall be performed after the last non-operating and the last operating environment test.

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EBW FIRING UNIT AND EBW TEST REQUIREMENTS

Table 4B7-3
EBW Lot Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Non-Destructive		
Visual Inspection	4B1.2.1	100%
Dimension	4B1.2.2	100%
Static Discharge	4B7.17	100%
Pull Test	4B1.3.8	100%
Bridgewire Continuity	4B7.18	100%
Spark Gap Breakdown	4B7.19	100%
Insulation Resistance	4B7.20	100%
Leakage	4B7.7	100%
X-Ray	4B1.2.5	100%
N-Ray	4B1.2.6	100%
Destructive		
Shock (a)	4B1.4.1.4	Lot Sample (b)
Thermal Cycling (a)	4B1.4.1.7	Lot Sample
High Temp. Storage (c)	4B7.25	Lot Sample
Random Vibration (a)	4B1.4.1.2	Lot Sample
X-Ray	4B1.2.5	Lot Sample
N-Ray	4B1.2.6	Lot Sample
Bridgewire Continuity	4B7.18	Lot Sample
Spark Gap Breakdown	4B7.19	Lot Sample
Insulation Resistance	4B7.20	Lot Sample
Leakage	4B1.2.7	Lot Sample
No Fire Verification		
125 VAC	4B7.21	Lot Sample
500 Vdc	4B7.21	Lot Sample
Firing Tests:		
Ambient Temperature		
All-Fire Voltage (d)	4B7.24	1/6 Lot Sample
Operating Voltage (e)	4B7.24	1/6 Lot Sample
High Temperature (f)		
All-Fire Voltage (d)	4B7.24	1/6 Lot Sample
Operating Voltage (e)	4B7.24	1/6 Lot Sample
Low Temperature (g)		
All-Fire Voltage (d)	4B7.24	1/6 Lot Sample
Operating Voltage (e)	4B7.24	1/6 Lot Sample

(a) Environmental tests shall be performed at qualification levels.

(b) Lot Sample is 10 percent of lot but not less than 30 units.

(c) This test is optional. If performed, the lot has initial service life of three years.

(d) All-Fire voltage is specified All-Fire voltage vs Bruceton All-Fire voltage.

(e) In event that operating voltage cannot be predicted the test voltage shall be 2 times Bruceton All-Fire Voltage.

(f) Fire at designed high temperature or +71°C whichever is higher.

(g) Fire at designed low temperature or -54°C whichever is lower.

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EBW FIRING UNIT AND EBW TEST REQUIREMENTS

Table 4B7-4
EBW Qualification Test Matrix
(Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED								
		5	230	45	5	5	6	5	5	105
Acceptance (Non-Destructive Test)	ACCEPTANCE TEST MATRIX	X	X	X	X	X	X	X	X	X
RF Sensitivity	4B7.22		<u>X</u> (a)							
All-Fire Bruceton	4B7.23			<u>X</u>						
Non-Operating Environment Tests										
Storage Temperature	4B1.3.1								X	X
Trans. Shock/Bench Hndlg.	4B1.3.3								X	X
Trans. Vibration	4B1.3.4									X
Fungus Resistance	4B1.3.5	X								
Salt Fog	4B1.3.6	X								
Fine Sand	4B1.3.7	X								
Operating Environment Tests:										
High Temp. Exposure	4B1.3.2				<u>X</u>					
Shock	4B1.4.1.4								X	X
Acceleration	4B1.4.1.5								X	X
Thermal Cycling	4B1.4.1.6							X	X	X
High Temp. Storage (b)	4B7.25									30
Random Vibration	4B1.4.1.2									X
Drop Test (6 Foot)	4B1.3.9								X	X
Drop Test (40 Foot)	4B1.3.10					<u>X</u>				
Bridgewire continuity	4B7.18							X	X	
Spark Gap Breakdown	4B7.19							<u>X</u>	<u>X</u>	<u>X</u>
Insulation Resistance	4B7.20							<u>X</u>	<u>X</u>	<u>X</u>
Leakage (c)	4B1.2.7							<u>X</u>	<u>X</u>	<u>X</u>
X-Ray	4B1.2.5							<u>X</u>	<u>X</u>	<u>X</u>
N-Ray	4B1.2.6							<u>X</u>	<u>X</u>	<u>X</u>
No Fire Verification Tests:										
125 VAC	4B7.21						X	X	X	X
230 VAC	4B7.21	<u>X</u>								
500 Vdc	4B7.21						X	X	X	X

(a) Underlining indicates units are considered destroyed.

(b) This test is optional. If performed, the lot has initial service life of 3 yr.

(c) This test shall be performed after the last non-operating and the last operating environment test.

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EBW FIRING UNIT AND EBW TEST REQUIREMENTS

Table 4B7-4
EBW Qualification Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED								
		5	230	45	5	5	6	5	5	105
Firing Tests:										
Ambient Temperature										
All-Fire Voltage (d)	4B7.24						X	X	X	
Ambient Temperature										
All-Fire Voltage (d)	4B7.24									<u>15</u>
Operating Voltage (e)	4B7.24									<u>15</u>
2x Operating Voltage	4B7.24									<u>5</u>
High Temperature (f)										
All-Fire Voltage (d)	4B7.24									<u>15</u>
Operating Voltage (e)	4B7.24									<u>15</u>
2x Operating Voltage	4B7.24									<u>5</u>
Low Temperature (g)										
All-Fire Voltage (d)	4B7.24									<u>15</u>
Operating Voltage (e)	4B7.24									<u>15</u>
2x Operating Voltage	4B7.24									<u>5</u>

(d) All-Fire voltage is specified All-Fire voltage vs Bruceton All-Fire Voltage.

(e) In the event that operating voltage cannot be predicted, the test voltage shall be 2 times Bruceton All-Fire Voltage.

(f) Fire at predicted high temperature or +71°C whichever is higher.

(g) Fire at predicted low temperature or -54°C whichever is lower.

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**Table 4B7-5
EBW Aging Surveillance Test Matrix**

TEST	TEST REQUIREMENT	QUANTITY TESTED	
		5 (a)	10 (b)
Non-Destructive Tests			
Visual Inspection	4B1.2.1	X	X
Dimension	4B1.2.3	X	X
Static Discharge	4B7.17	X	X
Bridgewire Continuity	4B7.18	X	X
Spark Gap Breakdown	4B7.19	X	X
Insulation Resistance	4B7.20	X	X
Leakage	4B1.2.7	X	X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Destructive Tests			
Shock (c)	4B1.4.1.4	X	X
Thermal Cycling (c)	4B1.4.1.7	X	X
High Temperature Storage	4B7.25		X
Random Vibration (c)	4B1.4.1.2	X	X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Bridgewire Continuity	4B7.18	X	X
Spark Gap Breakdown	4B7.19	X	X
Insulation Resistance	4B7.20	X	X
Leakage	4B1.2.7	X	X
No Fire Verification			
125 VAC	4B7.21	X	X
500 Vdc	4B7.21	X	X
Ambient Temperature Firing			
All-Fire Voltage (d)	4B7.24	1	4
High Temperature Firing (e)			
All-Fire Voltage (d)	4B7.24	2	3
Low Temperature Firing (f)			
All-Fire Voltage (d)	4B7.24	2	3

(a) Testing that can be conducted to extend service life for one year.

(b) Testing that can be conducted to extend service life for three years.

(c) Environmental tests shall be performed at qualification levels.

(d) All-Fire voltage is specified All-Fire voltage vs Bruceton All-Fire voltage.

(e) Fire at predicted high temperature or +71°C whichever is higher.

(f) Fire at predicted low temperature or -54°C whichever is lower.

APPENDIX 4B7

EBW FIRING UNIT AND EBW TEST REQUIREMENTS

4B7.1 Resistances

a. Verify the EBW-Firing Unit (FU) isolation, insulation, and grounding resistances between case ground and all power leads, outputs, including returns, and between power leads and signal leads, including returns.

b. Measure all external parts of the unit to verify that they are at case ground potential.

4B7.2 Reverse Polarity Protection

Verify that the EBW-FU will not be damaged, have a permanent deterioration of performance, or issue an outputting command when it is subjected to the reversal of the input voltage for a period of 5 min.

4B7.3 Overvoltage Protection

Verify that the EBW-FU will not be damaged when it is subjected to the application of up to 45 Vdc or the OCV of the power source, whichever is greater, to the power input port for a period not less than 5 min.

4B7.4 Power-on Duty Cycle

Verify that the EBW-FU is capable of operating reliably for a period of not less than 45 min after its power is turned off for less than 2 min.

4B7.5 Destruct (FIRE⁺) Command

Verify that the current draw of the EBW-FU is within the requirements of the component specification during a destruct command at maximum and minimum input voltages.

4B7.6 Arm Command

Verify that the current draw of the EBW-FU is within the requirements of the component specification during the arm command at maximum and minimum input voltages.

4B7.7 Monitor Functions

Verify that all of the required monitor signals are within the component specification.

4B7.8 Output Pulse

Verify that the destruct output pulse is within the requirements of the component specification when it is subjected to either low and high input voltage at the FIRE⁺ command.

4B7.9 Function Time

Verify that the firing unit responds to the FIRE⁺ command and that the firing unit outputs the required pulse within the requirements of the component specification.

4B7.10 HV Charge Voltage

Verify that the high voltage capacitor final charge is within the requirements of the component specification when it is subjected to either a low or a high arming input voltage.

4B7.11 HV Capacitor Discharge Time

Verify that the high voltage capacitor will discharge to the specific final voltage within the specified time.

4B7.12 Inhibit (F⁰) Command

Verify that the firing unit will not produce an output with an inhibit command voltage present.

4B7.13 FIRE⁺ Nominal Voltage

Verify that the current draw of the EBW-FU is within the requirements of the component specification during a destruct command when a nominal input voltage is applied at the FIRE⁺ command.

4B7.14 FIRE⁺ Maximum Voltage

Verify that the current draw of the EBW-FU is within the requirements of the component specification during a destruct command when a maximum input voltage is applied at the FIRE⁺ command.

4B7.15 FIRE⁺ Minimum Voltage

Verify that the current draw of the EBW-FU is within the requirements of the component specification during a destruct command when a minimum input voltage is applied at the FIRE⁺ command.

4B7.16 Cycle Life

Verify that the firing unit is capable of meeting its required performance at the end of 1000 firing minimum.

4B7.17 Static Discharge Sensitivity

a. Purpose. To verify that the EBW can withstand electrostatic discharge without being fired, duded, or deteriorating in performance.

b. Procedure

1. Use the static discharge test shown in Figure

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EBW FIRING UNIT AND EBW TEST REQUIREMENTS

4B7-1.

2. For a pin-to-case test mode, discharge 25 kV from a 500 picofarad (pf) capacitor that is applied without a series resistor at the test points. **NOTE:** Pins shall be shorted during this test.

3. For a pin-to-pin test, discharge 25 kV from a 500 pf capacitor that is applied through a 5 k ohm resistor at the test points.

NOTE: The method used for 2 and 3 above shall preclude external arcing.

c. Pass/Fail Criteria. The EBW shall not fire, dud, or deteriorate in performance as a result of this test.

4B7.18 Bridgewire Continuity (Grid Dip)

Bridgewire continuity tests using the grid dip test shall be used on EBWs instead of resistance measurement.

4B7.19 Gap Breakdown

Perform EBW gap breakdown voltage tests to verify compliance with the component specification.

4B7.20 Insulation Resistance

a. Purpose. To determine the extent to which the insulating properties are affected by deterioration influences, heat, moisture, dirt, oxidation, or the loss of volatile materials

b. Conditions

1. Insulation resistance measurements shall be made on an apparatus that is suitable for the characteristics of the component to be measured. Such apparatus include: a megohm bridge, megohm meter, insulation resistance test set, or other suitable apparatus.

2. When special preparations or conditions such as special test fixtures, reconnections, grounding, isolation, low atmospheric pressure, humidity, or immersion in water are required, they shall be specified.

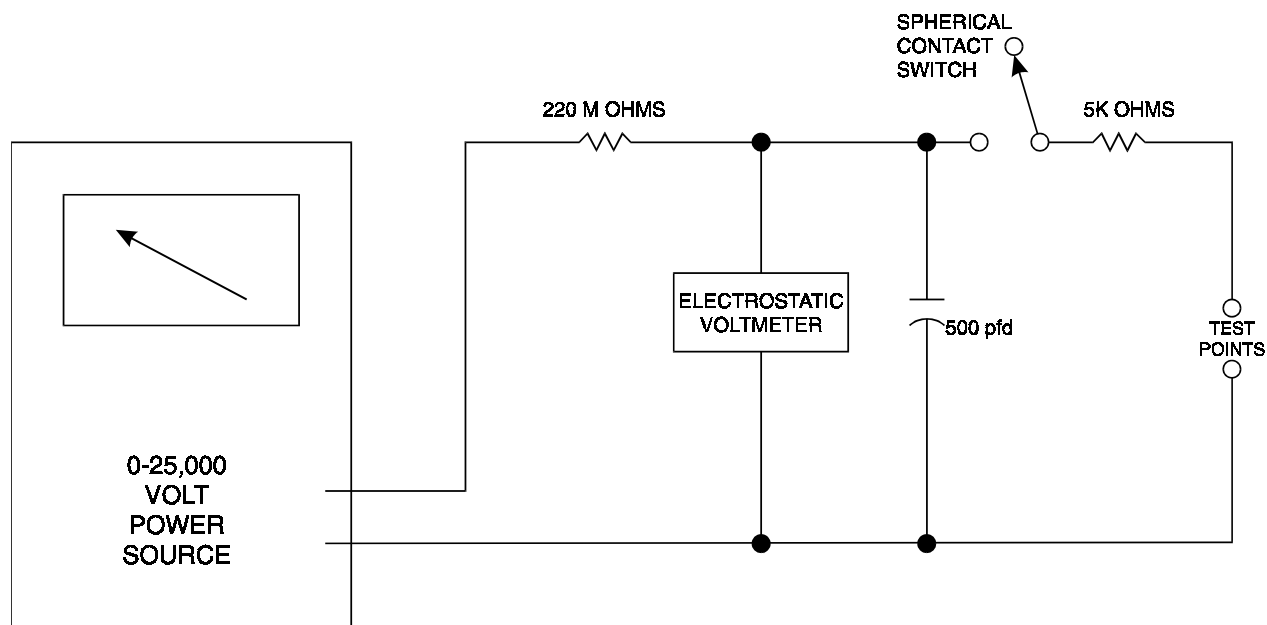


Figure 4B7-1
Static Discharge Test Circuit

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EBW FIRING UNIT AND EBW TEST REQUIREMENTS

3. The applied test voltage shall be a minimum of 500 Vdc.

4. All current carrying components and conductors shall be electrically insulated from each other and system grounded.

5. Unless otherwise specified, the measurement error at the required insulation resistance value shall not exceed 10 percent.

c. Procedure. Perform insulation resistance measurements between the mutually insulated points or between insulated points and ground immediately after a 2-min period of uninterrupted test voltage application.

d. Pass/Fail Criteria. The insulation resistance between all insulated parts, at a potential of 500 Vdc, shall be greater than 2 megohms after exposure to the environment specified herein.

