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MIL-HDBK-1587 (USAF)
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DEPARTMENT OF DEFENSE HANDBOOK

MATERIALS AND PROCESS REQUIREMENTS FOR AIR FORCE WEAPON SYSTEMS

AMSC N/A AREA MFFP

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FOREWORD

1. This military standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: WL/MLSA, Materials Directorate, Wright-Patterson AFB OH 45433-6533, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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1. SCOPE

1.1 Scope. This standard establishes the requirements for materials and processes used during design and production of aerospace weapon systems. When used in conjunction with MIL–STD–1530, the other integrity program documents (MIL–STD–1783, 1798, etc.), and MIL–STD–1568, it is expected that structurally reliable aerospace systems having a good balance between acquisition costs and life cycle costs will result.

1.2 Applicability. This standard is applicable for use by all Air Force procuring activities and their respective contractors involved in the design and procurement of aerospace weapon systems. Numerous materials and processes used in propulsion and electronic subsystems and ground support equipment are not specifically covered by this standard.

2. REFERENCED DOCUMENTS

2.1 Government documents

2.1.1 Specifications, standards, and handbooks. Unless otherwise specified, the following specifications, standards, and handbooks of the issue listed in that issue of the Department of Defense Index of Specifications and Standards (DoDISS) specified in the solicitation form a part of this standard to the extent specified herein.

SPECIFICATIONS

FEDERAL

QQ-A-367	–	Aluminum Alloy Forgings
ZZ-R-765	–	Rubber, Silicone (General Specification)

MILITARY

MIL-W-5088	–	Wiring, Aerospace Vehicle
MIL-P-5315	–	Packing, Preformed, Hydrocarbon Fuel Resistant
MIL-P-5510	–	Packing, Preformed, Straight Thread Tube Fitting Boss, Type I Hydraulic
MIL-H-6088	–	Heat Treatment of Aluminum Alloys
MIL-R-6855	–	Rubber, Synthetic, Sheets, Strips, Molded or Extruded Shapes, General Specification for
MIL-W-6858	–	Welding, Resistance: Spot and Seam
MIL-I-6870	–	Inspection Program Requirements, Nondestructive, for Aircraft and Missile Materials and Parts
MIL-W-6873	–	Welding; Flash, Carbon and Alloy Steel
MIL-F-7190	–	Forging, Steel, for Aircraft/Aerospace Equipment and Special Ordnance Applications
MIL-R-7362	–	Rubber, Synthetic, Solid, Sheet, Strip and Fabricated Parts, Synthetic Oil Resistant
MIL-C-7438	–	Core Material, Aluminum, for Sandwich Construction
MIL-B-7883	–	Brazing of Steels, Copper, Copper Alloys, Nickel Alloys, Aluminum and Aluminum Alloys
MIL-C-8073	–	Core Material, Plastic Honeycomb, Laminated Glass Fabric Base, for Aircraft Structural and Electronic Applications
MIL-C-8087	–	Core Material, Foamed-in-Place, Urethane Type
MIL-S-8516	–	Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically Cured
MIL-S-8802	–	Sealing Compound, Temperature-Resistant Integral Fuel Tanks and Fuel Cell Cavities, High-Adhesion
MIL-S-9041	–	Sandwich Construction; Plastic Resin, Glass Fabric Base, Laminated Facings and Honeycomb Core for Aircraft Structural and Electronic Applications

MIL–T–9046	–	Titanium and Titanium Alloy, Sheet, Strip, and Plate
MIL–T–9047	–	Titanium and Titanium Alloy Bars (Rolled or Forged) and Reforging Stock, Aircraft Quality
MIL–S–13165	–	Shot Peening of Metal Parts
MIL–I–16923	–	Insulating Compound, Electrical, Embedding
MIL–A–21180	–	Aluminum–Alloy Castings, High Strength
MIL–A–22771	–	Aluminum Alloy Forgings, Heat Treated
MIL–S–23586	–	Sealing Compound, Electrical, Silicone Rubber, Accelerator Required
MIL–M–24041	–	Molding and Potting Compound, Chemically Cured, Polyurethane
MIL–S–25392	–	Sandwich Construction, Plastic Resin, Glass Fabric Base, Laminated Facings and Urethane Foamed–in–Place Core, for Structural Applications
MIL–P–25732	–	Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Limited Service at 275° F (132° C)
MIL–R–25988	–	Rubber, Fluorosilicone Elastomer Oil– and Fuel–Resistant, Sheets, Strips, Molded Parts, and Extruded Shapes
MIL–R–25988/1	–	Rubber, Fluorosilicone Elastomer, Oil– and Fuel–Resistant, O–Rings, Class 1, Grade 70
MIL–R–25988/2	–	Rubber, Fluorosilicone Elastomer, Oil– and Fuel–Resistant, O–Rings, Class 3
MIL–R–25988/3	–	Rubber, Fluorosilicone Elastomer, Oil– and Fuel–Resistant, O–Rings, Class 1, Grade 60
MIL–R–25988/4	–	Rubber, Fluorosilicone Elastomer, Oil– and Fuel–Resistant, O–Rings, Class 1, Grade 80
MIL–C–27725	–	Coating, Corrosion Preventive, for Aircraft Integral Fuel Tanks
MIL–A–46106	–	Adhesive–Sealants, Silicone, RTV, One Component
MIL–A–46146	–	Adhesives–Sealants, Silicone, RTV, Noncorrosive (for Use with Sensitive Metals and Equipment)
MIL–E–47231	–	Electrical Components, Potting of
MIL–H–81200	–	Heat Treatment of Titanium and Titanium Alloys
MIL–I–81550	–	Insulating Compound, Electrical, Embedding, Reversion Resistant Silicone
MIL–T–81556	–	Titanium and Titanium Alloys, Extruded Bars and Shapes, Aircraft Quality
MIL–S–81732	–	Sealing Compound, Electrical High Strength, Accelerator Required
MIL–F–83142	–	Forging, Titanium Alloys, Premium Quality
MIL–R–83248	–	Rubber, Fluorocarbon Elastomer, High Temperature, Fluid, and Compression Set Resistant
MIL–R–83248/1	–	Rubber, Fluorocarbon Elastomer, High Temperature, Fluid, and Compression Set Resistant (O–Rings, Class 1, 75 Hardness)
MIL–R–83248/2	–	Rubber, Fluorocarbon Elastomer, High Temperature, Fluid, and Compression Set Resistant (O–Rings, Class 2, 90 Hardness)
MIL–R–83285	–	Rubber, Ethylene–Propylene General Purpose

MIL–A–83377	–	Adhesive Bonding (Structural) for Aerospace and Other Systems, Requirements for
MIL–R–83397	–	Rubber, Polyurethane, Castable, Humidity Resistant
MIL–S–83430	–	Sealing Compound, Integral Fuel Tanks and Fuel Cell Cavities, Intermittent Use to 360 °F
MIL–P–83461	–	Packings, Preformed, Petroleum Hydraulic Fluid Resistant, Improved Performance at 275 °F (135 °C)
MIL–P–83461/1	–	Packing, Preformed, Petroleum Hydraulic Fluid Resistant Improved Performance at 275 °F (135 °C) Sizes and Tolerances
MIL–T–83483	–	Thread Compound, Antiseize, Molybdenum Disulfide–Petrolatum
MIL–R–83485	–	Rubber, Fluorocarbon Elastomer, Improved Performance at Low Temperatures
AFGS–87221	–	Aircraft Structures, General Specification for
MIL–A–87244	–	Avionic/Electronic Integrity Program Requirements (AVIP)