4B7.21 No-Fire Verification

Verify that the EBW will not fire or degrade when subjected to the following voltages:

a. 125 VAC - Subject the EBW to 125 ± 5 Vrms at 60 Hz for 5 min. Apply the voltage across the terminals and between the terminal and the body.

b. 230 VAC - Subject the EBW to 230 ± 10 Vrms at 60 Hz for 5 min. Apply the voltage across the terminals and between the terminals and the body.

c. 500 Vdc - Subject the EBW to 500 ± 25 Vdc, for 60 sec, that is discharged from a 1 ± 10 percent microfarad capacitor. Apply the voltage across the terminals and between the terminals and the body.

4B7.22 RF Sensitivity

To verify that exposure to 1.0 W of absorbed power over a wide range of frequencies as specified in the Table 4B7-6 will not fire or degrade the EBW detonators. The frequency shall be applied across the input terminals of the EBW for 5 sec.

4B7.23 All-Fire/No-Fire Bruceton for EBW

a. Purpose. To determine pin-to-pin voltage characteristics of EBWs based on an assumed voltage log normal density function.

b. Conditions

1. A 5-min constant voltage pulse stimulus is required for determining the maximum no-fire level.

Table 4B7-6
RF Sensitivity

Frequency (MHz)	Type
5 - 100	CW ^a
250 - 300	CW
400 - 500	CW
800 - 1000	CW
2000 - 2400	CW
2900 - 3100	CW
5000 - 6000	CW
9800 - 10000	CW
16000 - 23000	P ^b
32000 - 40000	P

^a Continuous Wave

^b Pulse repetition frequency shall not be less than 100 Hz and the pulse width shall be a minimum of 1 microsecond.

2. A 30-millisecond constant voltage pulse is required for determining the all-fire level.

3. Forty-five EBWs are required for each test.

4. Test Temperature. The test should be performed under ambient (approximately 25°C) temperature conditions, or operational temperatures if conditions include exposure of the EBW to potentially hazardous pin-to-pin stimuli at elevated temperatures. The EBW and heat sink intended to simulate actual installation shall be allowed to come to thermal equilibrium at the test temperature before the stimulus is applied to the EBW.

5. Heat Sink (as applicable). The heat sink environment of the EBW shall approximate the predicted operational thermal environment. If the thermal environments for the EBW usage are multiple or unknown, the minimum heat sinking should be used during the test. If hazards related to "hand held" environments are to be evaluated, the EBW should be mounted in a fixture that effectively insulates the EBW against heat transfer to the environment.

6. During testing, each exposure shall be monitored to provide a permanent record (an oscilloscope picture, digital recording on floppy disk) of the voltage and current of the bridgewire during the 5-min pulse. These records shall be retained by the facility performing the test.

7. Test equipment shall be checked for calibration before any data is taken and an estimate made of maximum errors that are possible in pulse amplitudes and durations.

4B7.23.1 No-Fire Procedure

APPENDIX 4B7

EBW FIRING UNIT AND EBW TEST REQUIREMENTS

a. Expose 5 units to a constant voltage pulse for 5 min to determine the mean and Standard Deviation of the firing voltage assumed log normal density function.

b. Expose 40 units to a constant voltage pulse for 5 min. **NOTE:** The voltage pulse amplitudes used for this test are chosen so that neighboring tests vary by a logarithmic increment approximately equal (0.5 to 1.25) to the Standard Deviation obtained in paragraph *a* above. Improper selection of the mean and Standard Deviation will cause a failure of the Bruceton test and will require another 40 items.

c. In the event of a no-fire, do not disconnect the EBW from the system.

(1) Apply a voltage pulse large enough to ensure firing of the EBW.

(2) If the EBW still fails to fire, omit the no-fire data point from the test, determine the reason for the no-fire, and report it in the test report.

NOTE: Any deviation exceeding 10 percent between the fire (*X*) determined sigma and the no fire (0) determined sigma will be sufficient to void the test and be cause for rerun of the test. The difference is computed by the ratio of the larger sigma to the smaller sigma, and a ratio greater than 110 percent will void the test. Tests showing less than four or greater than seven levels shall also be considered void and the test shall be rerun.

d. Compute the results of the Bruceton test on both *X* and 0 data. **NOTE:** The actual computations of the Bruceton results should be performed by a computer program that is capable of demonstrating its accuracy by calculating log normal density function parameters from simulated Bruceton procedure test results. These simulated results shall be consistent with an assumed log normal

density function. This verification, that consists of simulated test results, the assumed distribution parameters and the Bruceton calculation, should be included with the test results.

e. Calculate the confidence levels using the average of the Standard Deviations and the average of the means (log) as determined by the *X* and 0 data.

f. Compute the 0.001 (0.1%) firing level of the EBW, in volts with 95 percent confidence, from the Bruceton test results.

4B7.23.2 All-Fire Procedure

The all-fire test shall be conducted following the steps described in the **No-Fire Procedure** section above with the following conditions:

a. Substitute a 30-millisecond constant voltage pulse in lieu of the 5-min requirement.

b. Compute the 0.999 (99.9 percent) firing level of the EBW in volts with a 95 percent confidence level from the Bruceton results.

4B7.24 EBW Firing Test

a. Purpose. To verify that the EBW will fire upon application of a specified voltage after being subjected to a specified preconditioning and to verify that the output of the electroexplosive device meets the requirements of the component specifications.

b. Condition. Detonating explosives shall be tested using a metal witness plate to record output through a dent depth measurement technique.

4B7.25 High Temperature Storage

a. Purpose. To verify that long term storage at high temperatures will not shorten the service life of an explosive component.

b. Condition. The storage conditions shall be +71°C and 40-60 percent relative humidity for 30 days.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-1
Laser Firing Unit Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Test (a)		
Performance Tests:		
Resistances	4B8.1	100%
Power-on Duty Cycle	4B8.4	100%
Destruct Command	4B8.5	100%
Arm Command	4B8.6	100%
Monitor Functions	4B8.7	100%
Output Pulse	4B8.8	100%
Function Time	4B8.9	100%
TBD Tests (b)	---	--
Safety Test:		
Inhibit Command	4B8.10	100%
Output Pulse	4B8.8	100%
TBD Tests (b)	---	--
Reference Functional Test: (c)		
Destruct Command Nominal Voltage	4B8.11	100%
Destruct Command Maximum Voltage	4B8.12	100%
Destruct Command Minimum Voltage	4B8.13	100%
Output Pulse	4B8.8	100%
Function Time	4B8.9	100%
Inhibit Command	4B8.10	100%
TBD Tests (b)	---	--
Operating Environment Tests:		
Acoustic (d)	4B1.4.2.2	100%
Acceleration	4B1.4.2.3	100%
Thermal Cycling (e)	4B1.4.2.4	100%
Thermal Vacuum (d)	4B1.4.2.5	100%
Random Vibration (d)	4B1.4.2.1	100%
Burn-in	4B1.4.2.6	100%
Leakage (f)	4B1.2.7	100%

(a) These tests shall be performed prior to and after all environmental tests.

(b) These tests will be established by Range Safety after reviewing and approving the Laser Firing Unit conceptual design.

(c) These tests shall be performed after each environmental test.

(d) The Laser Firing Unit shall be functioned and critical parameters monitored during these environmental tests.

(e) Full functional tests shall be performed at high voltage input on the 1 and 7 cycles, low voltage input on the 2 and 8 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(f) This test shall be performed after the last operating environment test.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-2
Laser Firing Unit Qualification Test Matrix
 (Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Acceptance	ACCEPTANCE TEST MATRIX	X	X	X
Cycle Life	4B8.14	X	X	X
Functional Tests (a)				
Performance Tests:				
Resistances	4B8.1	X	X	X
Reverse Polarity (b)	4B8.2	X	X	X
Overvoltage (b)	4B8.3	X	X	X
Power-on Duty Cycle	4B8.4	X	X	X
Destruct Command	4B8.5	X	X	X
Arm Command	4B8.6	X	X	X
Monitor Functions	4B8.7	X	X	X
Output Pulse	4B8.8	X	X	X
Function Time	4B8.9	X	X	X
TBD Tests (c)	---	-	-	-
Safety Tests:				
Inhibit Command	4B8.10	X	X	X
Output Pulse	4B8.8	X	X	X
TBD Tests (c)	---	-	-	-
Reference Functional Tests (d)				
Destruct Command Nominal Voltage	4B8.11	X	X	X
Destruct Command Maximum Voltage	4B8.12	X	X	X
Destruct Command Minimum Voltage	4B8.13	X	X	X
Output Pulse	4B8.8	X	X	X
Function Time	4B8.9	X	X	X
Inhibit Command	4B8.10	X	X	X
TBD Tests (c)	---	-	-	-
Non-Operating Environment Tests:				
Storage Temperature	4B1.3.1	X	X	X
Transport Shock/Bench Handling	4B1.3.3	X	X	X
Transportation Vibration	4B1.3.4	X	X	X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6		X	
Fine Sand	4B1.3.7			X

(a) These tests shall be performed after all non-operating environment tests have been completed. These tests shall also be performed after all operating environment tests have been completed.

(b) One time test

(c) These tests will be established by Range Safety after reviewing and approving the Laser Firing Unit conceptual design.

(d) These tests shall be performed after each environmental test.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-2
Laser Firing Unit Qualification Test Matrix
(2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Operating Environment Tests				
Sinusoidal Vibration (e)	4B1.4.1.1	X	X	X
Acoustic (e)	4B1.4.1.3	X	X	X
Shock	4B1.4.1.4	X	X	X
Acceleration	4B1.4.1.5	X	X	X
Humidity (e)	4B1.4.1.6			X
Thermal Cycling (f)	4B1.4.1.7	X	X	X
Thermal Vacuum (e)	4B1.4.1.8	X	X	X
Random Vibration (e)	4B1.4.1.2	X	X	X
EMI/EMC (e)	4B1.4.1.9		X	X
Explosive Atmosphere (e)	4B1.4.1.10	X		
TBD Tests (c)	---	X	X	X
Leakage (g)	4B1.2.7	X	X	X
Disassembly	4B1.4.1.11	X	X	X

- (c) These tests will be established by Range Safety after reviewing and approving the Laser Firing Unit conceptual design.
- (e) The Laser Firing Unit shall be functioned and critical parameters monitored during these environmental tests.
- (f) Full functional tests shall be performed at high voltage input on the 1 and 23 cycles, nominal voltage on the 12 and 13 cycles, low voltage input on the 2 and 24 cycles and reference functional tests for the remaining cycles at nominal voltage input.
- (g) This test shall be performed after the last non-operating and the last operating environment test.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-3
Optical S&A Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Test (a)		
Full Bench Test (b)	4B8.15	100%
Reference Functional Test (c)		
Limited Bench Test (b)	4B8.16	100%
Operating Environment Tests:		
Thermal Cycling	4B1.4.2.4	100%
Random Vibration (d)	4B1.4.2.1	100%
Leakage (e)	4B1.2.7	100%

(a) These tests shall be performed prior to and after all environmental tests.

(b) These tests will be established by Range Safety after reviewing and approving the optical S&A conceptual design.

(c) This test shall be performed prior to the random vibration test.

(d) During random vibration testing, the following S&A parameters shall be monitored continuously: arm/safe, barriers locked/unlocked, main laser power connected/disconnected and continuity of optical firing line.

(e) This test shall be performed after the last operating environment test.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-4
Optical S&A Qualification Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED	
		1	2
Acceptance	ACCEPTANCE TEST MATRIX	X	X
Functional Test (a) Full Bench Test (b)	4B8.15	X	X
Reference Functional Test (c) Limited Bench Test (b)	4B8.16	X	X
Non-Operating Environment Tests			
Storage Temperature	4B1.3.1	X	X
Transport Shock/Bench Handling	4B1.3.3	X	X
Transportation Vibration	4B1.3.4	X	X
Fungus Resistance	4B1.3.5	X	
Salt Fog	4B1.3.6	X	
Fine Sand	4B1.3.7	X	
Operating Environment Tests:			
Sinusoidal Vibration (d)	4B1.4.1.1	X	X
Shock (d)	4B1.4.1.4	X	X
Acceleration	4B1.4.1.5	X	X
Humidity	4B1.4.1.6	X	X
Thermal Cycling	4B1.4.1.7	X	X
Random Vibration (d)	4B1.4.1.2	X	X
Explosive Atmosphere	4B1.4.1.10	X	
Leakage (e)	4B1.2.7	X	X
Firing Test at Operating Energy (f)			
At Ambient Temperature	4B8.21	X	X
At High Temperature (g)	4B8.21	X	X
At Low Temperature (h)	4B8.21	X	X
Safety Tests			
Cycle life	4B8.17	X	
Stall	4B8.18	X	
Barrier Tests	4B8.20		X
Disassembly	4B1.4.2.7	X	X

(a) These tests shall be performed after all non-operating environment tests have been completed. These tests shall also be performed after all operating environmental tests have been completed.

(b) These tests will be established by Range Safety after reviewing and approving the optical S&A conceptual design.

(c) These tests shall be performed after each environmental test.

(d) During these environmental tests, the following S&A parameters shall be monitored continuously: arm/safe, barriers locked/unlocked, main laser power connected/disconnected and continuity of optical firing line.

(e) This test shall be performed after the last non-operating and the last operating environment test.

(f) In the event that operating energy cannot be predicted, the test energy shall be 2 times their specified operating energy.

(g) Fire at predicted high temperature or +71°C whichever is higher.

(h) Fire at predicted low temperature or -34°C whichever is lower.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-5
Ordnance S&A Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Test (a)		
Full Bench Test	4B8.34	100%
Reference Functional Test (b)		
Limited Bench Test	4B8.35	100%
Operating Environment Tests		
Thermal Cycling (c)	4B1.4.2.4	100%
Random Vibration (d)	4B1.4.2.1	100%
Leakage (e)	4B1.2.7	100%

(a) These tests shall be performed prior to and after all environmental tests.

(b) This test shall be performed prior to the random vibration test.

(c) The number of thermal cycles shall be 8 with dwell time of 2 h at each temperature extreme.

(d) During random vibration testing, the S&A ARM/SAFE telemetry circuits and firing line circuits shall be continuously monitored for status.

(e) This test shall be performed after the last operating environment test.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-6
Ordnance S&A Qualification Test Matrix
Page 1 of 2

TEST	TEST REQUIREMENT	QUANTITY TESTED			
		1	1	6	3
Acceptance	ACCEPTANCE TEST MATRIX	X	X	X	
Functional Test (a)					
Full Bench Test	4B8.34	X		X	
Reference Functional Test (b)					
Limited Bench Test	4B8.35	X		X	
Non-Operating Environment Tests					
Storage Temperature	4B1.3.1	X		X	
Transport Shock/Bench Handling	4B1.3.3	X		X	
Transportation Vibration	4B1.3.4	X		X	
Fungus Resistance	4B1.3.5	X			
Salt Fog	4B1.3.6	X			
Fine Sand	4B1.3.7	X			
Operating Environment Tests					
Stall, 5 minutes	4B8.37.1	X		X	
Sinusoidal Vibration (c)	4B1.4.1.1	X		X	
Shock (c)	4B1.4.1.4	X		X	
Acceleration	4B1.4.1.5	X		X	
Humidity	4B1.4.1.6	X		X	
Thermal Cycling (d)	4B1.4.1.7	X		X	
Random Vibration (c)	4B1.4.1.2	X		X	
Explosive Atmosphere	4B1.4.1.10	X			
Leakage (e)	4B1.2.7	X		X	
Disassembly	4B1.4.1.11			2	
Firing Tests					
At High Temperature (f)	4B8.40			2	
At Low Temperature (g)	4B8.40			2	

(a) These tests shall be performed after all non-operating environment tests have been completed and also after all operating environment tests have been completed.