STANDARDS

FEDERAL

FED–STD–191	–	Textile Test Methods

MILITARY

MIL–STD–129	–	Marking for Shipment and Storage
MIL–STD–454	–	Standard General Requirements for Electronic Equipment
MIL–STD–810	–	Environmental Test Methods and Engineering Guidelines
MIL–STD–838	–	Lubrication of Military Equipment
MIL–STD–866	–	Grinding of Chrome Plated Steel and Steel Parts Heat Treated to 180,000 psi or Over
MIL–STD–889	–	Dissimilar Metals
MIL–STD–970	–	Standards and Specifications, Order of Preference for the Selection of
MIL–STD–1523	–	Age Controls of Age–Sensitive Elastomeric Material (for Aerospace Applications)
MIL–STD–1530	–	Aircraft Structural Integrity Program, Airplane Requirements
MIL–STD–1568	–	Materials and Processes for Corrosion Prevention and Control in Aerospace Weapons Systems
MIL–STD–1595	–	Qualification of Aircraft, Missile and Aerospace Fusion Welders
MIL–STD–1783	–	Engine Structural Integrity Program (ENSIP)
MIL–STD–1798	–	Mechanical Equipment and Subsystems Integrity Program
MIL–STD–1807	–	Crash Survivability of Aircraft Personnel
MIL–STD–2000	–	Standard Requirements for Soldered Electrical and Electronic Assemblies
MIL–STD–2175	–	Castings, Classification and Inspection of
MIL–STD–2219	–	Fusion Welding for Aerospace Applications
MS28775	–	Packing, Preformed, Hydraulic, +275 °F (O–Ring)

MS28778	–	Packing, Preformed, Straight Thread Tube Fitting Boss
MS29512	–	Packing, Preformed, Hydrocarbon Fuel Resistant, Tube Fitting O-Ring
MS29513	–	Packing, Preformed, Hydrocarbon Fuel Resistant O-Ring
MS29561	–	Packing, Preformed, O-Ring, Synthetic Lubricant Resistant

HANDBOOKS

MILITARY

MIL-HDBK-5	–	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-HDBK-17 Vol I	–	Polymer Matrix Composites, Guidelines
MIL-HDBK-17 Vol II	–	Polymer Matrix Composites, Material Properties
MIL-HDBK-17 Vol III	–	Polymer Matrix Composites, Utilization of Data
MIL-HDBK-275	–	Guide for Selection of Lubricant Fluids and Compounds for Use in Flight Vehicles and Components

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from theStandardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia PA 19111-5094.

2.1.2 Other Government documents and publications. The following other Government documents and publications form a part of this standard to the extent specified herein.

PUBLICATIONS

DEPARTMENT OF THE AIR FORCE

AFSC DH 1-2	–	General Design Factors
AFSC DH 1-7	–	Aerospace Materials
AFSC DH 2-1	–	Airframe

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

AIR FORCE WRIGHT LABORATORIES (WL)

ADD436124L	–	DOD/NASA Structural Composites Fabrication Guide, Vol I
ADD436125L	–	DOD/NASA Structural Composites Fabrication Guide, Vol II
		DOD/NASA Advanced Composites Design Guide, Vol I – Vol IV
ADB077732L	–	Advanced Composite Repair Guide, AFWAL-TR-83-3092

(Application for copies should be addressed to the Defense Technical Information Center, Defense Logistics Agency, Cameron Station, Alexandria VA 22314.)

FEDERAL AIR REGULATION (FAR)

FAR 25.853	–	Compartment Interior
FAR 25.853	–	Amendment 25–59 Appendix F, Part II. Flammability of Seat Cushions

(Application for copies should be addressed to the Flight Standards Service, Federal Aviation Administration, 800 Independence Avenue, SW, Washington DC 20591.)

2.2 Other publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the solicitation. The issues of documents which have not been adopted shall be those in effect on the date of the cited DoDISS.

PUBLICATIONS

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E162	–	Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source (DoD adopted)

(Application for copies should be addressed to American Society for Testing and Materials, 1916 Race Street, Philadelphia PA 19103–1187.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

AS 568	–	Aerospace Size Standard for O–Rings (DoD adopted)
AMS 2300	–	Premium Aircraft–Quality Steel Cleanliness, Magnetic Particle Inspection Procedure (DoD adopted)
AMS 2301	–	Aircraft Quality Steel Cleanliness Magnetic Particle Inspection Procedure
AMS 2303	–	Aircraft–Quality Steel Cleanliness Martensitic Corrosion–Resistant Steels Magnetic Particle Inspection Procedure (DoD adopted)
AMS 2750	–	Pyrometry (DoD adopted)
AMS 2759	–	Heat Treatment, Steel Parts, General Requirements
AMS 2770	–	Heat Treatment of Wrought Aluminum Alloy Parts (DoD adopted)
AMS 3100	–	Adhesion Promoter for Polysulfide Sealing Compounds
AMS 3856	–	Cloth, Upholstery, Flame Resistant
AMS 5343	–	Steel Castings, Investment, Corrosion Resistant 16CR – 4.0Ni – 0.28 (Cb+Ta) – 3.1 Cu Homogenization, Solution, and Precipitation Heat Treated 150,000 psi (1035 MPa) Tensile Strength (DoD adopted)

(Application for copies should be addressed to Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale PA 15096–0001.)

METALS AND CERAMICS INFORMATION CENTER (MCIC)

MCIC-HB-01	–	Damage Tolerant Design Handbook

(Application for copies should be addressed to National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield VA 22161-0001.)

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1-90	–	Structural Welding Code Steel Twelfth Edition (DoD adopted)
AWS D1.2-83	–	Structural Welding Code Aluminum (DoD adopted)

(Application for copies should be addressed to the American Welding Society, Inc., 550 NW LeJeune Road, P O Box 351040, Miami FL 33135-0440.)

NATIONAL AEROSPACE STANDARDS (NAS)

NAS 1514	–	Radiographic Standard for Classification of Fusion Weld Discontinuities (DoD adopted)

(Application for copies should be addressed to the National Aerospace Standards Association, Aerospace Industries Association of America, Inc., 1250 I Street, NW, Washington DC 20005-3922.)

(Industry association standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.)

2.3 Order of precedence. In the event of a conflict between the text of this standard and the references cited herein, the text of this standard shall take precedence.

3. DEFINITIONS

3.1 Definitions. Definitions will be in accordance with the documents listed in section 2 and as specified herein.

4. GENERAL REQUIREMENTS

4.1 Material selection. The selection of materials and processes shall be the result of design studies which shall be performed for each system. These studies shall include all the relevant parameters such as operational environments, performance, manufacturing capabilities, safety of flight structure, life cycle costs, and reliability and maintainability requirements as specified by the contract. These studies shall determine the acceptable initial flaw sizes, defects, and tolerances associated with the manufacturing processes, fabrication, and assembly. Inspection shall be capable of ensuring that the initial manufactured quality of the design meets the fatigue and damage tolerance requirements specified in the contract. Materials related considerations that shall form a part of the trade studies include mechanical properties as identified in MIL-HDBK-5 or other acceptable sources, stability under environmental conditions, corrosion susceptibility, fracture toughness, and crack growth (da/dn) under the service stresses. The service experience of established materials in similar applications shall also be considered.

4.2 Restricted materials. The materials listed in table I are restricted from use on Air Force weapons systems.

4.3 Material properties/fracture mechanics. The contractor shall use the Damage Tolerant Design Handbook (MCIC-HB-01) as a guide for establishing material properties when conducting fracture mechanics analysis as required by MIL-STD-1530, 1783, 1798, MIL-A-87244, or other such contractual documents.

4.4 Disclosure of materials. Proposed materials and processes, to the extent possible, shall be submitted as a part of the technical proposal. The technical proposal shall include information identifying the operating environment and loading conditions as well as rationale for the materials and processes selection. Selection of Standards and Specifications shall be in accordance with MIL-STD-970. A complete list of materials and processes shall be submitted when final selection has been made.