(b) These tests shall be performed after each environmental test, excluding leakage, explosive atmosphere, and disassembly.

(c) During these tests, the S&A ARM/SAFE telemetry circuits shall be continuously monitored for status.

(d) The number of thermal cycles shall be 24 with dwell time of 2 h at each temperature extreme.

(e) This test shall be performed after the last non-operating and the last operating environment test

(f) Fire at designed high temperature or +71°C whichever is higher.

(g) Fire at designed low temperature or -54°C whichever is lower.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-6
Ordnance S&A Qualification Test Matrix
Page 2 of 2

TEST	TEST REQUIREMENT	QUANTITY TESTED			
		1	1	6	3
Safety Tests					
Cycle life (<i>h</i>)	4B8.36	X			
Stall, 60 minutes (<i>h</i>)	4B8.37	X			
Six Foot Drop Test (<i>i</i>)	4B8.38.1		X		
Twenty Foot Drop Test (<i>h</i>)	4B8.38.2	X			
Visual Inspection (<i>j</i>)	- - -	X			
Barrier Test (<i>k</i>)	4B8.39				X

(*h*) The S&A exposed to these tests shall not be fired.

(*i*) A limited bench test shall be performed after this test. Also, the S&A shall be fired at ambient temperature after the limited bench test.

(*j*) The S&A shall be inspected for hazardous condition prior to disposal.

(*k*) Test units that duplicate all dimensions, including gaps between explosive components, free volume and diaphragm thickness (if used); of the operational S&A, shall be used. The explosive transfer assemblies that are normally mated to the S&A in flight shall be used.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-7
Fiber Optic Cable Assembly Lot Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Non-Destructive Tests		
Visual Inspection	4B1.2.1	100%
Dimension	4B1.2.3	100%
Leakage	4B1.2.7	100%
Pull Test (a)	4B1.3.8	100%
X-Ray	4B8.41	100%
Laser Pulse	4B8.22	100%
Optical Continuity	4B8.23	100%
TBD tests (b)	--	--
Destructive Tests		
Shock (c)(d)	4B1.4.1.4	Lot Sample (e)
Thermal Cycling (c)(d)	4B1.4.1.7	Lot Sample
Random Vibration (c)(d)	4B1.4.1.2	Lot Sample
Optical Continuity	4B8.23	Lot Sample
X-Ray	4B1.2.5	Lot Sample
Leakage	4B1.2.7	Lot Sample
Firing Tests: (f)		
Ambient Temperature LFU Operating Energy	4B8.29	1/3 Lot Sample
Maximum Predicted High Temperature LFU Operating Energy (g)	4B8.29	1/3 Lot Sample
Maximum Predicted Low Temperature LFU Operating Energy (h)	4B8.29	1/3 Lot Sample

(a) Pull test shall be performed at 50 lb.

(b) These tests will be established by Range Safety after reviewing and approving the FOCA conceptual design.

(c) Optical continuity shall be monitored continuously during these tests.

(d) Environmental tests shall be performed at qualification level.

(e) Lot Sample is 10 percent or 9 assemblies.

(f) A laser firing unit (LFU) and a pulse catcher capable of measuring output energy shall be connected to the FOCA during these tests. These tests shall demonstrate the FOCA's ability to transmit the required laser energy from the LFU to the pulse catcher at the noted temperature extremes.

(g) Fire at designed high temperature or +71°C whichever is higher.

(h) Fire at designed low temperature or -34°C whichever is lower.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-8
Fiber Optic Cable Assembly Qualification Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		10	35	15
Acceptance (Non-Destructive)	ACCEPTANCE TEST MATRIX	X	X	X
Stray Energy Sensitivity	4B8.24		<u>X</u> (a)	
Non-Operating Environment Tests				
Storage Temp.	4B1.3.1			X
Trans. Shock	4B1.3.3			X
Trans. Vibration	4B1.3.4			X
Fungus Resistance (b)	4B1.3.5			X
Salt Fog (b)	4B1.3.6			X
Fine Sand (b)	4B1.3.7			X
Operating Environment Tests				
Shock (c)	4B1.4.1.4			X
Acceleration	4B1.4.1.5			X
Thermal Cycling (c)	4B1.4.1.7			X
Random Vibration (c)	4B1.4.1.2			X
Pull Test (d)(e)	4B1.3.8			X
Drop Test (e)	4B8.19			X
Impact Test (e)	4B8.25			X
Bend Test (e)	4B8.26			X
Cycle Test (e)	4B8.27			X
Mate/Demate (e)	4B8.28			X
TBD Test (f)	---			---
Leakage (g)	4B1.2.7			X
X-Ray	4B1.2.5			X
Firing Tests: (h)				
Ambient Temperature 2x Operating Energy	4B8.29			<u>5</u>
High Temperature 2x Operating Energy (i)	4B8.29			<u>5</u>
Low Temperature 2x Operating Energy (j)	4B8.29			<u>5</u>
Random Vibration/High Temperature Firing				
LFU Operating Energy (j)(k)	4B8.29	<u>5</u>		
Random Vibration/Low Temperature Firing				
LFU Operating Energy (j)(k)	4B8.29	<u>5</u>		

(a) Underlining indicates assemblies are potentially damaged; therefore, the test ends.

(b) Requires only five assemblies for this test.

(c) Optical continuity shall be monitored continuously during these tests.

(d) Pull test shall be performed at 100 Pounds.

(e) Optical continuity shall be performed after the noted tests.

(f) These tests will be established by Range Safety after reviewing and approving the FOCA conceptual design.

(g) This test shall be performed after the last non-operating and the last operating environment test.

(h) A laser firing unit (LFU) and a pulse catcher capable of measuring output energy shall be connected to the FOCA during these tests. These tests shall demonstrate the FOCA's ability to transmit the required laser energy from the LFU to the pulse catcher at the noted temperature extremes.

(i) Fire at designed high temperature or +71°C whichever is higher.

(j) Fire at designed low temperature or -34°C whichever is lower.

(k) During these tests, an LFU and pulse catcher shall be connected to the FOCA (in flight configuration). The FOCA shall be vibrated (qualification level) at the noted temperature and then a laser shall be fired through the FOCA to the pulse catcher.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-9
LID Lot Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Non-Destructive Tests		
Visual Inspection	4B1.2.1	100%
Dimension	4B1.2.3	100%
Leakage	4B1.2.7	100%
Static Discharge	4B8.30	100%
Pull Test (a)	4B1.3.8	100%
X-Ray	4B1.2.5	100%
N-Ray	4B1.2.6	100%
Destructive Tests		
Shock (b)	4B1.4.1.4	Lot Sample (c)
Thermal Cycling (b) (d)	4B1.4.1.7	Lot Sample
Random Vibration (b)	4B1.4.1.2	Lot Sample
X-Ray	4B1.2.5	Lot Sample
N-Ray	4B1.2.6	Lot Sample
Leakage	4B1.2.7	Lot Sample
No Fire Verification	4B8.31	Lot Sample
Firing Tests		
Ambient Temperature		
All-Fire Energy (e)	4B8.33	1/6 Lot Sample
Operating Energy (f)	4B8.33	1/6 Lot Sample
Max. Predicted High Temp. (g)		
All-Fire Energy (e)	4B8.33	1/6 Lot Sample
Operating Energy (f)	4B8.33	1/6 Lot Sample
Max. Predicted Low Temp (h)		
All-Fire Energy (e)	4B8.33	1/6 Lot Sample
Operating Energy (f)	4B8.33	1/6 Lot Sample

(a) Pull test shall be performed on LIDs having an integral fiber optic cable (pigtail).

(b) Environmental tests shall be performed at qualification level.

(c) Lot sample is 10 percent of lot but not less than 30 units.

(d) The number of thermal cycles shall be 24 with dwell time of 2 h at each temperature extreme.

(e) All-Fire Energy is specified All-Fire Energy vs. Bruceton All-Fire Energy.

(f) In the event that operating energy cannot be predicted the test energy shall be 2 times Bruceton All-Fire Energy.

(g) Fire at designed high temperature or +71°C whichever is higher.

(h) Fire at designed low temperature or -54°C whichever is lower.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-10
LID Qualification Test Matrix
(Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED									
		60	315	45	45	5	5	6	5	5	105
Acceptance (Non-Destructive Test)	ACCEPTANCE TEST MATRIX	X	X	X	X	X	X	X	X	X	X
Stray Energy Sensitivity	4B8.24		<u>X</u> (a)								
No Fire Bruceton	4B8.32			<u>X</u>							
All-Fire Bruceton	4B8.32				<u>X</u>						
Non-Operating Environment Tests											
Storage Temperature	4B1.3.1									X	X
Trans. Shock/Bench Handling	4B1.3.3									X	X
Trans. Vibration	4B1.3.4										X
Fungus Resistance	4B1.3.5							X			
Salt Fog	4B1.3.6							X			
Fine Sand	4B1.3.7							X			
Operating Environment Tests											
High Temp. Exposure	4B1.3.2					<u>X</u>					
Shock	4B1.4.1.4									X	X
Acceleration	4B1.4.1.5									X	X
Thermal Cycling (b)	4B1.4.1.7								X	X	X
Random Vibration	4B1.4.1.2										X
Pull Test (c)	4B1.3.8									X	X
Drop Test (6 ft)	4B1.3.9									X	X
Drop Test (40 ft)	4B1.3.10						<u>X</u>				
Leakage (d)	4B1.2.7								X	X	X
X-Ray	4B1.2.5								X	X	X
N-Ray	4B1.2.6								X	X	X
No Fire Verification	4B8.31	X						X	X	X	X

(a) Underlining indicates units are considered destroyed.

(b) The number of thermal cycles shall be 24 with dwell time of 2 h at each temperature extreme.

(c) Pull tests shall be performed on LIDs having an integral fiber optic cable (pigtail).

(d) This test shall be performed after the last non-operating and the last operating environment test.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-10
LID Qualification Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED									
		60	315	45	45	5	5	6	5	5	105
Firing Tests											
Ambient Temperature											
All-Fire Energy (e)	4B8.33							X	X	X	
Ambient Temperature											
All-Fire Energy (e)	4B8.33										15
Operating. Energy (f)	4B8.33										15
2x Operating. Energy	4B8.33										5
High Temperature (g)											
All-Fire Energy (e)	4B8.33										15
Operating. Energy (f)	4B8.33										15
2x Operating. Energy	4B8.33										5
Low Temperature (h)											
All-Fire Energy (e)	4B8.33										15
Operating. Energy (f)	4B8.33										15
2 x Operating. Energy	4B8.33										5
Random Vibration/High Temperature/Operating Energy (f)(g)(i)	4B8.33	30									
Random Vibration/Low Temperature/Operating Energy (f)(h)(i)	4B8.33	30									

(e) All-Fire energy is specified All-Fire energy vs Bruceton All-Fire energy.

(f) In the event that operating energy cannot be predicted, the test energy shall be 2 times Bruceton All-Fire Energy.

(g) Fire at designed high temperature or +71°C whichever is higher.

(h) Fire at designed low temperature or -54°C whichever is lower.

(i) During these tests, a fiber optic cable shall be connected to the LIDs in flight configuration. The LIDs shall be vibrated (qualification level) at the noted temperature and then fired.

APPENDIX 4B8
LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

Table 4B8-11
LID Age Surveillance Test Matrix (a)

TEST	TEST REQUIREMENT	QUANTITY TESTED 5
Non-Destructive Tests		
Visual Inspection	4B1.2.1	X
Dimension	4B1.2.3	X
Leakage	4B1.2.7	X
Static Discharge	4B8.30	X
X-Ray	4B1.2.5	X
N-Ray	4B1.2.6	X
Destructive Tests		
Shock (b)	4B1.4.1.4	X
Thermal Cycling (b) (c)	4B1.4.1.7	X
Random Vibration (b)	4B1.4.1.2	X
X-Ray	4B1.2.5	X
N-Ray	4B1.2.6	X
Leakage	4B1.2.7	X
No Fire Verification	4B8.31	X
Firing Test		
Ambient Temperature All-Fire Energy (d)	4B8.33	X

(a) Testing shall be conducted one year after lot acceptance testing and each year thereafter to extend service life indefinitely.

(b) Tests shall be performed at qualification levels.

(c) The number of thermal cycles shall be 24 with dwell time of 2 h at each temperature extreme.

(d) All-Fire energy is specified All-Fire energy vs Bruceton All-Fire energy.

APPENDIX 4B8

LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

4B8.1 Resistances TBD

4B8.2 Reverse Polarity TBD

4B8.3 Overvoltage TBD

4B8.4 Power-on Duty Cycle TBD

4B8.5 Destruct Command TBD

4B8.6 Arm Command TBD

4B8.7 Monitor Functions TBD

4B8.8 Output Pulse TBD

4B8.9 Function Time TBD

4B8.10 Inhibit Command TBD

4B8.11 Destruct Command Nominal Voltage
TBD

4B8.12 Destruct Command Maximum Voltage
TBD

4B8.13 Destruct Command Minimum Voltage
TBD

4B8.14 Cycle Life (LFU) TBD

4B8.15 Full Bench Test TBD

4B8.16 Limited Bench Test TBD

4B8.17 Cycle Life (Optical S&A) TBD

4B8.18 Stall TBD

4B8.19 Drop Test TBD

4B8.20 Barrier Test TBD

4B8.21 Firing Test (Optical S&A) TBD

4B8.22 Laser Pulse TBD

4B8.23 Optical Continuity TBD

4B8.24 Stray Energy Sensitivity TBD

4B8.25 Impact Test TBD

4B8.26 Bend Test TBD

4B8.27 Cycle (FOCA) TBD

4B8.28 Mate/Demate TBD

4B8.29 Firing (FOCA) Test TBD

4B8.30 Static Discharge TBD

4B8.31 No Fire Verification TBD

4B8.32 No Fire/All-Fire Bruceton TBD

4B8.33 Firing (LID) Test TBD

4B8.34 Full Bench Test

a. Purpose

1. To verify that the component is capable of cycling within its specified operating time.

2. To verify the capability to manually safe the component.

3. To confirm the effort that is needed to remove the safing pin and to determine the safing pin retention capability.

b. Procedure

1. Remove the safing pin and measure the force/torque that is required to remove the pin.

2. Cycle the component (SAFE to ARM and ARM to SAFE) 25 more times and measure each cycle time.

3. Remotely arm the component and measure the cycle time.

4. Manually safe the component and measure the angular or the sliding displacement of safe rotation/travel if possible.

5. Verify that the S&A safing pin can be inserted and removed without binding.

6. Install the safing pin.

7. When component is in the SAFE position and the arming current is applied, measure the retention capability of the safing pin.

c. Pass/Failure Criteria. The component shall be capable of operating within the requirements of the component specification.