4.5 Contractor prepared specifications. If the contractor proposes to use a material or process not covered by an existing military or non-Government standards body (AMS, etc.) specification, the rationale, including appropriate test data, shall be provided to the Acquisition Agency (DI-E-3130).

TABLE I. Restricted materials.

Metal	Alloy	Temper	Mill products
Aluminum	7178	All	All
	7079	All	All
	2014	All	All except wheel forgings
	2020	All	All
	2024	–T8XX	Forgings
	7XXX	–T6XX	Extrusion over 0.250 inch thick and all bar, plate, and forgings
	7XXX	Overaged*	
Alloy Steel	4340	200 to 260 ksi	All
	4340	260 to 280 ksi	All except for constant diameter pins and shafts
	4330M	Above 240 ksi	All
	H–11	Above 240 ksi	All
	4130	Above 180 ksi	All
	4140	Above 180 ksi	All
	D6AC	All ksi	All
Corrosion Resistant Steel	431	All	All
	19–9DL, 9–9 DX	All	All
	17–4PH, Cond H900/925	All	All
	17–7PH, Cond H900/RH950	All	All
	Custom 445, Cond H900/950	All	All
	Maraging steel, annealed	All	All
	15–5PH, Cond H900/925	All	All
	PH 13–8 Mo, Cond H950	All	All
	400 Series, 150–180 ksi	All	All
	PH CRES Cond A	All	All
	303, 303S, 303SE	All	All

*Must be equal to or exceed 25 ksi stress corrosion cracking threshold resistance in short transverse direction in order to be used in aircraft structure.

5. DETAILED REQUIREMENTS

5.1 Metals

5.1.1 Minimum thicknesses. The minimum thickness of material permissible for structural applications (except sandwich construction) shall be as specified in table II.

TABLE II. Minimum thickness of material permissible for structural applications.

Material	Thickness	
	Inch	cm
Corrosion resistant steel	0.008	0.020
Aluminum alloys located in noncorrosion prone environments	0.016	0.041
Aluminum alloys located in corrosion prone environments	0.025	0.0635
Magnesium alloys	0.032	0.081
Titanium	0.008	0.020
Superalloys	0.015	0.038
Metal tubing for wing ribs, central surface ribs, and trailing edge structures	0.035	0.089
All other structural metal tubing	0.024	0.061
Hydraulic tubing – aluminum	0.028	0.071
Hydraulic tubing – stainless steel	0.020	0.051
Hydraulic tubing – titanium	0.016	0.041
Graphite/epoxy and boron/epoxy skins, exterior	0.020	0.051
Graphite/epoxy and boron/epoxy skins, interior	0.015	0.038

The minimum thickness for countersinking shall be in accordance with Design Note 4A1 of DH 1-2. Deviations to these thickness limits may be permitted depending upon structural design requirements and exact material selection.

5.1.2 Aluminum

5.1.2.1 Heat treatment. Heat treatment of aluminum mill products shall be in accordance with MIL-H-6088. Heat treatment of aluminum alloy parts shall be in accordance with AMS 2770. Wrought aluminum parts shall be heat treated in accordance with AMS 2770. In all cases, maximum thickness for heat treatment shall be controlled to assure that through thickness design properties are met.

5.1.2.2 Forming and straightening. Forming and straightening operations performed on sheet metal, plate extrusions or forgings shall be limited to processes which do not result in detrimental residual stresses or losses in mechanical properties on structurally critical parts or lead to stress corrosion sensitivity of the part. Shot peen forming is permissible. The contractor shall maintain adequate controls and supportive data which substantiate that the employed forming and straightening processes meet the foregoing requirements.

5.1.3 Steel. Steels used at or above 200 ksi (1379 MPa) ultimate tensile strength (UTS) shall meet AMS 2300 cleanliness requirements except that the cleanliness rating for heat treatments to 260 ksi (1793 MPa) and above shall have a frequency/severity rating of 0.10/0.20 maximum, respectively. Steels used below 200 ksi (1379 MPa) shall meet AMS 2301 cleanliness requirements. Ferromagnetic corrosion resistant steels shall meet AMS 2303 cleanliness requirements. Compositions shall be selected which have ductile to brittle transition temperature measured by impact that are below any temperature which the part is likely to experience in service.

5.1.3.1 Heat treatment. Heat treatment shall be accomplished in accordance with AMS 2759 or methods recognized therein. The equipment and controls shall comply with AMS 2750. After heat treatment, parts shall meet the reduction in area requirements in table III.

5.1.3.2 Shot peening. After final machining, shot peen in accordance with MIL-S-13165 all surfaces of critical or highly stressed parts which have been heat treated to or above 200 ksi (1379 MPa) UTS except for rolled threads; inaccessible areas of holes; pneumatic or hydraulic seat contact areas; and thin sections or parts which, after shot peening, violate engineering and functional configuration. Areas requiring lapped, honed, or polished surfaces shall be shot peened prior to such finishing. Surface removal of up to 0.0038 cm (0.0015 inches) based on pre-shot peened dimensions shall be permissible.

5.1.3.3 Hardenability. Hardenability shall be sufficient to ensure transformation during quenching to not less than 90 percent martensite at the center of the maximum cross section.

TABLE III. Minimum reduction of area (steels).

Item	Material	Strength 2/ min. UTS ksi	Strength 2/ min. UTS MPa	Cross sectional area 3/ of billet from which specimens are taken	Reduction of area (percent) Minimum value single test
a	4330 VAR 1/				
	Longitudinal	220	(1517)	To and including 1452 sq cm (225 sq in)	35
	Transverse	220	(1517)	To and including 1452 sq cm (225 sq in)	25
b	D6AC				
	Longitudinal	220	(1517)	To and including 1452 sq cm (225 sq in)	35
	Transverse	220	(1517)	To and including 1452 sq cm (225 sq in)	25
c	4340 VAR				
	Longitudinal	260	(1793)	To and including 1452 sq cm (225 sq in)	25
	Transverse	260	(1793)	To and including 1452 sq cm (225 sq in)	15
d	300M (VAR)				
	Longitudinal	280	(1931)	To and including 1452 sq cm (225 sq in)	25
	Transverse	280	(1931)	To and including 1452 sq cm (225 sq in)	15
e	9Ni–4Co (VAR)				
	Longitudinal (0.30 Carbon)	220	(1517)	All sizes	30
	Longitudinal (0.20 Carbon)	190	(1310)	All sizes	40
f	H–11 (VAR)				
	Longitudinal	220	(1517)	To and including 1452 sq cm (225 sq in)	35
	Transverse	220	(1517)	To and including 1452 sq cm (225 sq in)	25
g	PH13–8Mo				
	Longitudinal	205	(1413)	All sizes	50
	Transverse				40
h	17–4PH				
	Longitudinal	190	(1310)	All sizes	50
	Transverse				40

1/ VAR – Vacuum arc remelted material.

2/ A range of 20 ksi is normal, however, material meeting ductility and other specification requirements but exceeding the 20 ksi provision shall not be subject to rejection.

3/ For cross–sectional areas larger than the upper limits, the properties need to be negotiated between the contractor and procuring agency.

5.1.3.4 Forming or straightening of steel parts. All reasonable precautions shall be taken to minimize warping during heat treatment of steel parts. NDI shall be performed on parts after room temperature straightening. Steel parts shall be formed or straightened unless otherwise noted in accordance with the following:

a. Parts hardened up to 165 ksi (1138 MPa) UTS may be room temperature straightened.

b. Parts hardened from 165 to 200 ksi (1138 to 1379 MPa) may be straightened at room temperature providing they are given a stress relieving heat treatment subsequent to straightening.

c. Parts hardened over 200 ksi (1379 MPa) UTS shall be hot formed or straightened within a temperature range from the tempering temperature to 128 °C (50 °F) below the tempering temperature.

5.1.3.5 Decarburization. Unless otherwise specified, completed decarburization shall not be present in a finished machined surface. On steels heat treated below 200 ksi (1379 MPa) UTS partial decarburization to a maximum depth of 0.0127 cm (0.005 inches) may be present. On steels heat treated above 200 ksi (1379 MPa) UTS, partial decarburization to a maximum depth of 0.0076 cm (0.003 inches) may be present. The difference in hardness from the surface to any point below the surface shall not exceed 30 points Knoop microhardness or equivalent.

5.1.3.6 Carburization. Minimum carburization of fully hardened steel parts shall be a prime objective. Furnace atmospheres which increase the carbon content of surface zones above the maximum for the respective composition are not acceptable. Surface of steel parts shall show no evidence of carbon increase as a result of heat treating.

5.1.3.7 Drilling of high strength steels. The drilling of holes, including chamfering and spot facing, in martensitic steels subsequent to hardening to strength levels of 180 ksi (1241 MPa) UTS and above shall be avoided whenever practicable. When such drilling and reaming is unavoidable because of manufacturing sequence, tooling and techniques necessary to avoid formation of any untempered martensite shall be used. All holes, straight or tapered, shall be reamed with sharp, carbide reamers having a sufficient number of flutes to avoid chattering. The documents controlling such techniques shall specify a final sizing pass with minimum radial loads, speed and feed rates, coolant flow rates, tool life limits, inspection techniques, and other requirements necessary to assure the production of holes of high quality, smooth bore surfaces, and free from "hard spots" and microcracks. Tooling and processes used shall be qualified by demonstration. Microhardness and metallurgical examinations of test specimens shall be used to determine the depth of disturbed metal and possible untempered martensitic areas resulting from drilling. The surface roughness of the finished hole, including any countersink or spot faced surfaces, shall not be greater than RHR 63. Both ends of the holes shall be deburred by a method which has been demonstrated not to cause untempered martensite except where the materials stackups or assemblies preclude accessibility of both ends of the holes in each layer of the stackups. Cobalt high speed steel or carbide reamers shall be used in steel heat treated at 200–260 ksi (1517–1793 MPa) UTS. Carbide reamers shall be used in steel heat treated to 260 ksi (1793 MPa) UTS and above. For tapered holes, reamers having not less than 12 flutes shall be used.

5.1.3.8 Grinding of high strength steel. Grinding of martensitic steels hardened to 180 ksi (1241 MPa) UTS and above shall be performed in accordance with MIL-STD-866. Grinding of chromium plated martensitic steels hardened to 180 ksi (1241 MPa) UTS and above shall also be performed in accordance with MIL-STD-866.

5.1.3.9 Corrosion resistant steels

5.1.3.9.1 Austenitic stainless steels. Free machining stainless steels intended for fatigue critical applications shall be avoided. Sulfur or selenium additions improve machinability but lower fatigue life.

5.1.3.9.2 Precipitation hardening stainless steels. These steels shall be aged at temperatures not less than 538 °C (1000 °F). Exception is made for castings which may be aged at 501.5 ± 9.4 °C (935 ± 15 °F), for fasteners which may be used in the H950 condition, and for springs which have optimum properties at the CH 900 condition. H950 is not permitted for 17-4 PH or 15-5 PH alloys.

5.1.4 Titanium

5.1.4.1 Forgings. All titanium bar and forging stock shall be procured in accordance with the requirements of MIL-T-9047 supplemented by such contractor documents as necessary to assure the metallurgical and structural properties required to meet the reliability and durability requirements of the system.

5.1.4.2 Sheet and plate. Titanium sheet and plate stock shall be procured to meet the requirements of MIL-T-9046, as supplemented by contractor specifications, drawing notes, or other approved documents which reflect the quality, properties and processing to provide material suitable for its intended use.

5.1.4.3 Extrusions. All titanium extruded bars, rods, or special shaped sections shall be procured to meet the requirements of MIL-T-81556 and supplemented by such contractor documents as necessary to assure that the metallurgical and structural properties required to meet the reliability and durability requirements of weapon system are met.

5.1.4.4 Heat treatment. Heat treatment of titanium shall be in accordance with MIL-H-81200 as supplemented by a contractor specification.

5.1.5 Beryllium. The use of beryllium shall be restricted to applications where its properties offer definite performance and cost advantages and in applications where its expected service life matches that of the surrounding structure. The capability to provide predictable and adequate service longevity must be demonstrated by preproduction tests under simulated service loading conditions and environments. Load paths must be oriented so that large stresses do not occur in the short transverse grain direction. The toxicity of beryllium dust and fumes is a critical problem and must be considered during fabrication, assembly, and in service usage and maintenance of beryllium parts.

5.1.6 Other metals. Magnesium alloys shall be used only with specific approval of the procuring activity. Other commonly used metals such as nickel base alloys and copper base alloys, may be used without specific approval. Where the design trade studies show the desirability of the use of less common metals other than those discussed above, the contractor shall submit the trade studies, together with the design properties, proposed processing, finishing, and manufacturing for review and approval.

5.2 Nonmetallic materials. Where nonmetallic materials are used in aerospace weapon systems, they shall be selected and used in compliance with the requirements contained in the following subparagraphs. In situations where the contractor proposes to use materials or processes for which only a limited amount of data or experience is available, the contractor should provide the procuring activity with sufficient background data so that a determination of the suitability of the material for the system can be made.

5.2.1 Composites. Composite materials are material systems made up of more than one constituent, usually a strong stiff reinforcing fiber and a relatively weak matrix. For the purposes of this standard, composite materials are divided into three broad categories, these being conventional composites, advanced composites, and metal matrix composites. Conventional composites are fiberglass reinforced organic resins. Advanced composites are organic resins reinforced with high strength, high stiffness fibers such as boron or carbon (graphite). Metal matrix composites are fiber, whisker, or particulate reinforced metals. Selection of materials and processes for composites must consider all aspects of the intended application. These include: service environment, systems requirements, structural and functional requirements, serviceability and repairability, etc.

5.2.1.1 Organic resins. The organic matrix (binder, resin, plastic, and matrix are interchangeable terms) of the conventional or advanced composite can be thermoset or thermoplastic. A thermoset composite is processed to a product form by a chemical reaction known as cure. The curing reaction can be facilitated by heat and pressure, as in an autoclave cure, or by other means such as radio frequency or radiation exposure. Typically, the cure temperature can be room temperature, 121 °C (250 °F), 176 °C (350 °F), etc. A thermoplastic composite is physically processed to a product form by a softening transition at the melting temperature, and subsequent operations such as deformation forming or injection molding.

5.2.1.2 Metal matrices. In a metal matrix composite, the metal serves the same purpose as the organic binder of an organic matrix composite. Aluminum, magnesium, and titanium alloys are common metal matrices.

5.2.1.3 Conventional composites. Glass fiber reinforced plastic materials usually find aerospace applications in radomes, secondary structure, and interior appointments. Glass fiber, continuous or chopped, can be used to reinforce any number of various organic resins. The many aspects of materials and processes for conventional composites are discussed in MIL–HDBK–17, Volume I and Volume III.