4B8.35 Limited Bench Test

a. Purpose

1. To verify that the device is capable of cycling within its specified operating time.

2. To verify the capability to manually safe the component.

b. Procedure

1. Cycle the component 5 more times and measure each cycle time (SAFE to ARM and ARM to SAFE).

2. Remotely safe the component.

3. Install the safing pin.

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LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

c. Pass/Fail Criteria. The component shall be capable of operating within its specified operating time.

4B8.36 Cycle Life

a. Purpose. To verify that the unit can withstand repeated cycling from the armed to the disarmed position for at least 1000 cycles without any malfunction, failure or deterioration in electromechanical performance.

b. Procedure

1. Cycle the component 1000 times using nominal operational arming voltage.

2. Perform a limited bench test in accordance with the **Limited Bench Test** section of this appendix at every 1/3 interval of cycle time.

c. Pass/Fail Criteria. The component shall be capable of operating within its specified operating time.

4B8.37 Stall

4B8.37.1 5-Min Stall

a. Purpose. To verify that electrically actuated S&As will meet the specified electro-mechanical performance requirements after the application of maximum operational arming voltages continuously for up to 5 min with the safing pin installed

b. Procedure

1. With the safing pin installed, apply a maximum value arming voltage for 5 min.

2. Verify the performance by performing a limited bench in accordance with the **Limited Bench Test** section of this Appendix.

c. Pass/Fail Criteria. The component shall be capable of operating within the requirements of the component specification.

4B8.37.2 60-Min Stall

a. Purpose. To verify that the explosive that is in the S&A will not detonate after the application of maximum operational arming voltages continuously for up to 60 min with the safing pin installed.

b. Procedure. With the safing pin installed, apply a maximum value arming voltage for 60 min.

c. Pass/Fail Criteria. The detonator/explosive in the S&A shall not detonate.

4B8.38 Drop Test

4B8.38.1 6-ft Drop Test

a. Purpose. To demonstrate that the explosive in the S&A device will not initiate when dropped from 6 ft and will perform to specification after impact if the effects of the drop are not detectable

b. Condition. The S&A device shall be dropped onto a 1/2-in. thick steel plate from a height of 6 ft. (one drop)

c. Pass/Fail Criteria

1. The explosive in the device shall not initiate as a result of the impact and will be safe to handle.

2. If the effects of the drop are not detectable, the S&A device shall be required to fire and properly propagate.

4B8.38.2 20-ft Drop Test

a. Purpose. To demonstrate that the explosive in the S&A device will not initiate when dropped from 20 ft and will be safe to handle for subsequent disposal

b. Condition. The S&A device shall be dropped onto a 1/2-in. thick steel plate from a height of 20 ft. (one drop)

c. Pass/Fail Criteria

1. The explosive in the device shall not initiate as a result of the impact and will be safe to handle.

2. The device shall be safe to handle for subsequent disposal.

3. The device need not be functional following this test.

4B8.39 Barrier Test

a. Purpose. To verify that the S&A barrier will prevent the initiation of subsequent explosive charges in the event of an inadvertent firing of the detonator when the device is in the safe condition

b. Condition(s)

1. A test unit can be used that duplicates all nominal dimensions (including gaps between explosive components, free volume, and diaphragm thickness) of the operational S&A.

2. The explosive transfer line shall be mated to the test unit for this test.

c. Procedure

1. For Rotating Barriers. Position the test unit rotor 50 degrees or greater from the full safe position.

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LASER INITIATED ORDNANCE SYSTEM TEST REQUIREMENTS

2. For Sliding Barriers. Position the test unit barrier midway between the safe and the arm position.

3. Temperatures.

(a) Fire one test unit at least 10°C above the maximum predicted temperature or +71°C whichever is greater.

(b) Fire one test unit at ambient (approximately 25°C) temperature.

(c) Fire one test unit at least 10°C below the minimum temperature or -54° C whichever is lower.

(d) Temperature conditioning of at least 4 h is required.

d. Pass/Fail Criteria.

1. S&As that use rotor leads shall not have their rotor leads undergo a low or a high order detonation as the result of the test unit firing.

2. S&As that couple the detonator directly to an external ordnance train shall not have that external ordnance train undergo a low or a high order detonation as the result of the test unit firing.

4B8.40 S&A Firing

a. Purpose. To verify that the explosives will

fire upon application of a specified energy and that the output of the device will initiate a specified explosive train after being subjected to a specified preconditioning

b. Conditions

1. The S&A device shall be fired at ambient, high, and low temperatures.

2. The predicted operating energy shall be used. **NOTE:** If the operating energy is unknown, the test energy of 2 times Bruceton All-Fire of the LID shall be used.

3. With both detonators receiving energy simultaneously, test half of the test sample.

4. With the detonators receiving energy sequentially to demonstrate complete redundancy, test the remaining half of the test sample. **NOTE:** A minimum of 1 min shall be provided between the sequenced detonators firings.

5. A witness target shall be used to verify successful initiation.

c. Pass/Fail Criteria

1. The S&A explosives shall fire upon application of a specified energy.

2. The output of the S&A device shall initiate a specified explosive train after being subjected to a specified preconditioning.

APPENDIX 4B9
ETS AND DESTRUCT CHARGE TEST REQUIREMENTS

Table 4B9-1
ETS and Destruct Charge Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Non-Destructive		
Visual Inspection	4B1.2.1	100%
Dimension	4B1.2.3	100%
Leakage	4B1.2.7	100%
X-Ray	4B1.2.5	100%
N-Ray	4B1.2.6	100%
Destructive		
Pull Test (a)	4B1.3.8	Lot Sample(c)
Shock (b)	4B1.4.1.4	Lot Sample
Thermal Cycling (b)	4B1.4.1.7	Lot Sample
High Temp. Storage (d)	(e)	Lot Sample
Random Vibration (b)	4B1.4.1.2	Lot Sample
X-Ray	4B1.2.5	Lot Sample
N-Ray	4B1.2.6	Lot Sample
Leakage	4B1.2.7	Lot Sample
Firing Test (f)		
Ambient Temperature	--	1/3 Lot Sample
High Temperature (g)	--	1/3 Lot Sample
Low Temperature (h)	--	1/3 Lot Sample

(a) The pull test shall be performed at 100 lb for ETS and associated fittings; 50 lb for destruct charge and associated fittings.

(b) Tests shall be performed at qualification level.

(c) The sample size is 10 percent of the lot, but not less than 9 units from the lot.

(d) This test is optional. If performed, the lot has initial service life of three years.

(e) The item shall be subjected to high temperature storage environment as part of an accelerated aging test. The storage conditions shall be +71°C and 40-60 percent relative humidity for 30 days.

(f) Item shall be function against a witness plate.

(g) Fire at designed high temperature or +71°C whichever is higher.

(h) Fire at designed low temperature or -54°C whichever is lower.

APPENDIX 4B9

ETS AND DESTRUCT CHARGE TEST REQUIREMENTS

Table 4B9-2
ETS and Destruct Charge Qualification Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		2	4	21
Acceptance (Non-Destructive)	ACCEPTANCE TEST MATRIX	X	X	X
Non-Operating Environment Test				
Storage Temperature	4B1.3.1		X	
Transport Shock/Bench Handling	4B1.3.3		X	
Transportation Vibration	4B1.3.4		X	
Fungus Resistance	4B1.3.5		X	
Salt Fog	4B1.3.6		X	
Fine Sand	4B1.3.7		X	
Operating Environment Test (a)				
Pull Test (b)	4B1.3.8		X	X
Sinusoidal Vibration	4B1.4.1.1	X	X	
Shock	4B1.4.1.4			X
Acceleration	4B1.4.1.5			X
Humidity	4B1.4.1.6	X	X	
Thermal Cycling	4B1.4.1.7	X	X	X
High Temperature Storage (c)	(d)			10
Random Vibration	4B1.4.1.2			X
Drop Test (6 Foot) (e)	4B1.3.9	1		
Drop Test (40 Foot) (f)	4B1.3.10	1	X	
Leakage (g)	4B1.2.7		X	X
X-Ray	4B1.2.5		X	X
N-Ray	4B1.2.6			X
Firing Test (h)				
Ambient Temperature	--			7
High Temperature (i)	--		2	7
Low Temperature (j)	--		2	7

- (a) ETS manifold (if used) shall be tested with ETS assembly attached during all operating environment tests.
- (b) The pull test shall be performed at 100 lb for ETS and associated fittings, 50 lb for Destruct Charge and associated fittings.
- (c) This test is optional. If performed, the lot has initial service life of three years.
- (d) The item shall be subject to high temperature storage environment as part of an accelerated aging test. The storage conditions shall be +71°C and 40-60 percent relative humidity for 30 days.
- (e) Component is required to function if the effects of the drop test are not detectable.
- (f) Component is not required to be functioned after this test.
- (g) This test shall be performed after the last non-operating and the last operating environment test.
- (h) Item shall be functioned against a witness plate.
- (i) Fire at designed high temperature or +71°C whichever is higher.
- (j) Fire at designed low temperature or -54°C whichever is lower.

APPENDIX 4B9

ETS AND DESTRUCT CHARGE TEST REQUIREMENTS

Table 4B9-3
ETS and Destruct Charge Age Surveillance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED	
		5 (a)	10 (b)
Non-Destructive Tests			
Visual Inspection	4B1.2.1	X	X
Dimension	4B1.2.3	X	X
Leakage	4B1.2.7	X	X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Destructive Tests			
Pull Test (c)	4B1.3.8	X	X
Shock	4B1.4.1.4	X	X
Thermal Cycling (d)	4B1.4.1.7	X	X
High Temperature Storage	(e)		X
Random Vibration (d)	4B1.4.1.2	X	X
Leakage	4B1.2.7	X	X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Firing Test (f)			
High Temperature (g)		3	5
Low Temperature (h)		2	5

(a) Testing that can be conducted to extend service life for one year.

(b) Testing shall be conducted to extend service life for three years.

(c) The pull test shall be performed at 100 lb for ETS and associated fittings; 50 lb for destruct charges and associated fittings.

(d) Tests shall be performed at qualification level.

(e) The item shall be subjected to an extreme storage environment as part of an accelerated aging test. The storage conditions shall be +71°C and 40 to 60 percent relative humidity for 30 days.

(f) Item shall be function against a witness plate.

(g) Fire at predicted high temperature or +71°C whichever is higher.

(h) Fire at predicted low temperature or -54°C whichever is lower.

APPENDIX 4B10

PERCUSSION ACTIVATED DEVICE TEST REQUIREMENTS

Table 4B10-1
PAD Acceptance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED
Non-Destructive Tests:		
Visual	4B1.2.1	100%
Dimension	4B1.2.3	100%
Pull Test (a)	----	100%
Pin Locking Test (b)	----	100%
Pin Insertion/Removal Test (c)	----	100%
Pin Retention Test (d)	----	100%
Leakage	4B1.2.7	100%
X-Ray	4B1.2.5	100%
N-Ray	4B1.2.6	100%
Destructive Test		
Shock (e)	4.B.4.1.4	Lot Sample (f)
Thermal Cycling (e)	4B1.4.1.7	Lot Sample
Random Vibration (e)	4B1.4.1.2	Lot Sample
High Temp. Storage (g)	(h)	Lot Sample
Leakage	4B1.2.7	Lot Sample
X-Ray	4B1.2.5	Lot Sample
N-Ray	4B1.2.6	Lot Sample
Firing Test at Operation Pull		
Distance (i)(j)		
At Ambient Temperature	----	1/3 of Lot Sample
At High Temperature (k)	----	1/3 of Lot Sample
At Low Temperature (l)	----	1/3 of Lot Sample

- (a) PAD shall be pulled with 50 lb of force. Spring constant and mechanical movement shall be verified.
- (b) The PAD shall be pulled to 100 lb with the safing pin installed. The PAD firing assembly shall not show any motion nor experience any mechanical anomalies.
- (c) The force required for pin insertion/removal shall be between 20-40 pounds or 20-40 in-lb of torque.
- (d) This test places a load test on the PAD lanyard of 50 lb with the safing pin installed. The safing pin shall be subjected to a Insertion/Removal force and shall not disengage from the PAD.
- (e) Tests shall be performed at qualification levels.
- (f) A lot sample consists of 10% of the lot or 9 units whichever is greater.
- (g) This test is optional, if performing, the lot has initial service of 3 years.
- (h) The item shall be subjected to high temperature storage environment as part of an accelerated aging test. The storage candidates shall be +71 degrees C and 40 to 60 percent relative humidity for 30 days.
- (i) The pull distance shall be measured during this test and verified within acceptable tolerances.
- (j) The spring constant shall be measured while pulling the PAD during the firing test.
- (k) Fire at designed high temperature or +71 degrees C whichever is higher.
- (l) Fire at designed low temperature or -54 degrees C whichever is lower.

APPENDIX 4B10 PERCUSSION ACTIVATED DEVICE TEST REQUIREMENTS

Table 4B10-2
PAD Qualification Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		4	2	21
Acceptance (Non-Destructive Test)	ACCEPTANCE TEST MATRIX	X	X	X
No-Fire Impact Test (a) (b) (c)	----			X
Pin Locking Test (d)	----	X	X	X
Pin Retention Test (e)	----	X	X	X
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X		X
Transport Shock/Bench Handling	4B1.3.3	X		X
Transportation Vibration	4B1.3.4	X		X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6	X		
Fine Sand	4B1.3.7	X		
Operating Environment Tests				
Sinusoidal Vibration	4B1.4.1.1	X		X
Shock	4B1.4.1.4	X		X
Acceleration	4B1.4.1.5	X		X
Humidity	4B1.4.1.6	X		
Thermal Cycling	4B1.4.1.7	X		X
High Temperature Storage (f)	(g)			X
Random Vibration	4B1.4.1.2	X		X
Leakage	4B1.2.7	X		X
N-Ray	4B1.2.5	X		X
X-Ray	4B1.2.6	X		X
Disassembly	4B1.4.1.11	1		3
Firing Test at Operation Pull Distance (a)				
(h)				
At Ambient Temperature	----			6
At High Temperature (i)	----	2		6
At Low Temperature (j)	----	1		6
Safety Test				
Drop Test (6 Foot)	4B1.3.9		1	
Drop Test (20 Foot) (k)(l)	4B1.3.10		1	

(a) The spring constant verification shall be measured while pulling the PAD during the firing test.

(b) This test to be performed using the maximum guaranteed no-fire pull distance (50 lb). The PAD assembly shall be released and the PAD shall not fire. The PAD primer initiation assembly shall not disengage inadvertently when pulled the guaranteed no-fire distance.