5.2.1.4 Advanced composites. Advanced composites consist of an organic matrix reinforced by high modulus and/or high strength (compared to fiberglass) fibers. The fiber reinforcement takes the form of continuous unidirectional filaments (tape), woven fabric (cloth), chopped fibers, etc. The fiber materials are boron, carbon (graphite), aromatic polyamide (aramid), etc. Guidance in the processing and production of advanced composite materials and structures can be found in the DoD/NASA Structural Composites Fabrication Guide. Guidance in the effective utilization of advanced composite materials and design concepts in aerospace structures can be found in the DoD/NASA Advanced Composites Design Guide, Volume I – Volume IV, and in MIL-HDBK-17, Volume I and Volume III.

5.2.1.4.1 Material property design allowables. The contractor shall develop material property design allowables as necessary according to a material characterization and design allowables substantiation plan. This plan shall be subject to review and approval by the procuring activity. Although static strength design allowables are important, other properties such as creep, fatigue, stress corrosion cracking, etc., shall be addressed as necessary. Mechanical property design allowables shall be derived from a statistically significant amount of test data, and the derivation of design allowables from the test data shall consider the distribution of property values within the sample data population. The material qualification, procurement, and manufacturing process specifications used in preparation of test specimens shall be identical to those used in production. The system contractor shall evaluate the effects of variations in processing and resulting products upon the design allowables for conditions such as; fiber (ply) misorientations, temperature and pressure variations, nonuniform chopped fiber distribution, thermoplastic morphology, etc. During production, material properties shall be verified periodically by testing of materials processed during a production run. The system contractor shall evaluate the effects upon the design allowables of impact damage and repairs. Some material property design allowables can be obtained from MIL-HDBK-17, Volume II.

5.2.1.4.2 Specifications. The contractor shall establish specifications for qualification, procurement, material processing, and product fabrication. The contractor shall provide adequate direction to his subcontractors so that the quality of materials and manufactured product is maintained.

5.2.1.4.2.1 Material acquisition specification. The contractor shall establish a specification for qualification (typically by mechanical, chemical, and/or thermal performance) for materials supplied by material vendors to be used in a particular aerospace application. This specification is to be used for generation of a Qualified Product List (DI-E-3131).

5.2.1.4.2.2 Material qualification specification. The contractor shall establish a specification for acceptance (typically by mechanical, chemical and/or thermal analysis) of individual purchase lots of incoming material, after that material has been qualified and characterized. The material procurement specification shall identify in detail the types of chemical, mechanical, and other tests to be performed, the types and numbers of test specimens to be employed, and the range of test results that will qualify the incoming material as acceptable for manufacturing. Raw material shelf or freezer life limits shall be specified, including requalification procedures prior to use, if needed. Storage and marking requirements shall also be specified. Material shall be labeled for storage with date of freezer life expiration, date received, batch or lot number, name, specification or procurement document number, unique storage requirements, etc., or as by MIL-STD-129 (DI-E-3131).

5.2.1.4.2.3 Process specification. The contractor shall establish a material process specification that provides for and specifies all processes which are essential to fabrication or procurement of a product or material, particularly the processing of the raw material or preform into the final part form ready for trim and assembly. Process quality control shall include a tracking method, preferably companion (or traveler) coupons that accompany all production parts during the manufacturing process cycle. These coupons shall be tested to verify that the manufacturing cycle has produced parts within an acceptable quality range. Adequate process controls and quality control inspection procedures shall be employed to exclude the possibility of adhesive and composite carrier/release films being unintentionally included in an assembly. Considerations during manufacturing process development shall include sealing of honeycomb sandwich panel porous face sheets, control of shop relative humidity at levels that do not adversely affect laminate porosity, debulking or other procedures used to produce void-free thick laminates, warming from freezer to room temperature in a package to avoid condensation on the material itself, etc. (DI-E-3130).

5.2.1.4.2.4 Product fabrication specification. The contractor shall establish a manufacturing specification which clearly designates each step of the manufacturing process which his production staff will be required to use in preparation of shop direction sheets. This specification will also provide for and specify control of all incoming material, control of all in-shop handling, use in manufacturing of parts, shop environmental controls (cleanliness, humidity, temperature, presence of food or silicone spray, etc.), quality control inspection procedures, identification of what to inspect and establishment of acceptable defect limits in each case. This practice will continue through the entire manufacturing process, including curing of the part, removal from tool, trimming, drilling (for installation), and final acceptance inspection (DI-E-3103A).

5.2.1.4.3 Joining and fastening. The suitability of fastening methods (bonding, bolting, stitching, welding, brazing, soldering, etc.) for the chosen materials and processes shall be validated. The effect of joining and fastening techniques on the net material property design allowables shall be evaluated, including sensitivities to material and process variations such as hole quality, bondline thickness, stitching quality, etc. Hole tolerances, fastener pull-through resistance, and corrosion implications must be evaluated during design development. The effect of repeated removal and insertion of fasteners into holes in composite joints shall be evaluated. Allowances shall also be made to preclude problems from overtorqued fasteners and fit-up mismatches on removable/interchangeable structures. Components that are cured together (co-cured) as an assembly for purposes of bonding by the parent matrix material in a single or multiple cure cycle shall be treated as bonded assemblies for the purposes of paragraph 5.3.5. Some joining methods are sensitive to contaminants (adhesive bonding is sensitive to silicone contamination, for example). When these processes are used, contaminants in the production environment must be kept to a minimum (substitute dry film mold release, for example).

5.2.1.4.3.1 Thermal expansion. The effects of thermal expansion mismatches between dissimilar materials (different coefficients of thermal expansion) and resulting induced stresses shall be evaluated during design and manufacturing process evaluation. The effect of residual stresses, introduced by cool-down from some stress-free elevated temperature existing during cure, shall be evaluated in design. Particular attention shall be paid to thermal expansion mismatch in evaluation of any manufacturing process that employs multiple elevated temperature cure cycles. Any elevated temperature cure (including secondary bonding and post-curing operations) shall not result in degradation of bondline integrity, either for load transfer or sealing purposes. Aluminum fittings, etc., shall not be bonded in conjunction with graphite composites unless demonstrated to be thermally compatible by an acceptable thermal stress analysis procedure.

5.2.1.4.3.2 Galvanic corrosion. Certain metals, such as aluminum, in contact with graphite composites will corrode, and such metal composite combinations shall be considered as dissimilar metals in contact under the requirements of MIL–STD–1568 and MIL–STD–889. Designs shall provide for elimination of direct contact between graphite composites and metals prone to galvanic attack, such as by a barrier of fiber glass cloth. Selection of metals, in general, shall be so as to prevent dissimilar metal contact as defined in MIL–STD–889.

5.2.1.4.4 Repairability. The selection of materials and processes shall be compatible with the system repair and maintenance requirements. The selection of materials and processes shall facilitate identification of repair concepts that will meet or exceed repair requirements. The contractor shall provide test data substantiating repairs that include bolt hole quality, size of repairs, multiple repairs, skill level, required support, repair time, and equipment. Other issues to be addressed in bonded repairs are laminate and honeycomb dry–out, bondline porosity caused by heating of a wet laminate, compatibility of repair adhesives and substrates, and the effects of the repair temperature spike on the material being repaired. Information and guidance in the selection of repair materials and processes, identification of appropriate standardized repair methods, and engineering design of repairs can be found in the Advanced Composite Repair Guide.

5.2.1.4.5 Supportability. The system contractor shall provide data validating the supportability of the composites. This data shall be correlated with mechanical property design allowables data when selecting materials.

5.2.1.4.6 Electrical/electromagnetic behavior. The system contractor shall evaluate the material characteristics as required to provide the proper design of structural and electrical/electromagnetic features. Of particular concern are shielding effectiveness, joint design (condition, corrosion, sealing, maintainability, etc.), fuel tank design (spark–free fuel tanks, lightning–strike hot spots, etc.), power system grounding, high and low frequency antenna performance, analytical techniques, combined space environmental effects, etc.