(c) PAD No-Fire Bruceton impact energy testing is not required for PADs using a design that prevents impact with the primer unless the firing assembly is pulled to its operational fire distance. **NOTE:** This testing will be performed during the Primer qualification test.

(d) The PAD shall be pulled to 200 lb with the safing pin installed. The PAD firing assembly shall not show any motion nor experience any mechanical anomalies.

(e) This test places a load test on the PAD lanyard of 100 lb with the safing pin installed. The safing pin shall be subjected to twice the Insertion/Removal force and shall not disengage from the PAD.

(f) This test is optional; if performed, the lot has initial service life of 3 years.

(g) The item shall be subjected to high temperature storage environment as part of an accelerated aging test. The storage candidates shall be +71 degrees C and 40 to 60 percent relative humidity for 30 days.

(h) Operational impact energy shall assure 2 times the Bruceton all-fire energy (energy is a function of spring constant and distance calculated from the Bruceton all-fire impact test set). The pull distance shall be measured during this test and verified within acceptable tolerances.

(i) Fire at designed high temperature or +71 degrees C whichever is higher.

(j) Fire at designed low temperature or -54 degrees C whichever is lower.

(k) The PAD exposed to these tests shall not be fired.

(l) The PAD shall be inspected for hazardous condition prior to disposal.

APPENDIX 4B10

PERCUSSION ACTIVATED DEVICE TEST REQUIREMENTS

Table 4B10-3
PAD Primer/Booster/Charge Lot Acceptance Test Matrix

TEST	TEST REQUIREMENTS	QUANTITY TESTED
Non-Destructive Test		
Visual Inspection	4B1.2.1	100%
Dimension	4B1.2.3	100%
Leakage	4B1.2.7	100%
X-Ray	4B1.2.5	100%
N-Ray	4B1.2.6	100%
Destructive Test		
Shock (b)	4B1.4.1.4	Lot Sample (a)
Thermal Cycling (b)	4B1.4.1.7	Lot Sample
High Temperature Storage (c)	(d)	Lot Sample
Random Vibration (b)	4B1.4.1.2	Lot Sample
Leakage	4B1.2.7	Lot Sample
X-Ray	4B1.2.5	Lot Sample
N-Ray	4B1.2.6	Lot Sample
Firing Tests (e)		
Ambient Temperature		
All-Fire Impact Test (f)	----	1/6 Lot Sample
Operational Impact Test (g)	----	1/6 Lot Sample
High Temperature (h)		
All-Fire Impact Test (f)	----	1/6 Lot Sample
Operational Impact Test (g)	----	1/6 Lot Sample
Low Temperature (i)		
All-Fire Impact Test (f)	----	1/6 Lot Sample
Operational Impact Test (g)	----	1/6 Lot Sample

(a) Lot sample is 10% of lot but not less than 30 units.

(b) Tests shall be performed at qualification levels.

(c) This test is optional; if performed, the lot has initial service life of 3 years.

(d) The item shall be subjected to high temperature storage environment as part of an accelerated aging test. The storage candidates shall be +71 degrees C and 40- to 60 percent relative humidity for 30 days.

(e) Delay time shall be measured from primer impact to ordnance output.

(f) All-Fire is determined by the Bruceton all-fire impact series.

(g) Operational Impact shall be at least 2 times the all-fire impact.

(h) Fire at designed high temperature or +71 degrees C whichever is higher.

(i) Fire at designed low temperature or -54 degrees C whichever is lower.

APPENDIX 4B10 PERCUSSION ACTIVATED DEVICE TEST REQUIREMENTS

**Table 4B10-4
PAD Primer/Booster Charge Qualification Test Matrix**

TEST	TEST REQUIREMENT	QUANTITY TESTED					
		45	5	6	5	5	105
Acceptance (Non-Destructive Test)	ACCEPTANCE TEST MATRIX	X	X	X	X	X	X
All-Fire Bruceton (a)	----	<u>X(b)</u>					
High Temp. Exposure	4B1.3.2		<u>X</u>				
Shock	4B1.4.1.4					X	X
Thermal Cycling	4B1.4.1.7				X	X	X
High Temperature Storage (c)	(d)						30
Random Vibration	4B1.4.1.2						X
Leakage	4B1.2.7				X	X	X
X-Ray	4B1.2.5				X	X	X
N-Ray	4B1.2.6				X	X	X
Firing Tests (a)(e):							
Ambient Temperature							
All-Fire Impact (f)	----			<u>X</u>	<u>X</u>	<u>X</u>	
Ambient Temperature							
All-Fire Impact (f)	----						<u>15</u>
Operational Impact (g)	----						<u>15</u>
2X Operational Impact	----						<u>5</u>
High Temperature (h)							
All-Fire Impact (f)	----						<u>15</u>
Operational Impact (g)	----						<u>15</u>
2X Operational Impact	----						<u>5</u>
Low Temperature (i)							
All-Fire Impact (f)	----						<u>15</u>
Operational Impact (g)	----						<u>15</u>
2X Operational Impact	----						<u>5</u>

(a) These tests shall be performed utilizing primer/booster charge in a test set-up that duplicates the PAD striking assembly (e.g. spring and firing pin).

(b) Underlining indicates units are considered destroyed.

(c) This test is optional; if performed, the lot has initial service life of 3 years.

(d) The item shall be subjected to high temperature storage environment as part of an accelerated aging test. The storage candidates shall be +71 degrees C and 40 to 60 percent relative humidity for 30 days.

(e) Delay time shall be measured from primer impact to ordnance output.

(f) All-Fire is determined by the Bruceton all-fire impact series.

(g) Operational Impact shall be at least 2 times the all-fire impact.

(h) Fire at designed high temperature or +71 degrees C whichever is higher.

(i) Fire at designed low temperature or -54 degrees C whichever is lower.

APPENDIX 4B10

PERCUSSION ACTIVATED DEVICE TEST REQUIREMENTS

Table 4B10-5
PAD and Primer/Booster Charge Aging Surveillance Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED	
		5 (a)	10 (b)
Non-Destructive Test			
Visual Inspection	4B1.2.1	X	X
Dimension	4B1.2.3	X	X
Leakage	4B1.2.7	X	X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Destructive			
Shock (c)	4B1.4.1.4	X	X
Thermal Cycling (c)	4B1.4.1.7	X	X
High Temperature Storage	(d)		X
Random Vibration (c)	4B1.4.1.2	X	X
Leakage	4B1.2.7	X	X
X-Ray	4B1.2.5	X	X
N-Ray	4B1.2.6	X	X
Firing Test: (e)(f)			
High Temperature (g)			
All-Fire Impact (h)	----	3	5
Low Temperature (i)			
All-Fire Impact (h)	----	2	5

(a) Testing that can be conducted to extend service for one year.

(b) Testing that can be conducted to extend service for three years

(c) Tests shall be performed at qualification levels.

(d) The item shall be subjected to high temperature storage environment as part of an accelerated aging test. The storage candidates shall be +71 degrees C and 40 to 60 percent relative humidity for 30 days.

(e) Delay time shall be measured from primer impact to ordnance output.

(f) These tests shall be performed utilizing primer/booster charge in a test set-up that duplicates the PAD striking assembly (e.g. spring and firing pin).

(g) Fire at designed high temperature or +71 degrees C whichever is higher.

(h) All-Fire is determined by the Bruceton all-fire impact series.

(i) Fire at designed low temperature or -54 degrees C whichever is lower.

APPENDIX 4B11

SHOCK AND VIBRATION ISOLATOR TEST REQUIREMENTS

a. Purpose.

1. To detect material and workmanship defects prior to acceptance of the isolator for flight
2. To ensure each isolator meets the performance criteria as defined in the component specification

b. Procedure

1. Subject each isolator to a sinusoidal vibration in at least one of the principal axes. **NOTE:** If the resonant frequency and amplification factor are different for each axes, subject the isolator to sinusoidal vibration in all 3 axes.
2. The frequency range for the sinusoidal input shall be representative of the MPE of the vehicle.
3. The amplitude for sinusoidal input to each isolator shall be computed as follows:

$$S = \frac{1}{N} \left[\frac{\pi \times Q \times F_n \times W}{2} \right]^{\frac{1}{2}}$$

WHERE:

- S = Total sinusoidal input to the isolator system in peak G's.
- π = 3.141
- Q = Isolator resonant amplification factor (specification value)
- F_n = Isolator resonant frequency (specification value)
- W = Power spectrum density value of random input spectrum, MPE at F_n
- N = Number of isolators used in system

4. Record the resonant frequency (F_n) and amplification factor (Q) of each isolator.

c. Pass/Fail Criteria. The resonant frequency and amplification factor shall be within the specified limit.

APPENDIX 4B12 TRANSPONDER TEST REQUIREMENTS

Table 4B12-1
Transponder Acceptance Test Matrix
(Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Tests (a)		
Continuity & Isolation	4B12.1	100%
Time to See (delay timer)	4B12.2	100%
Time to Stabilize	4B12.3	100%
Transmit Frequency	4B12.4	100%
Frequency Drift Rate	4B12.5	100%
Peak Power Output	4B12.7	100%
Pulse Width	4B12.8	100%
Pulse Rise Time	4B12.9	100%
Pulse Fall Time	4B12.10	100%
Pulse Width Jitter	4B12.11	100%
Pulse RF Spectrum (6 dB B/W)	4B12.12	100%
Measured RF Threshold Sensitivity	4B12.13	100%
Receiver Bandwidth (3 dB)	4B12.14	100%
Receiver Bandwidth (40 dB)	4B12.15	100%
Image Rejection	4B12.16	100%
Reply Delay (-55 dBm)	4B12.17	100%
Delay Variation vs Signal Strength (dBm)	4B12.18	100%
Delay Jitter vs Signal Strength (dBm)	4B12.19	100%
Delay Variation vs Freq.(MHz)	4B12.20	100%
Delay Jitter vs Freq. (MHz)	4B12.21	100%
Delay Variation vs PRF (pps)	4B12.22	100%
Delay Jitter vs PRF (pps)	4B12.23	100%
Delay Variation vs Operating Voltage	4B12.24	100%
Delay Jitter vs Operating Voltage	4B12.25	100%
Operating Current vs Oper. Voltages	4B12.26	100%
Decoder Accept Limits	4B12.27	100%
Decoder Reject Limits	4B12.28	100%
Pulse Width Acceptance	4B12.29	100%
Recovery Time (0 dBm)	4B12.30	100%
Random Triggering	4B12.31	100%

(a) These tests shall be performed prior to and after each environmental test.

APPENDIX 4B12 TRANSPONDER TEST REQUIREMENTS

Table 4B12-1
Transponder Acceptance Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED
Functional Tests (continued) (a)		
Decoder Immunity (0 dBm)	4B12.32	100%
Pulse Amplitude Variations	4B12.33	100%
Pulse Amplitude Jitter	4B12.34	100%
Over Interrogation	4B12.35	100%
Carrier Phase Coherency	4B12.36	100%
Carrier Line Width (3 dB)	4B12.37	100%
Spectral Skew	4B12.38	100%
Interline Noise (relative)	4B12.39	100%
Dynamic Pulse Spectrum	4B12.40	100%
Frequency Tracking	4B12.41	100%
Signal Strength Monitor	4B12.42	100%
Reference Functional Tests (b)		
Threshold Sensitivity	4B12.13	100%
Random Triggering	4B12.31	100%
Peak Power Output	4B12.7	100%
Transmit Frequency	4B12.4	100%
Delay Var. vs Sig. Strength (dBm)	4B12.18	100%
Delay Variation vs PRF (pps)	4B12.22	100%
Reply Delay (-55 dBm)	4B12.17	100%
Operating Environment Tests		
Acoustic	4B1.4.2.2	100%
Acceleration	4B1.4.2.3	100%
Thermal Cycling (c)	4B1.4.2.4	100%
Thermal Vacuum (d)	4B1.4.2.5	100%
Random Vibration	4B1.4.2.1	100%
Burn-in	4B1.4.2.6	100%
Leakage (e)	4B1.2.7	100%

(a) These tests shall be performed prior to and after each environmental test.

(b) These tests shall be performed or monitored to the maximum extent possible during the operating environment test.

(c) Reference functional tests shall be performed at high voltage input on the 1 and 7 cycles, low voltage input on the 2 and 8 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(d) Perform reference functional test during the high and low temperatures soak periods.

(e) This test shall be performed after the last operating environment test.

APPENDIX 4B12 TRANSPONDER TEST REQUIREMENTS

Table 4B12-2
Transponder Qualification Test Matrix
(Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Acceptance Test	ACCEPTANCE TEST MATRIX	X	X	X
Functional Test (a)				
Continuity & Isolation	4B12.1	X	X	X
Time To See (delay timer)	4B12.2	X	X	X
Time To Stabilize	4B12.3	X	X	X
Transmit Frequency	4B12.4	X	X	X
Frequency Drift Rate	4B12.5	X	X	X
Peak Power Output	4B12.7	X	X	X
Pulse Width	4B12.8	X	X	X
Pulse Rise Time	4B12.9	X	X	X
Pulse Fall Time	4B12.10	X	X	X
Pulse Width Jitter	4B12.11	X	X	X
Pulse RF Spectrum (6 dB B/W)	4B12.12	X	X	X
Measured RF Threshold Sensitivity	4B12.13	X	X	X
Receiver Bandwidth (3 dB)	4B12.14	X	X	X
Receiver Bandwidth (40 dB)	4B12.15	X	X	X
Image Rejection	4B12.16	X	X	X
Reply Delay (-55 dBm)	4B12.17	X	X	X
Delay Variation vs Signal Strength (dBm)	4B12.18	X	X	X
Delay Jitter vs Signal Strength (dBm)	4B12.19	X	X	X
Delay Variation vs Freq.(MHz)	4B12.20	X	X	X
Delay Jitter vs Freq. (MHz)	4B12.21	X	X	X
Delay Variation vs PRF (pps)	4B12.22	X	X	X
Delay Jitter vs PRF (pps)	4B12.23	X	X	X
Delay Variation vs Operating Voltage	4B12.24	X	X	X
Delay Jitter vs Operating Voltage	4B12.25	X	X	X
Operating Current vs Operating Voltages	4B12.26	X	X	X
Decoder Accept Limits	4B12.27	X	X	X
Decoder Reject Limits	4B12.28	X	X	X
Pulse Width Acceptance	4B12.29	X	X	X
Recovery Time (0 dBm)	4B12.30	X	X	X
Random Triggering	4B12.31	X	X	X
Decoder Immunity (0 dBm)	4B12.32	X	X	X
Pulse Amplitude Variations	4B12.33	X	X	X
Pulse Amplitude Jitter	4B12.34	X	X	X
Over Interrogation	4B12.35	X	X	X
Carrier Phase Coherency	4B12.36	X	X	X
Carrier Line Width (3 dB)	4B12.37	X	X	X
Spectral Skew	4B12.38	X	X	X
Interline Noise (relative)	4B12.39	X	X	X
Dynamic Pulse Spectrum	4B12.40	X	X	X
Frequency Tracking	4B12.41	X	X	X
Signal Strength Monitor	4B12.42	X	X	X
CW Immunity	4B12.43	X	X	X

(a) These tests shall be performed prior to and after each environmental test.

APPENDIX 4B12 TRANSPONDER TEST REQUIREMENTS

Table 4B12-2
Transponder Qualification Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Reference Functional Tests (b)				
Threshold Sensitivity	4B12.13	X	X	X
Random Triggering	4B12.31	X	X	X
Peak Power Output	4B12.7	X	X	X
Transmit Frequency	4B12.4	X	X	X
Delay Variation vs Signal Strength (dBm)	4B12.18	X	X	X
Delay Variation vs PRF (pps)	4B12.22	X	X	X
Reply Delay (-55 dBm)	4B12.17	X	X	X
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X	X	X
Transport Shock/Bench Handling	4B1.3.3	X	X	X
Transportation Vibration	4B1.3.4	X	X	X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6	X		
Fine Sand	4B1.3.7		X	
Operating Environment Tests				
Sinusoidal Vibration	4B1.4.1.1	X	X	X
Acoustic	4B1.4.1.3	X	X	X
Shock	4B1.4.1.4	X	X	X
Acceleration	4B1.4.1.5	X	X	X
Humidity	4B1.4.1.6			X
Thermal Cycling (c)	4B1.4.1.7	X	X	X
Thermal Vacuum (d)	4B1.4.1.8	X	X	X
Random Vibration	4B1.4.1.2	X	X	X
EMI/EMC	4B1.4.1.9		X	X
Explosive Atmosphere	4B1.4.1.10	X		
Leakage (e)	4B1.2.7	X	X	X
Disassembly	4B1.4.1.11	X	X	X

(b) This test shall be performed or monitored to the maximum extent possible during the operating environment tests.

(c) Reference functional tests shall be performed at high voltage input on the 1 and 23 cycles, nominal voltage on the 12 and 13 cycles, low voltage input on the 2 and 24 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(d) Perform reference functional test during the high and low temperatures soak periods of first and last cycles.

(e) This test shall be performed after the last non-operating and the last operating environment test.

APPENDIX 4B12

TRANSPONDER TEST REQUIREMENTS

NOTE: Unless otherwise specified in the individual test, all tests shall be performed at the transponder guarantee RF threshold sensitivity level (usually -70 dBm).

4B12.1 Continuity & Isolations

a. Verify that the transponder continuity and isolation resistances between the case ground and all power leads, and signal outputs, including returns, and between power leads and signal leads, including returns are within the requirements that are specified in the component specification.

b. Measure all external parts of the unit to verify that they are at case ground potential.

4B12.2 Time To See - Power Delay Timer

a. Verify that the transponder power supply delay timer is working.

b. Measure the delay time.

c. Record the time in seconds.

4B12.3 Time To Stabilize

a. Determine at which 30 sec interval, after the first application of DC power, the transponder reply frequency begins to drift less than 0.5 MHz per 30 second period.

b. Record the time in seconds.

4B12.4 Transmit Frequency

a. At 180 sec after application of DC power to the transponder, measure and record the transponder transmit frequency as "Start +3 min".

b. At 600 sec of transponder reply, measure and record the transponder transmit frequency as "Stop +10 min". Record the transmit frequency in megahertz (MHz).

4B12.5 Frequency Drift Rate

a. Measure the difference between the minimum and the maximum reply frequency measurements that were recorded during the first 180 sec of application of DC power to the transponder in the **Transmit Frequency** section of this Appendix.

b. Divide this difference by the number of minutes during which the measurements were obtained.

c. Record the quotient in MHz.

4B12.6 Intentionally Left Blank

4B12.7 Peak Power Output

a. Measure the actual transponder peak power output.

b. Record the measurement in watts.

4B12.8 Pulse Width

a. Measure the width of the transponder reply pulse at the medial point of the pulse.

b. Record the measurement in microseconds.

4B12.9 Pulse Rise Time

a. Measure the transponder reply pulse rise time.

NOTE: The rise time is the time between the 10 percent and the 90 percent amplitude points of the leading edge of the unsaturated reply pulse.

b. Record the rise time in microseconds.

4B12.10 Pulse Fall Time

a. Measure the transponder reply pulse fall time.

NOTE: The fall time is the time between the 90 percent and the 10 percent amplitude points of the falling edge of the unsaturated reply pulse.

b. Record the fall time in microseconds.

4B12.11 Pulse Width Jitter

a. Measure the transponder reply pulse width jitter. **NOTE:** Measure the pulse width variations at the 50 percent amplitude points of each pulse, one standard deviation value of 1000 samples.

b. Record the measurement in microseconds.

4B12.12 Pulse RF Spectrum at the 6 dB Bandwidth point

Measure the transponder reply RF bandwidth at the -6 dB (1/4th power) RF spectrum points.

NOTE: Normally performed with a spectrum analyzer and recorded in MHz.

4B12.13 Measured RF Threshold Sensitivity

a. Measure the minimum RF that is required to interrogate the transponder at the assigned interrogation RF frequency. **NOTE:** A valid reply is defined as no more than 1 percent missing reply pulses.

b. Record the measurement in dBm.

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TRANSPONDER TEST REQUIREMENTS

4B12.14 Receiver Bandwidth (3 dB)

a. Measure the bandwidth, at the 3 dB points, of the transponder receiver. **NOTE:** The bandwidth is defined as the frequency point where the transponder continues to reply with no more than 1 percent missing pulses.

b. Record the measurement in MHz.

4B12.15 Receiver Bandwidth (40 dB)

a. Measure the bandwidth, at the 40 dB points, of the transponder receiver. **NOTE:** The bandwidth is defined as the frequency point where the transponder continues to reply with no more than 1 percent missing pulses.

b. Record the measurement in MHz.

4B12.16 Image Rejection

a. Measure the transponders receiver image rejection quality. **NOTE:** This measurement is obtained with the rise and fall time of the interrogation pulses adjusted to 100 nanoseconds, or as slow as possible, and the RF input set to 0 dBm. The interrogation RF frequency is set to the image frequency of the transponder. The image frequency is determined by:

$$F_{\text{image}} = 2(F_{\text{LO}}) - F_o$$

where:

F_{image} = Image frequency

F_{LO} = Local oscillator frequency of the transponder in MHz

F_o = Center frequency (MHz) to which the transponder is tuned

b. Record the measurement in dB.

4B12.17 Reply Delay (-55 dBm)

a. Measure the transponder fixed delay with the interrogation signal RF level set to -55 dBm. **NOTE:** Measure the time in microseconds, ± 0.01 microseconds, between the 50 percent amplitude point on the leading edge of the second interrogate pulse and the 50 percent amplitude point on the leading edge of the unsaturated reply pulse. Delays of the test system shall be subtracted.

b. Record the measurement in microseconds.

4B12.18 Delay Variation vs Signal Strength (dBm)

NOTE: Each delay measurement should be an average of 1000 samples.

a. Measure the transponder delay variations as a direct result of varying the signal strength of the interrogation signal. **NOTE:** Measure the reply delay, in microseconds ± 0.01 microseconds, with the interrogation RF level set to 0, -10, -20, -30, -40, -50, -57, -60, -62, -65, -67, and -70 dBm.

b. Record each delay measurement in microseconds.

c. Compute the difference between the maximum and the minimum delay measurements that are taken between the levels of 0 and -65 dBm and record this value as the delay variation vs signal strength in microseconds.

4B12.19 Delay Jitter vs Signal Strength (dBm)

NOTE: Each delay measurement should be an average of 1000 samples.

a. Measure the transponder delay jitter as a direct result of varying the signal strength of the interrogation signal.

b. Measure the total (one sigma) fluctuation in reply delay, in microseconds ± 0.001 microseconds, with each of the RF interrogations levels set to 0, -10, -20, -30, -40, -50, -57, -60, -62, -65, -67, and -70 dBm.

c. Record the delay jitter maximum value in microseconds.

4B12.20 Delay Variation vs Frequency (MHz)

NOTE: Each delay measurement should be an average of 1000 samples.

a. Measure the transponder delay variation as a direct result of varying the frequency of the interrogation signal.

b. Measure the reply delay, in microseconds ± 0.001 microseconds, with the interrogation signal level set to -55 dBm and the frequency changed in 0.5 MHz steps from 1.5 MHz above the transponder receiver assigned frequency to 1.5 MHz below the transponder receiver assigned frequency.

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TRANSPONDER TEST REQUIREMENTS

c. Record the delay, in microseconds, for -1.5, -1, -0.5, +0.5, +1, and +1.5 MHz.

d. Compute the difference between the minimum and the maximum delay measurements.

e. Record the delay variation vs frequency in microseconds.

4B12.21 Delay Jitter vs Frequency (MHz)

NOTE: Each measurement should be an average of 1000 samples.

a. Measure the transponder delay jitter as a direct result of varying the frequency of the interrogation signal.

b. Measure the standard deviation (one sigma) jitter in reply delay, in microseconds ± 0.001 microseconds, with the interrogation signal level set to -55 dBm and the frequency changed to 0.5 MHz steps from 1.5 MHz above the transponder receiver assigned frequency to 1.5 MHz below the transponder receiver assigned frequency.

c. Record the delay, in microseconds, for -1.5, -1, -0.5, +0.5, +1, and +1.5 MHz.

d. Record the delay jitter maximum value in microseconds.

4B12.22 Delay Variation vs PRF (pps)

NOTE: Each measurement should be an average of 1000 samples.

a. Measure the transponder delay variation as a direct result of varying the pulse repetition frequency (pps) of the interrogation signal.

b. Measure the reply delay in microseconds, ± 0.001 microseconds,

c. With the interrogation RF signal level set to -55 dBm, measure and record the delay, in microseconds, when the PRF is set to 160, 480, 800, 960, 1440, and 1600 pps.

d. Compute the difference between the minimum and the maximum delays and record delay variation vs PRF in microseconds.

4B12.23 Delay Jitter vs PRF (pps)

NOTE: Each measurement should be an average of 1000 samples.

a. Measure the transponder delay jitter as a direct result of varying the pulse repetition frequency (pps) of the interrogation signal.

b. Measure and record, in microseconds, the standard deviation (one sigma) jitter in reply delay, in microseconds ± 0.001 microseconds, with the interrogation RF signal level set to -55 dBm and the PRF set to 160, 480, 800, 960, 1440, and 1600 pps.

c. Record the delay jitter maximum value in microseconds.

4B12.24 Delay Variation vs Operating Voltage

NOTE: Each measurement should be an average of 1000 samples.

a. Measure the transponder delay variation as a direct result of varying the transponder supply DC voltage.

b. Measure and record the reply delay, in microseconds ± 0.001 microseconds, with the interrogation RF signal level set to -55 dBm and the DC supply voltage incremented in 2 volt steps from 24 to 32 Vdc.

c. Compute the difference between the minimum and the maximum delays.

d. Record delay variation vs operating voltage.

4B12.25 Delay Jitter vs Operating Voltage

NOTE: Each measurement should be an average of 1000 samples.

a. Measure the transponder delay jitter as a direct result of varying the transponder supply DC voltage.

b. Measure the standard deviation (one sigma) jitter in reply delay, in microseconds ± 0.001 microseconds, with the interrogation RF signal level set to -55 dBm.

c. Measure and record the delay, in microseconds, when the DC supply voltage is incremented in 2 volt steps from 24 to 32 Vdc.

d. Record the delay jitter maximum value in microseconds.

4B12.26 Operating Current vs Operating Voltage

a. Measure the amount of current that the transponder requires for the operating voltage supplied.

b. Measure and record the amount of current drawn by the transponder while the DC power source is set to 24, 26, 28, 30, and 32 Vdc.

c. Record the measurement in amps or milliamps as appropriate.

4B12.27 Decoder Accept Limits

a. Measure the upper and lower limits of the interrogation pulse code spacing. Set the RF amplitude to -55 dBm, and vary the code spacing of the interrogation pulses. **NOTE:** The upper and lower limits are where the transponder first indicates 1 percent missing pulses.

b. Record the upper and lower limits in microseconds. **NOTE:** The 1 percent missing pulse is

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TRANSPONDER TEST REQUIREMENTS

referenced to 1000 pulses.

c. Compute and record the center as the average of the upper and lower limits.

4B12.28 Decoder Reject Limits

a. Measure the interrogation code spacing where the transponder fails to reply (99 percent missing pulses out of 1000 interrogations). **NOTE:** This measurement is obtained by varying the code spacing of the interrogation above and below the assigned code spacing while observing the transponder reply for evidence of 99 percent missing reply pulses. The points where the reply pulse first indicates 99 percent missing reply pulses.

b. Record the measurement in microseconds.

4B12.29 Pulse Width Acceptance

a. Measure the minimum and the maximum interrogation pulse widths that the transponder will respond to with no more than 1 percent missing pulses out of 1000 interrogations. **NOTE:** This measurement is obtained by varying the interrogation pulse width from nominal until the transponder reflects 1 percent missing reply pulses. The pulse width is measured at the 50 percent point of the leading edge of the interrogation pulse.

b. Record the low and the high acceptance limits in microseconds.

4B12.30 Recovery Time (0 dBm)

a. Determine the minimum time that is permissible between interrogations that will allow the transponder to recover with no more than 1 percent missing pulses. **NOTE:** The repetition period between the two groups of pulses is reduced to a point where the reply pulse from the second group of interrogation pulses indicates no more than 1 percent missing returns.

b. Record the time in microseconds.

4B12.31 Random Triggering

a. Determine if the transponder has any random replies. **NOTE:** This test is conducted at high RF input level (0 dBm) and the transponder is monitored for random replies during both interrogation and non-interrogation conditions.

b. Record the number of replies that were observed in pps.

4B12.32 Decoder Immunity (0 dBm)

a. Determine if the transponder is immune to single pulse interrogation signals (only replies to

double pulse coded signals). **NOTE:** The test is performed with the RF amplitude at a high level (0 dBm) and the interrogation set to single pulse.

b. Record the number of replies observed in pps.

4B12.33 Pulse Amplitude Variations

a. Determine the variations in the pulse amplitude. **NOTE:** The variations in pulse amplitude are measured at the top of each pulse while varying the interrogation signal amplitude, PRF and transponder DC input voltage.

b. Record the variations in dB.

4B12.34 Pulse Amplitude Jitter

a. Determine the jitter in the pulse-to-pulse amplitude. **NOTE:** The jitter in pulse-to-pulse amplitude is measured at the top of each pulse while varying the interrogation signal amplitude, PRF, and transponder DC input voltage.

b. Record the jitter in dB.

4B12.35 Overinterrogation

a. Determine the actual maximum interrogation rate that the transponder can continue to reply to with no more than 1 percent missing pulses.

b. Record the rate in pps.

4B12.36 Carrier Phase Coherency

a. Measure the coherency of coherent tracking transponders to the interrogation source. **NOTE:** The measurement compares the phase relationship of each reply pulse to the interrogation pulse, in a very large sample (usually 16,000) size.

b. Record the results in Hz for standard deviation and feet/second for velocity accuracy.

4B12.37 Carrier Line Width (3 dB)

a. Measure the width of the pulse in the RF domain of a coherent tracking transponder. **NOTE:** The pulse width is usually measured as a part of the **Carrier Phase Coherency** test described above.

b. Measure the fine line carrier at the 3 dB points and record the measurement in Hz.