5.2.2 Elastomeric materials

5.2.2.1 General requirements. All elastomeric components shall be hydrolytically stable and possess adequate resistance to aging, operational environmental conditions, and fluid exposure for the intended system use.

5.2.2.1.1 Cured elastomers. Cured elastomers that are age sensitive shall be controlled by MIL–STD–1523. All cured elastomeric materials shall be cure dated either on the item itself or on the packaging. A policy of first in, first out shall be maintained. Cured elastomeric materials shall be protected from sunlight, fuel, oil, water, dust, and ozone (which is generated by electric arcs, fluorescent lamps, and similar electrical equipment). The storage temperature should not exceed 38 °C (100 °F) and shall not exceed 55 °C (125 °F).

5.2.2.1.2 Non-cured elastomers. Materials that are procured in non-cured state such as sealants and potting compounds, shall be held in controlled temperature storage not to exceed 26 °C (80 °F). Some specific materials may require storage at reduced temperatures and these materials should be given such storage as recommended by the manufacturer. Materials requiring reduced temperature storage should be avoided if possible because of the added burden on reduced temperature storage and the likelihood of reduced temperature storage not being maintained at all times. Adequate storage times shall be set up and those times maintained. Most polysulfide sealants can be stored for at least 9 months at less than 26 °C (80 °F) and the materials remain suitable for use. A policy of first in, first out shall be maintained. If materials become overage, suitable tests shall be conducted to ensure the material is adequate for use.

5.2.2.1.3 Silicone elastomers. Some one-part silicone products liberate acetic acid during cure. This includes commercial adhesives/sealants and those meeting MIL-A-46106. These materials can cause corrosion to electronic materials such as copper wire, aluminum connectors, steel containers, and cadmium plated surfaces. Do not specify these materials to pot, seal, embed, encapsulate, or to be used in any manner on or near avionics, electronics, or electrical equipment. These materials have, however, performed well in many applications and they may be used in applications other than electronic provided proper precautions are taken. When they are used, the following are required:

a. Good ventilation during cure.

b. Thickness limit of 1/4 inch, maximum.

c. Glueline limit of 1 inch, maximum when used between nonporous surfaces.

d. Sufficient moisture to complete cure.

e. Full cure before enclosure (7 days, minimum).

There are one-part silicone sealants available which are noncorrosive, liberating alcohol during cure. These are covered by MIL-A-46146. These materials do not cure as fast nor always adhere as well as the acetic acid liberating materials. It is suggested, however, that the alcohol liberating sealants be used in preference to the acetic acid liberating sealants.

5.2.2.2 O-rings. Dimensions and tolerances for all o-rings shall conform to AS 568. It is preferred that o-rings conforming to the following specifications be used:

System	Materials Specification	Applicable Drawing
Fuel	MIL-P-5315 (Buna N)	MS29512 MS29513
	MIL-R-25988 (Fluorosilicone)	MIL-R-25988/1, /2, /3, & /4
Lubricating oil	MIL-R-83248 (Fluorocarbon elastomer)	MIL-R-83248/1 & /2
	MIL-R-7362 (Buna N)	MS29561
	MIL-R-25988 (Fluorosilicone)	MIL-R-25988/1, /2, /3, & /4
Hydraulic	MIL-P-83461 (Buna N)	MIL-R-83461/1
	MIL-P-25732 (Buna N)	MS28775
	MIL-P-5510 (Buna N)	MS28778

5.2.2.3 Other molded parts, sheets, strips, and extruded shapes. These items are preferably obtained from the following specifications:

Specification	Material
MIL–R–6855	Buna N, Neoprene, and Buna S
MIL–R–7362	Buna N
MIL–R–25988	Fluorosilicone
MIL–R–83248	Fluorocarbon elastomer
MIL–R–83285	Ethylene–propylene
MIL–R–83397	Polyurethane
MIL–R–83485	Low Temp Fluoroelastomer
ZZ–R–765	Silicone

5.2.2.4 Potting compounds. Potting compounds shall be in accordance with Requirement 47 of MIL–STD–454. This requires that potting compounds conform to one of the following specifications:

Specification	Material
MIL–S–8516	Polysulfide
MIL–I–16923	Epoxy
MIL–S–23586	Silicone
MIL–M–24041	Polyurethane
MIL–I–81550	Silicone
MIL–S–81732	Silicone

If materials other than those meeting the above specifications must be used, approval must be obtained from the procuring activity. The potting process is controlled by MIL–E–47231.

5.2.2.5 Integral fuel tank sealing. Integral fuel tank sealing shall be accomplished by the use of sealant conforming to MIL–S–8802 or MIL–S–83430. When noncuring groove injection type sealing is used, the material shall be beaded similarly to Dow Corning Corporation's 94–031. It has been found that the use of an adhesion promoter is very worthwhile when applying curing type sealant over polyurethane coating conforming to MIL–C–27725. While the sealant will adequately adhere to new polyurethane coating, as the coating becomes older, the obtaining of proper adhesion becomes more difficult. This is true, not only with fuel aged coating, but also with coating that has only been subjected to air. An adhesion promoter (AMS 3100) shall be used prior to sealing over MIL–C–27725 polyurethane coating. Refer to MIL–STD–1568 for sealing other than fuel tanks.

5.2.3 Foamed plastics. Foamed plastics can absorb water when exposed to humidity or to water. Foams shall be hydrolytically stable. Polyester based polyurethane foams lack such stability and shall not be used in a moisture containing environment. The design of foam core sandwich or other constructions shall provide complete sealing against exposure to humidity and to fluids and the designs shall be thoroughly tested to ensure adequate sealing. The design shall provide resistance to vibration and acoustic noise and shall be validated by tests.

5.2.4 Flexible and semiflexible materials for manned aircraft interiors. The provisions of FAR 25.853, including Amendments 25–59 and 25–61, and other Federal Aviation regulations shall apply in the design and selection of aircraft cabin interiors. The primary purpose of FAA Amendment 25–61 is to ensure that aircraft cabin interior materials with large outer surface areas will not become involved rapidly and contribute to a fire when exposed to flames. See MIL–STD–1807 for background information for the design and selection of materials for aircraft cabin interiors to minimize fires and emission of smoke and toxic fumes. Certain components are exempt from the FAA Amendment 25–61 fire standards (i.e., internal structure of galleys and storage bins, lenses on signs and lights, window materials, door and window molding, seat trays, arm rests, etc.) and those components must pass the FAR 25.853 tests including the bunsen burner test, the flash resistance test and the ASTM E162 radiant panel test. Any material which is used on military aircraft cabin interior design which has not been certified by the FAA testing requirements shall be self extinguishing and meet the following requirements when tested in accordance with Method 5903 of Federal Test Standard 191.

After flame time (seconds, maximum)

Average for 5 specimens	–2
Single determination	–5

After glow time (seconds, maximum)

Average for 5 specimens	–5
Single determination	–10

Char length (inches, maximum)

Average for 5 specimens	–3.5
Single determination	–4.5

For upholstery fabric, only self–extinguishing materials shall be used which meet the flame resistance and smoke generation requirements of the respective material types as specified in AMS 3856. For carpeting, material used shall meet a maximum average of 75 when tested in accordance with ASTM E162. Any cabin furnishings, upholstery fabrics and carpeting materials used which contains wool must be properly treated with fire retardants. Polyvinyl chloride (vinyl or vinyon), modified aramid (durette), and phosphorous based fire retardant treated cotton, shall be prohibited due to the toxic hazard level of the thermal decomposition products. Polyvinyl chloride coated fabrics shall also be prohibited due to the toxic hazard level of the thermal decomposition products. Materials in fabric category for usage as curtains, coated fabrics, insulation covers, outermost seat coverings, headliners, nonwoven, and thermal barriers shall be self extinguishing and if not certified to FAA testing requirements shall meet the Federal Test Standard 191 testing requirement stated herein.