4B12.38 Spectral Skew

a. Measure the spectral skew of the pulse RF carrier about the assigned center frequency of a coherent tracking transponder. **NOTE:** The amplitude of the pulsed spectrum is measured at the plus and minus 350 kHz points.

b. Record the difference in amplitude in dB.

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TRANSPONDER TEST REQUIREMENTS

4B12.39 Interline Noise (Relative)

a. Measure the noise level that is present on the RF spectrum between the modulating pulses on a coherent tracking transponder. **NOTE:** The measurement is the difference between the fine line pulse and the noise just preceding or following the fine line pulse.

b. Record the difference in dB.

4B12.40 Dynamic Pulse Spectrum

a. Measure the delta amplitude and the delta frequency of the first side lobe as compared to the main lobe of a coherent tracking transponder.

b. Record the measurements in delta Hz and delta dB.

4B12.41 Frequency Tracking

a. Measure the ability of a coherent tracking transponder to follow an interrogation source that is moving in frequency. **NOTE:** The measurement is the point when the transponder reply frequency is 1.0 MHz different from the interrogation source.

b. Record the high and low limits in MHz.

4B12.42 Signal Strength Monitor

Determine the transponder signal strength monitor voltage (Automatic Gain Control (AGC)) when the transponder is designed for an appropriate output voltage that represents the SST voltage. **NOTE:** This test is an x-y plot of an RF interrogation signal strength verses SST voltage in increments of no more than 2 dB from the measured RF threshold sensitivity to 0 dBm.

4B12.43 CW Immunity

Verify the transponder does not respond to CW signal at RF amplitude between 0 and -55 dBm (in 10 dB steps).

APPENDIX 4B13 GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS

**Table 4B13-1
Digital Translator Acceptance Test Matrix**

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Test (a)		
Continuity & Isolation	4B13.1	100%
DC Input Voltage	4B13.2	100%
Input Current	4B13.3	100%
Noise Figure	4B13.4	100%
Pseudo-Range	4B13.5	100%
Time Delay	4B13.6	100%
S-Band Frequency Stability	4B13.7	100%
S-Band Frequency Accuracy	4B13.8	100%
Power Output	4B13.9	100%
S-Band Frequency Drift	4B13.10	100%
S-Band Spectral Charac. & Spurious Emissions	4B13.11	100%
Carrier Suppression	4B13.12	100%
Apparent Bandwidth (30 dB)	4B13.13	100%
Phase Linearity	4B13.14	100%
Bit Error Rate	4B13.15	100%
L ₁ /L ₂ Bandpass Character	4B13.16	100%
Phase Jitter	4B13.17	100%
Out-of-Band Signals	4B13.20	100%
Reference Functional Test (b)		
Input Current	4B13.3	100%
Power Output	4B13.9	100%
S-Band Frequency Stability	4B13.7	100%
Phase Linearity	4B13.14	100%
Phase Jitter	4B13.17	100%
Operating Environment Test		
Acoustic	4B1.4.2.2	100%
Acceleration	4B1.4.2.3	100%
Thermal Cycling (c)	4B1.4.2.4	100%
Thermal Vacuum (d)	4B1.4.2.5	100%
Random Vibration	4B1.4.2.1	100%
Burn-In	4B1.4.2.6	100%
Leakage (e)	4B1.2.7	100%

(a) These tests shall be performed prior to and after each environmental test.

(b) These tests shall be performed or monitored to the maximum extent possible during the operating environment tests.

(c) Full functional tests shall be performed at high voltage on the 1 and 7 cycles, low voltage input on the 2 and 8 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(d) Perform reference functional test during the high and low temperature soak periods.

(e) This test shall be performed after the last operating environment test.

APPENDIX 4B13 GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS

Table 4B13-2
Digital Translator Qualification Test Matrix
(Page 1 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Perform Acceptance Test)	ACCEPTANCE TEST MATRIX	X	X	X
Functional Test (a)				
Continuity & Isolation	4B13.1	100%		
DC Input Voltage	4B13.2	100%		
Input Current	4B13.3	100%		
Noise Figure	4B13.4	100%		
Pseudo-Range	4B13.5	100%		
Time Delay	4B13.6	100%		
S-Band Frequency Stability	4B13.7	100%		
S-Band Frequency Accuracy	4B13.8	100%		
Power Output	4B13.9	100%		
S-Band Frequency Drift	4B13.10	100%		
S-Band Spectral Characteristics & Spurious Emissions	4B13.11	100%		
Carrier Suppression	4B13.12	100%		
Apparent Bandwidth (30 dB)	4B13.13	100%		
Phase Linearity	4B13.14	100%		
Bit Error Rate	4B13.15	100%		
L ₁ /L ₂ Bandpass Character	4B13.16	100%		
Phase Jitter	4B13.17	100%		
Out-of-Band Signals	4B13.20	100%		
Reference Functional Test (b)				
Input Current	4B13.2	100%		
Power Output	4B13.9	100%		
S-Band Frequency	4B13.7	100%		
Phase Linearity	4B13.14	100%		
Phase Jitter	4B13.17	100%		
One-Time Special Tests (c)				
Peak Input Voltage	4B13.18	X	X	X
RF Overload	4B13.19	X	X	X
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X	X	X
Transport Shock/Bench Handling	4B1.3.3	X	X	X
Transportation Vibration	4B1.3.4	X	X	X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6	X		
Fine Sand	4B1.3.7		X	

(a) These tests shall be performed prior to and after each environmental test.

(b) These tests shall be performed or monitored to the maximum possible extent during the operating environment tests.

(c) Perform these tests once per unit.

APPENDIX 4B13 GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS

Table 4B13-2
Digital Translator Qualification Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Operating Environment Tests				
Sinusoidal Vibration	4B1.4.1.1	X	X	X
Acoustic	4B1.4.1.3	X	X	X
Shock	4B1.4.1.4	X	X	X
Acceleration	4B1.4.1.5	X	X	X
Humidity	4B1.4.1.6		X	
Thermal Cycling (d)	4B1.4.1.7	X	X	X
Thermal Vacuum (e)	4B1.4.1.8	X	X	X
Random Vibration	4B1.4.1.2	X	X	X
EMI/EMC	4B1.4.1.9		X	
Explosive Atmosphere	4B1.4.1.10	X		
Leakage (f)	4B1.2.7	X	X	X
Disassembly	4B1.4.2.7			X

- (d) Full functional tests shall be performed at high voltage input on the 1 and 23 cycles, nominal voltage on the 12 and 13 cycles, low voltage input on the 2 and 24 cycles, and reference functional tests for the remaining cycles at nominal voltage input.
- (e) Perform reference functional test during the high and low temperature soak periods of the first and last cycles.
- (f) Full functional tests shall be performed at high voltage on the 1 and 7 cycles, low voltage input on the 2 and 8 cycles, and reference functional tests for the remaining cycles at nominal voltage input.
- (g) This test shall be performed after the last operating environment test.

APPENDIX 4B13 GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS

**Table 4B13-3
GPS Receiver Acceptance Test Matrix**

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Test (a)		
Continuity & Isolation	4B13.21	100%
DC Input Voltage	4B13.22	100%
Input Current	4B13.23	100%
Noise Figure	4B13.24	100%
System Test	4B13.25	100%
Phase Linearity	4B13.26	100%
L ₁ /L ₂ Bandpass Character	4B13.27	100%
Phase Jitter	4B13.28	100%
Sensitivity	4B13.29	100%
Rapid Relock Test	4B13.30	100%
Time to First Fix	4B13.31	100%
Deselection Faulty Satellites	4B13.32	100%
Immunity to In-Band Signals	4B13.33	100%
Out-of-Band Signals	4B13.34	100%
Reference Functional Test (b)		
Input Current	4B13.23	100%
System Test	4B13.25	100%
Phase Linearity	4B13.26	100%
Phase Jitter	4B13.28	100%
Operating Environment Test		
Acoustic	4B1.4.2.2	100%
Acceleration	4B1.4.2.3	100%
Thermal Cycling (c)	4B1.4.2.4	100%
Thermal Vacuum (d)	4B1.4.2.5	100%
Random Vibration	4B1.4.2.1	100%
Burn-In	4B1.4.2.6	100%
Leakage (e)	4B1.2.7	100%

(a) These tests shall be performed prior to and after each environmental test.

(b) These tests shall be performed or monitored to the maximum extent possible during the operating environment tests.

(c) Full functional tests shall be performed at high voltage on the 1 and 7 cycles, low voltage input on the 2 and 8 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(d) Perform reference functional test during the high and low temperature soak periods.

(e) This test shall be performed after the last operating environment test.

**APPENDIX 4B13
GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS**

**Table 4B13-4
GPS Receiver Qualification Test Matrix
(Page 1 of 2)**

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Acceptance Tests	ACCEPTANCE TEST MATRIX	X	X	X
Functional Tests (a)				
Continuity & Isolation	4B13.21	X	X	X
DC Input Voltage	4B13.22	X	X	X
Input Current	4B13.23	X	X	X
Noise Figure	4B13.24	X	X	X
System Test	4B13.25	X	X	X
Phase Linearity	4B13.26	X	X	X
L ₁ /L ₂ Bandpass Character	4B13.27	X	X	X
Phase Jitter	4B13.28	X	X	X
Sensitivity	4B13.29	X	X	X
Rapid Relock Test	4B13.30	X	X	X
Time to First Fix	4B13.31	X	X	X
Deselect Faulty Satellites	4B13.32	X	X	X
Immunity to In-Band Signals	4B13.33	X	X	X
Out-of-Band Signals	4B13.34	X	X	X
Reference Functional Test (b)				
Input Current	4B13.23	X	X	X
System Test	4B13.25	X	X	X
Phase Linearity	4B13.26	X	X	X
Phase Jitter	4B13.28	X	X	X
One-Time Special Tests (c)				
Peak Input Voltage	4B13.35	X	X	X
RF Overload	4B13.36	X	X	X
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X	X	X
Transport Shock/Bench Handling	4B1.3.3	X	X	X
Transportation Vibration	4B1.3.4	X	X	X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6	X		
Fine Sand	4B1.3.7		X	

(a) These tests shall be performed prior to and after each environmental test.

(b) These tests shall be performed or monitored to the maximum extent possible during the operating environment tests.

(c) Perform these tests once per unit.

APPENDIX 4B13 GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS

Table 4B13-4
GPS Receiver Qualification Test Matrix
(Page 2 of 2)

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Operating Environment Tests				
Sinusoidal Vibration	4B1.4.1.1	X	X	X
Acoustic	4B1.4.1.3	X	X	X
Shock	4B1.4.1.4	X	X	X
Acceleration	4B1.4.1.5	X	X	X
Humidity	4B1.4.1.6			X
Thermal Cycling (d)	4B1.4.1.7	X	X	X
Thermal Vacuum (e)	4B1.4.1.8	X	X	X
Random Vibration	4B1.4.1.2	X	X	X
EMI/EMC	4B1.4.1.9			X
Explosive Atmosphere	4B1.4.1.10	X		
Leakage (f)	4B1.2.7	X	X	X
Disassembly	4B1.4.2.7			X

(d) Full functional tests shall be performed at high voltage input on the 1 and 23 cycles, nominal voltage on the 12 and 13 cycles, low voltage input on the 2 and 24 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(e) Perform reference functional test during the high and low temperature soak periods of the first and last cycles.

(f) This test shall be performed after the last non-operating and the last operating environment test.

APPENDIX 4B13

GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS

DIGITAL TRANSLATOR

NOTE: The digital translator shall be tested at the frequencies incorporated (it shall be tested in the flight configuration). For example, if the translator is constructed to translate L_1 and L_2 data, then both frequencies must be tested during all applicable acceptance tests, even if only one of the two frequencies is intended for operational use. If an incorporated L-Band link carries both the CA code and the P code, then both codes must be processed by the ground station. Also, the digital translator must be tested at the telemetry bandwidth that will be employed operationally. Use of encryption modes must be approved by the Range; for approved encryption schemes, all applicable tests must be performed in the encrypted mode during acceptance and qualification testing. Finally, telemetry channels incorporated in digital translator-design to report state-of-the-health of the translator must be tested during acceptance testing.

4B13.1 Continuity and Isolation

The translator continuity and isolation resistance shall be verified between case ground and all power leads, and signal outputs, including returns, and between power leads and signal leads, including returns. All external parts of the unit shall be measured to verify they are at case ground potential. Isolation values will be specified in the applicable specification.

4B13.2 DC Input Voltage

The purpose of this test is to verify that translator power consumption is within the limits specified for normal operations. This test will also ensure that the translator will function normally at all voltage requirements as specified by the applicable specification. The DC power supply is to be varied from specified minimum to maximum.

4B13.3 Input Current

The maximum current shall be measured at the low, nominal, and high supply voltages.

4B13.4 Noise Figure

The noise figure for the digital translator shall be measured at 1574, 1575, and 1576 MHz for noise source applied at the L_1 input and at 1226, 1227, and 1228 MHz for noise applied at the L_2 input.

This measurement must be made at a point before signals are quantized for digital processing. Alternate test points and techniques must be approved by the Range (example, drop lock test).

4B13.5 Pseudo-Range

The translator shall be connected to a GPS signal simulator generating signals of known frequency, timing, and a range of signal levels. A Translator Processing System shall be used to recover the digitized GPS signal, track the signals, and measure the frequency timing. If antenna multiplexing is used, separate trackers shall be used for the signals from each antenna input. The standard deviation of the carrier of the recovered signal from the reference signal shall be less than .1 Hz. The standard deviation of the measured range from the predicted range shall be less than 20 nanoseconds following allowance for any known system biases such as filter delays and quadrature phase demodulation. Additionally, this test shall be conducted at input signal levels below and above translator sensitivity to establish the threshold sensitivity of the device under test. Finally, the test shall be conducted repetitively by ramping the signal simulator from 0 to 10g to demonstrate proper performance under a full range of accelerations.

4B13.6 Time Delay

An observable signal shall be provided at the digital translator L_1/L_2 inputs; delay time shall be measured. If a quadrature phase shift key (QPSK) demodulator is used, the delay time associated with the demodulator must be measured before the test and “subtracted out” for the final value. This test will be performed at -145 dBm and -110 dBm input signal power.

4B13.7 S-Band Frequency Stability

This test measures RF frequency of the digital translator S-Band output and verifies compliance with assigned center frequency. This test should be performed in conjunction with the Power Output test. S-Band output frequency (unmodulated) should be measured at power on plus 1, plus 2, plus 3, plus 4, and plus 5 minutes. Record each reading in MHz. If the GPS ground station provides sufficient measurement accuracy, it may be used for this test.

APPENDIX 4B13

GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS

4B13.8 S-Band Frequency Accuracy

The digital translator shall be tested for frequency accuracy of the unmodulated suppressed carrier. If the GPS ground station provides sufficient measurement accuracy, it may be used for this test.