5.2.4.1 Aircraft seats. Materials used for USAF aircraft seats must pass the following test(s): outermost covering used to cover ejection seats shall be tested in accordance with Method 5903 (vertical burn test) of FED–STD–191 and shall meet the *after flame time, after glow time,* and *char length* requirements of paragraph 5.2.4 above. Nonejection crew and passenger seating must pass the flame impingement test prescribed in FAR Part 25, Amendment 25–59. Fire blocking layers between the outermost seat upholstery and cushions (seat back and bottom) may be required to meet FAR Part 25 requirements. The outermost seat covering for all USAF seats must pass their respective flame retardancy test requirements before and after 10 dry cleanings (Method 5509 of FED–STD–191) or launderings (Method 5518 of FED–STD–191). The result of test samples must be reported individually as well as average value.

5.2.5 Lubricants and working fluids. Lubricants include lubricating oils, greases, solid film lubricants, and antiseize compounds. Fluids include hydraulic fluids, coolants, and heat transfer fluids. The selection of fluids and lubricants shall be in accordance with MIL–STD–838. MIL–HDBK–275 may be used as a guide in the selection process. Lubricants or antiseize compounds containing graphite normally shall not be used. They are, however, particularly suitable for use on aircraft engine spark plugs and threaded fasteners and fittings where temperatures are expected to be above 410 °C (800 °F). They may safely be used in contact with corrosion resistant stainless steels, titanium, nickel, and cobalt alloys, and similar corrosion resistant metals and alloys. Graphite containing lubricants may promote corrosion of aluminum, ferrous, magnesium, zinc, or cadmium alloys or platings and thus should not be used in contact with these metals. Instead molybdenum disulfide based antiseize compounds such as MIL–T–83483 shall be used but only up to 410 °C (800 °F). Solid film lubricants shall not be employed on the internal surfaces of hydraulic or fuel systems. When polytetrafluoroethane (PTFE) and similar materials are used as a self–lubricating surface, such as on wing pivot fittings, bearing races, and other applications, the design shall be based on demonstrating suitable wear life in the presence of fluids typically used on the system. This applies if fluids are considered to be likely in contact with such wear surfaces. Lubricants containing sulfur shall not be used in contact with gold or silver.

5.2.6 Transparent materials. Transparent materials shall be selected and applied in accordance with AFSC DH 2–1, DN 3A1, and the optical requirements of AFSC DH 1–7. MIL–HDBK–17, Part II, should be used for guidance in selecting materials and designing transparencies (windshields, canopies, etc.). As a general guide for the critical area of a transparency, distortion criteria rate of change of deviation are as follows:

Optically Flat Units	1.0 minutes of arc per inch of windshield or window surface
Flat Units	2.5 minutes of arc per inch of windshield or window surface
Units having Curvature in One Plane	4.0 minutes of arc per inch of windshield or window surface
Compound Curved Units	5.0 minutes of arc per inch of windshield or window surface

Polycarbonate, in either monolithic or laminated construction, provides the highest degree of bird impact protection obtainable of any transparent material. However, both its interior and exterior surfaces must be protected against adverse chemical and abrasion environments. This can be accomplished by laminating a thin sheet of either as–cast acrylic or glass to the exterior polycarbonate surfaces by means of a compatible, nonplasticized interlayer material. Polyvinyl butyral (PVB) interlayer material must not be used with polycarbonate since the plasticizer will attack polycarbonate. There are no impermeable barrier coatings that will prevent this attack. The plasticizer (butyl sebacate) will, in time, migrate or permeate through such a coating. This permeation can be accelerated in the presence of ultraviolet radiation (sunlight) and moisture. This transparent abrasion resistant coating ("hard coating") should not be used to protect the exterior surface of aircraft transparency enclosures. They will either lose adhesion and peel or erode off in a short period of time when exposed to operational service environments. However, these coatings ("hard coats") can be used on the interior surface of such transparencies. Extreme care must be exercised when drilling edge attachment holes into a polycarbonate transparency. Guidance for drilling holes is found in MIL-HDBK-17, Part II. If appropriate hole drilling procedures are not used, the integrity of the transparency can be very seriously degraded. Crazes can easily be induced which will develop into cracks or upon bird impact, provide a site for crack propagation thus causing a brittle failure of the transparency.

5.2.7 Electrical insulation. Vinyl and polyvinylchloride, as insulation on wiring or as sleeving shall not be used because of their well known fungus nutrient characteristics and the dangers of outgassing during storage. These organics give off corrosive vapors which are active in attacking metals, plastics, elastomers, and insulation. Outgassing proceeds under normal room temperature conditions but is accelerated by high temperature or low pressure, and is most serious in closed containers. Satisfactory insulation includes polytetrafluorethylene, fluorinated ethylene propylene (FEP), Kel-F, polyimide (H-film), polyamide (nylon), polyurethane, polycarbonate, polyethylene, polyalkene, polyethylene terephthalate, polyolefin, polysulfone, and silicone sleeving in all grades. Where materials other than these are required, fungus resistant classes shall be specified and established by test per MIL-STD-810. Caution must be exercised in the use of PTFE covered silver plated copper wire because of possible corrosion at pin holes. Obtaining adhesion when potting or encapsulating PTFE insulated wire is difficult. Coated wire, both PTFE and FEP, may "cold flow" when installed under stress, against sharp edges, and in sharp bend configurations resulting in shorting failures. Polyimide insulation is considered to be the best for elevated temperature wire. Wiring installation procedures as described in MIL-W-5088 shall be used to ensure long term insulation performance.

5.2.8 Tape. Tapes shall be selected which are noncorrosive, do not outgas, do not absorb moisture nor support fungus, however, this type of insulation shall not be used in exterior areas.

5.2.9 Hygroscopic materials. Nonwicking, nonhygroscopic gaskets shall be used to prevent moisture intrusion. Felt, leather, cork, or glycol impregnated gaskets shall be avoided as well as cotton core material in electrical cables. Asbestos shall not be used. The outer edges of laminated assemblies shall be sealed to prevent moisture intrusion.

5.2.10 Water displacing compounds. Water displacing compounds may be used to coat metal surfaces against moisture, fingerprints, and corrosion. On plated surfaces of electrical devices including leads, contacts, and terminal posts, the soft film types of such compounds have been found to be effective protection against corrosion at pores or pinholes in the protective plating, a defect frequently found with standard commercial items. The water displacing compounds shall be in accordance with applicable military specifications. Other corrosion preventive compounds must be approved by the procuring activity.

5.2.11 Moisture and fungus resistance. Parts and equipment shall be designed so that the materials are not nutrients for fungi except when used in permanent hermetically sealed assemblies and other accepted and qualified parts such as treated transformers. Other necessary fungi nutrient material applications shall require treatment by a method which will render the resulting exposed surface fungi resistant. The criteria for the determination of fungi and moisture resistance shall be that contained in MIL-STD-810.

5.3 Processes. Processing specifications for forgings, castings, welding, inspections, etc., specified herein represent minimum standards of quality required for aerospace weapon systems. In most cases, parts procurement and manufacturing processes are controlled by contractor specifications. The use of these specifications is acceptable provided the minimum standard of quality and testing required by the appropriate military specification is achieved. The overall objective must be to establish those processes which provide repeatable quality and properties of material which was assumed in the design. This is a major element of the damage control plan required by MIL-STD-1530.

5.3.1 Forging practices. All structural forgings shall comply with the following requirements.

5.3.1.1 Forging design. Forgings shall be produced in accordance with MIL-F-7190 for steel, MIL-A-22771 or QQ-A-367 for aluminum, and MIL-F-83142 for titanium or industry and contractor specifications for alloys not covered by the above specification. The forging dimensional design must consider forging allowances such as parting line with regard to final machining such that short transverse grains (end grains) are minimized at the surface of the part. After the forging techniques (including degree of working) are established, the first production forging shall be sectioned and etched to show the grain flow pattern and to determine mechanical properties at critical design points. This sectioning will be repeated after any major change in the forging technique. The internal grain flow shall be such that the principle stresses are in the direction of flow as limited by forging techniques. The pattern shall be essentially free from re-entrant or sharply folded flow lines. All such information shall be retained by the contractor and made available to the procuring activity for review.

5.3.1.2 Forging surfaces. Machined surfaces of structural forgings in regions identified by analyses as fatigue critical or in regions of major attachment shall be shot peened or placed in compression by other suitable means. Those areas of forgings requiring lapped, honed, or polished surface finishes for functional purposes shall be shot peened prior to the surface finish operations. Surface finish, clean up of shot peened surfaces, shall not exceed 0.0076 cm (0.003 inches) of material removal for aluminum and 0.0038 cm (0.0015 inches) for steels.

5.3.2 Castings. Castings shall be classified and inspected in accordance with MIL-STD-2175. Structural castings shall be procured to guaranteed property, premium quality specifications such as MIL-A-21180, AMS 5343, or equivalent. Design criteria shall be governed by AFGS-87221.

5.3.3 Welding. For ground support equipment (GSE), welds shall be designed within the requirements of the appropriate GSE specification. Welding on GSE may be accomplished per the requirements of the AWS Structural Welding Code (D1.1 and D1.2). For critical flight hardware welded joints shall be designed within the allowables and guideline requirements of MIL-HDBK-5. Welds in parts subject to fatigue loading or high stresses shall be fully heat treated after welding where possible. Heated metal should be protected from contaminants whose presence would lead to defects or detrimental conditions not subsequently removable by chipless machining or polishing. This precaution is mandatory on air sensitive metals. The suitability of the equipment, processes, supplies, and supplementary treatment and procedures shall be demonstrated by mechanical tests of joints representative of production joints. Conformance with MIL-W-6858, MIL-W-6873, MIL-STD-2219, and AWS D1.1 (AWS Structural Welding Code) is required as applicable. Weld quality shall conform to a designated class of NAS 1514. Weld tests and operator qualification shall conform to MIL-STD-1595.

5.3.3.1 Weld repair. Weld repair is limited to the repair by welding of defects in a production fusion weld revealed by inspection and repair must be accomplished by approved procedures. This is an acceptable practice and does not violate good workmanship concepts. Weld repair does not include the correction of dimensional deficiencies by weld build-up or "buttering" except with design approval. Weld repair of castings is acceptable when permitted by the applicable materials or processing specification.

5.3.4 Brazing. Brazing shall be in accordance with MIL-B-7883. Subsequent fusion welding operations or other high temperature operations in the brazed area shall be avoided unless it can be shown that the brazed joint is not damaged. Brazed joints shall be designed for shear loading. Allowable shear strength and design limitations shall conform to those specified in MIL-HDBK-5. Tension loaded joints require the approval of procuring activity. Metals not covered by MIL-B-7883 shall not be brazed without prior approval of brazing process by the procuring activity.

5.3.5 Adhesive bonding. Adhesive bonding shall be in accordance with MIL-A-83377.

5.3.6 Soldering. Soldered electrical connections shall be in accordance with MIL-STD-2000.

5.3.7 Sandwich assemblies. Honeycomb or foam core sandwich assemblies shall be designed and fabricated to preclude the accumulation and entrapment of water or other contaminants within the core structure. Post assembly edge sealing shall be used in addition to design techniques to preclude liquid entry. Perforated metallic honeycomb core shall not be used. However, other cores that permit free liquid passage or drainage may be used. Aluminum honeycomb core shall be in accordance with MIL-C-7438 and shall be of the corrosion resistant type. For sandwich construction using plastic honeycomb core and facings, paragraphs 3.1.2, 3.1.3, 3.1.3.1, 3.3, 3.6.1, 4.3.3, and table I of MIL-S-9041 do not apply. MIL-S-25392 applies for construction using foamed-in-place core and uniform plastic facings. Plastic and foam core materials shall conform to MIL-C-8073 and MIL-C-8087. Design of structural sandwich assemblies shall be guided by MIL-HDBK-17, Vol I. The design shall be validated by tests typical of the use environment. They shall include vibration and acoustic testing. All sandwich panel components or assemblies shall be leak tested in accordance with MIL-A-83377. Other core materials or designs for which the above specification do not apply may be utilized provided that the contractor provides a suitable test program to substantiate its structural and environmental suitability for the system use intended.

5.3.8 Material inspection. As specified by the contract, aircraft materials and components shall be inspected during production of the system in accordance with MIL–I–6870. When MIL–I–6870 is not a contractual requirement, the contractor shall perform sufficient inspection during and after fabrication to assure that the system can perform its intended function for its intended life without structural failure.

6. NOTES

(This section contains information of a general or explanatory nature which may be helpful, but is not mandatory.)

6.1 Intended use. This standard is intended to provide Air Force Systems Program Offices with a procurement document that provides timely and comprehensive consideration during systems design of the limitations of materials and processes and of the lessons learned over the years from operational systems worldwide. The use of this document will result in more durable systems in operational service. It should be used in conjunction with MIL–STD–1568 in selection of materials and processes which will meet the requirements of the system being designed in accordance with MIL–STD–1530 and other integrity program documents.

6.2 Issue of DoDISS. When this standard is used in acquisition, the issue of the DoDISS to be applicable to this solicitation must be cited in this solicitation (see 2.1.1 and 2.2).

6.3 Data requirements. The following Data Item Descriptions (DIDs) must be listed, as applicable, on the Contract Data Requirements List (DD Form 1423) when this standard is applied on a contract, in order to obtain the data, except where DoD FAR Supplement 27.475–1 exempts the requirement for a DD Form 1423.

Paragraph #	Data Requirement Title	Applicable DID
4.5	Process Specification	DI–E–3130
5.2.1.4.2.1	Material Specification	DI–E–3131
5.2.1.4.2.2	Material Specification	DI–E–3131
5.2.1.4.2.3	Process Specification	DI–E–3130
5.2.1.4.2.4	Configuration Item Product	DI–E–3103A

The above DIDs were those cleared as of the date of this standard. The current issue of DoD 5010.12–L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DIDs are cited on the DD Form 1423.

6.4 Subject term (key word) listing.

Systems design
Lessons learned
Metals
Composites
Properties
Materials and processes
Material selection
Nonmetals
Aircraft

6.5 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodian:
Air Force – 11

Preparing activity:
Air Force – 11

Review activity:
Air Force – 14

(Project No. MFFP-A489)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

NOTE: This form may not be used to request copies of documents, not to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL–STD–1587C(USAF)	2. DOCUMENT DATE *(YYMMDD)* 920721

3. DOCUMENT TITLE

Materials and Process Requirements for Air Force Weapon Systems

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)* (1) Commercial (2) AUTOVON *(If applicable)*	7. DATE SUBMITTED *(YYMMDD)*

8. PREPARING ACTIVITY

A. NAME	B. TELEPHONE *(Include Area Code)*
AF Code 11	(1) Commercial (513) 255–6281 (2) AUTOVON *(If applicable)* DSN 785–6281
C. ADDRESS *(Include Zip Code)* ASC/ENES Wright–Patterson AFB OH 45433–6503	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church VA 22041-3466 Telephone (703) 756–2340 AUTOVON 289–2340