4B13.9 Power Output

This test measures the specified power output from the translator. This test should be performed in conjunction with the S-Band Transmit Frequency Stability test. Power output should be measured at power on, and at plus 1, plus 2, plus 3, plus 4, and plus 5 minutes. Record each reading in dBm.

4B13.10 S-Band Carrier Frequency Drift

This test measures S-Band carrier frequency drift for comparison of the suppressed carrier frequency with specified value. The Allan variance technique shall be used with a minimum of 50 data points for each variance calculation.

4B13.11 S-Band Spectral Characteristics and Spurious Emissions

This test establishes the spectral characteristics of the digital translator S-Band downlink and checks for spurious emissions. For the first test, the spectrum analyzer shall be set up using assigned center frequency, span should cover the spectral profile for the modulated S-Band output ± 1 MHz, video bandwidth of 30 Hz, and resolution bandwidth of 3 kHz. The second test expands the span to 100 MHz and uses the same center frequency, video bandwidth, and resolution bandwidth. Spectral plots for both tests shall be included in the test report.

4B13.12 Carrier Suppression

This test measures the amount of carrier present in the S-Band downlink.

4B13.13 Apparent Bandwidth (30 dB)

This test measures the apparent bandwidth of the S-Band downlink.

4B13.14 Phase Linearity

A continuous wave signal shall be provided at the digital translator L_1/L_2 port. The input signal shall be swept from 1574 to 1576 MHz and 1226 to 1228 MHz in 100 kHz increments. Phase slope will be calculated for each measurement and plotted. Plots will be included in the test report. Measurements must be made at a point before signals are quantized for digital processing. Alternate test points and techniques must be approved by the Range.

4B13.15 Bit Error Rate

The bit error rate for digital translator (DGT)-generated telemetry shall be measured for compliance with specifications. The input shall be an operationally representative set of signals. The demodulated output shall be compared to the reference input and the bit error rate shall be included in the test report.

4B13.16 L_1/L_2 Bandpass Characteristics

A continuous wave input signal (-110 dBm) shall be provided at the digital translator L_1/L_2 input ports. The signal shall be stepped from 1100 MHz to 1700 MHz in 100 kHz increments. Results will be plotted and included in the test report. Measurements must be made at a point before signals are quantized for digital processing. Alternate test points and techniques must be approved by the Range.

4B13.17 Phase Jitter

The digital translator will be placed on a vibration table to measure phase jitter. The input signal is continuous wave; jitter will be monitored while the unit is vibrated at the maximum predicted environment for 3 minutes per axis. Measurements must be made at a point before signals are quantized for digital processing.

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GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS

Alternate test points and techniques must be approved by the Range (example, standard deviation of range rate measured by GPS ground station and codes).

4B13.18 Peak Input Voltage

This test verifies that the digital translator can withstand a 45 Vdc input.

4B13.19 RF Overload

This test verifies that the digital translator can withstand an in-band RF overload level of 10 dBm for 1 minute without degradation after overload is removed.

4B13.20 Susceptibility to Large Out-of-Band Signals

Susceptibility to combinations of up to and including three out-of-band continuous wave signals shall be tested for compliance with specifications. Reduction of C/N_0 for the following signals shall be measured and included in the acceptance test report per Table 4B13-5.

Table 4B13-5
Interfering Frequency

Frequency (MHz)	Signal Level (dBm)
$100 < F_i \leq 1496$	-30
$1496 < F_i \leq 1565$	1455.42 - F1
$1585 < F_i \leq 1655$	1694.58 - F1
$1555 < F_i \leq 12000$	-30

RECEIVER

4B13.21 Continuity & Isolation

The receiver continuity and isolation resistance shall be verified between case ground and all power leads, and signal outputs, including returns, and between power leads and signal leads, including returns. All external parts of the unit shall be measured to verify they are at case ground potential. Isolation values will be specified in the applicable specification.

4B13.22 DC Input Voltage

The purpose of this test is to verify that receiver power consumption is within the limits specified for normal operations. This test will also ensure that the receiver will function normally at all voltage requirements as specified by the applicable specification.

The DC power supply is to be verified from specified minimum to maximum.

4B13.23 Input Current

The maximum current shall be measured at the low, nominal, and high supply voltage.

4B13.24 Noise Figure

The noise figure for the receiver shall be measured at 1574, 1575, 1576 for noise applied at the L_1 input and at 1226, 1227, and 1228 MHz for noise applied at the L_2 input. This measurement must be made at a point before signals are quantized for digital processing. Alternate test points/techniques must be approved by the Range (example - drop lock test).

4B13.25 System Test

This test evaluates the receiver's ability to produce on accurate state vector as well as the full range of required telemetry data. The input to the receiver is a calibrated GPS signal simulator. The primary measurement will be an accurate state vector based upon satellite position data provided by the simulator. Also the receiver must provide correct telemetry data for satellite assignments, lock status, ephemeris ready, currency of ephemeris, pseudo and delta range, state vector quality, PDOP and GDOP, signal quality, C/N_0 , satellite health bit, and age of data. These data shall be measured against reference inputs provided by the GPS signal simulator. Pseudo range rate shall be measured by ramping the GPS signal simulator from zero to 10 g's and comparing range rate derived by the receiver with range rate provided by the simulator. Pseudo-range and delta pseudo-range rate tests shall be performed at -145 and -100 dBm.

4B13.26 Phase Linearity

A continuous wave signal shall be provided at the receiver L_1/L_2 port. The input signal shall be swept from 1574 to 1576 MHz and 1226 to 1228 MHz in 100 kHz increments. Phase slope will be calculated for each measurement and plotted. Plots will be included in the Test Report. Measurements shall be made at a point before signals are quantized for digital processing. Alternate test points/techniques shall be approved by the Range.

4B13.27 L_1/L_2 Bandpass Characteristics

A continuous wave input signal (-110 dBm) shall be

APPENDIX 4B13

GLOBAL POSITIONING SYSTEM TEST REQUIREMENTS

provided at the receiver L_1/L_2 input ports. The signal shall be stepped from 1100 MHz to 1700 MHz in 100 kHz increments. Results will be plotted and included in the Test Report. Measurements must be made at a point before signals are quantized for digital processing. Alternative test points/techniques must be approved by the Range.

4B13.28 Phase Jitter

The receiver will be placed on a vibration table to measure phase jitter. The input signal is continuous wave; jitter will be monitored while the unit is vibrated at the maximum predicted environment for 3 minutes per axis. Measurements must be made at a point before signals are quantized for digital processing. Alternative test points/techniques must be approved by the Range (example-standard deviation of range rate measured by GPS ground station).

4B13.29 Sensitivity

This test shall measure the minimum input level at which the receiver maintains lock and produces an accurate state vector. The input is a calibrated GPS signal simulator providing at least 4 satellites. Unless the receiver is capable of operating on only one L-Band frequency, both L_1 and L_2 center frequencies shall be tested for sensitivity. The codes (CA and/or P) that will be employed operationally must be used during this test.

4B13.30 Rapid Relock Test

This test shall verify the receiver's ability to relock after loss of a satellite and after the receiver's internal selection routine changes primary assignment. The input is a calibrated GPS signal simulator configured to drop one satellite and to provide geometry that will cause the receiver to change assignment during simulated flight.

Position uncertainty, velocity uncertainty, acceleration uncertainty, relock time, and time of change of

assignment will be recorded. Acceleration and jerk profiles will replicate vehicle dynamics for staging during the relock test.

4B13.31 Time to First Fix

Time to first fix shall be measured using a GPS signal simulator. The simulator shall inject signals for individual satellites ranging from -145 dBm to -135 dBm to represent a mix of levels representative of the operating environment.

4B13.32 Deselection of Faulty Satellites

This test shall verify the receiver's ability to identify and reject faulty signals from satellites. The input is a -145 dBm signal from a calibrated GPS signal simulator. The simulator shall be configured to suddenly change key parameters. The receiver's ability to identify and reject the faulty satellite, select another satellite, and provide a correct state vector using the new satellite shall be recorded. During this test, the receiver should be tracking several satellites to demonstrate that measurements from the faulty satellite are not used in computation of position and velocity.

4B13.33 Immunity to In-Band Interfering Signals

The receiver's immunity to specified amplitudes and frequencies of in-band interfering signals shall be measured and reported.

4B13.34 Out-of-Band Signals

This test measures the receiver's susceptibility to signals and combinations of signals provided in the receiver specification. Reduction of C/N_0 in the presence of large out-of-band signals shall be measured and recorded.

4B13.35 Peak Input Voltage

This test verifies that the receiver can withstand a 45 Vdc input.

4B13.36 RF Overload

This test verifies that the receiver can withstand an in-band RF overload of specified value without degradation after the overload is removed.

APPENDIX 4B14 TELEMETRY DATA TRANSMITTER TEST REQUIREMENTS

**Table 4B14-1
Telemetry Transmitter Acceptance Test Matrix**

TEST	TEST REQUIREMENT	QUANTITY TESTED
Product Examination		
Visual	4B1.2.1	100%
Weight	4B1.2.2	100%
Dimension	4B1.2.3	100%
Identification	4B1.2.4	100%
Functional Tests (a)		
Continuity & Isolation	4B14.1	100%
Power Output	4B14.2	100%
Frequency Stability	4B14.3	100%
Authorized Bdwidth and Spurious Emis.	4B14.4	100%
Carrier Suppression	4B14.5	100%
Apparent Bandwidth (30 dB)	4B14.6	100%
Accuracy	4B14.7	100%
Reference Functional Tests (b)		
Power Output	4B14.2	100%
Frequency Stability	4B14.3	100%
Modulation (c)	4B14.8	100%
Operating Environment Tests		
Acoustic	4B1.4.2.2	100%
Acceleration	4B1.4.2.3	100%
Thermal Cycling (d)	4B1.4.2.4	100%
Thermal Vacuum (e)	4B1.4.2.5	100%
Random Vibration	4B1.4.2.1	100%
Burn-in	4B1.4.2.6	100%
Leakage (f)	4B1.2.7	100%

(a) These tests shall be performed prior to and after each environmental test.

(b) These shall be monitored during the operating environment tests.

(c) To be performed and continuously monitored during random vibration test.

(d) Functional tests, except test 4B14.1, shall be performed at high voltage input on the 1 and 7 cycles, low voltage input on the 2 and 8 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(e) Perform the full functional test, except test 4B14.1, during the high and low temperature soak periods.

(f) This test shall be performed after the last operating environment test.

APPENDIX 4B14

TELEMETRY DATA TRANSMITTER TEST REQUIREMENTS

Table 4B14-2
Telemetry Transmitter Qualification Test Matrix

TEST	TEST REQUIREMENT	QUANTITY TESTED		
		1	1	1
Acceptance	ACCEPTANCE TEST MATRIX	X	X	X
Functional Tests (a)				
Continuity & Isolation	4B14.1	X	X	X
Power Output	4B14.2	X	X	X
Frequency Stability	4B14.3	X	X	X
Authorized Bandwidth and Spurious Emissions	4B14.4	X	X	X
Carrier Suppression	4B14.5	X	X	X
Apparent Bandwidth (30 dB)	4B14.6	X	X	X
Accuracy	4B14.7	X	X	X
Reference Functional Tests (b)				
Power Output	4B14.2	X	X	X
Frequency Stability	4B14.3	X	X	X
Modulation (c)	4B14.8	X	X	X
Non-Operating Environment Tests				
Storage Temperature	4B1.3.1	X	X	X
Transport Shock/Bench Handling	4B1.3.3	X	X	X
Transportation Vibration	4B1.3.4	X	X	X
Fungus Resistance	4B1.3.5	X		
Salt Fog	4B1.3.6	X		
Fine Sand	4B1.3.7		X	
Operating Environment Tests				
Sinusoidal Vibration	4B1.4.1.1	X	X	X
Acoustic	4B1.4.1.3	X	X	X
Shock	4B1.4.1.4	X	X	X
Acceleration	4B1.4.1.5	X	X	X
Humidity	4B1.4.1.6			X
Thermal Cycling (d)	4B1.4.1.7	X	X	X
Thermal Vacuum (e)	4B1.4.1.8	X	X	X
Random Vibration	4B1.4.1.2	X	X	X
EMI/EMC	4B1.4.1.9		X	X
Explosive Atmosphere	4B1.4.1.10	X		
Leakage (f)	4B1.2.7	X	X	X
Disassembly	4B1.4.2.7	X	X	X

(a) These tests shall be performed prior to and after each environmental test.

(b) These shall be monitored during the operating environment tests.

(c) To be performed and monitored continuously during random vibration test.

(d) Functional tests, except test 4B14.1, shall be performed at high voltage input on the 1 and 23 cycles, nominal voltage on the 12 and 13 cycles, low voltage input on the 2 and 24 cycles, and reference functional tests for the remaining cycles at nominal voltage input.

(e) Perform the full functional test, except test 4B14.1, during the high and low temperature soak periods of first and last cycle.

(f) This test shall be performed after the last non-operating and the last operating environment test.

APPENDIX 4B14

TELEMETRY DATA TRANSMITTER TEST REQUIREMENTS

4B14.1 Continuity & Isolations

a. Verify that the TDTS continuity and isolation resistances between the case ground and all power leads, and signal outputs, including returns, and between power leads and signal leads, including returns are within the requirements that are specified in the component specification.

b. Measure all external parts of the unit to verify that they are at case ground potential.

4B14.2 Power Output

a. Measure the specified power output from the transmitter. **NOTE:** This test should be performed in conjunction with the test in the **Frequency Stability** section of this Appendix. This test measures the power output at power on, and at power on plus 1, plus 2, plus 3, plus 4, and plus 5 minutes.

b. Record each reading in dBm.

4B14.3 Frequency Stability

a. Measure the RF frequency of the transmitter and verify that it complies with the assigned center frequency. **NOTE:** This test should be performed in conjunction with the **Power Output** section above. This test measures the transmitter frequency at power on and at power on plus 1, plus 2, plus 3, plus 4, and plus 5 minutes.

b. Record each reading in MHz.

4B14.4 Authorized Bandwidth and Spurious Emissions

a. Measure the authorized transmitter bandwidth and any spurious emissions that are present.

b. Record the bandwidth in MHz and note any spurious emissions.

NOTE: During this test the transmitter output carrier frequency shall be modulated in accordance with the flight operational modulation scheme. For example, if the modulation scheme employs phase shift keying (PSK), the carrier shall be PSK modulated using an operationally representative input (bit rate, return-to-zero scheme, and state transitions over time).

4B14.5 Carrier Suppression

Measure the amount of carrier that is present in the RF signal.

4B14.6 Apparent Bandwidth (30 dB)

a. Measure the apparent bandwidth of the transmitter at the 30 dB points.

b. Record the measurement in MHz.

4B14.7 Accuracy

a. Measure the PSK accuracy of the transmitter output and record the measurement in degrees of PSK, or

b. Measure the frequency shift keying accuracy of the transmitter output and record the measurement in kilohertz of carrier frequency shift.

4B14.8 Modulation

a. Measure the amplitude modulation (AM) and frequency modulation (FM) (both in the time and frequency domain) that is present when the transmitter output frequency is unmodulated (carrier only).

b. Record the modulation in percent for AM and kilohertz for FM.

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