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MILITARY STANDARDIZATION HANDBOOK

A GUIDE TO THE SELECTION OF
RUBBER O-RINGS



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A Guide to the Selection of Rubber O-Rings

1. This handbook was developed by the Army Materials and Mechanics Research Center, in accordance with established procedures.

2. This publication was approved on 29 September 1983 for printing and inclusion in the military standardization handbook series.

3. This handbook provides information to aid in the selection of the proper military specification or nationally recognized industry and technical society publication on rubber O-rings, based on the environment(s) in which the O-ring is to be used. The handbook is not intended to be referenced in purchase specifications or other contractual documents nor shall it supersede any specification requirements.

4. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, US Army Materials and Mechanics Research Center, ATTN: DRXMR-SMS, Watertown, MA 02172, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

MIL-HDBK-692B

FOREWORD

Designers and engineers, faced with the task of specifying a suitable type of rubber O-ring for use in a specific application, are often hindered by a lack of information as to which types of rubber will function properly under a given set of environmental conditions. It is the purpose of this handbook to provide such information.

MIL-HDBK-692B

TABLE OF CONTENTS

		<u>Page</u>
	FOREWORD.....	ii
	REFERENCED DOCUMENTS.....	iv
SECTION 1.	SCOPE.....	1
1.1	Scope.....	1
2.	USE OF HANDBOOK.....	2
2.1	Selection table.....	2
2.1.1	Inactive specifications.....	2
2.2	Table objective.....	2
2.3	Example.....	2
3.	COMPATIBILITY OF ELASTOMERS IN SERVICE FLUIDS.....	3
3.1	Service fluids.....	3
4.	ADDITIONAL INFORMATION.....	4
4.1	Source of information.....	4
5.	METRIC EQUIVALENTS.....	5
	APPENDIX.....	6
	O-RING SELECTION TABLE.....	9

MIL-HDBK-692B

REFERENCED DOCUMENTS

The following documents of the issue in effect on the date of this handbook form a part of this handbook.

SPECIFICATIONS

FEDERAL

- TT-S-735 - Standard Test Fluids; Hydrocarbon
- ZZ-R-710 - Rubber Gasket Material, 35 Durometer Hardness
- ZZ-R-765 - Rubber, Silicone

MILITARY

- MIL-P-116 - Preservation, Methods of
- MIL-R-900 - Rubber Gasket Material, 45 Durometer Hardness
- MIL-R-2765 - Rubber Sheet, Strip, Extruded, and Molded Shapes, Synthetic, Oil Resistant
- MIL-R-3065 - Rubber, Fabricated Parts
- MIL-R-3533 - Rubber, Synthetic; Sheet, Strip and Molded
- MIL-P-4861 - Packing, Preformed, Rubber, Packing - Packaging of
- MIL-P-5315 - Packing, Preformed, Hydrocarbon Fuel Resistant
- MIL-P-5425 - Plastic, Sheet, Acrylic, Heat Resistant
- MIL-P-5510 - Packing, Preformed, Straight Thread Tube Fitting Boss, Type I Hydraulic (-65° - 160°F)
- MIL-P-5516 - Packings, Preformed, Petroleum Hydraulic Fluid Resistant, 160°F
- MIL-G-5572 - Gasoline, Aviation: Grades 80/87, 100/130, 115/145
- MIL-H-5606 - Hydraulic Fluid, Petroleum Base; Aircraft, Missile, and Ordnance
- MIL-T-5624 - Turbine Fuel, Aviation, Grades JP-4 and JP-5
- MIL-R-6855 - Rubber, Synthetic, Sheets, Strips, Molded or Extruded Shapes
- MIL-R-7362 - Rubber, Synthetic, Solid, Sheets, Strips and Fabricated Parts, Synthetic Oil Resistant
- MIL-E-9500 - Ethylene Glycol, Technical
- MIL-P-17553 - Packing, Preformed, O-Ring, Synthetic Rubber
- MIL-H-19457 - Hydraulic Fluid, Fire Resistant, Non-Neurotoxic
- MIL-G-21569 - Gasket, Cylinder, Liner Seal, Synthetic Rubber
- MIL-G-21610 - Gasket, Heat Exchanger, Various Cross Section Rings, Synthetic Rubber
- MIL-G-22050 - Gasket and Packing Material, Rubber, for Use with Polar Fluids, Steam, and Air at Moderately High Temperatures

MIL-HDBK-692B

MIL-M-23573	- Monoethanolamine Chelating Agent Solution
MIL-G-23652	- Gasket and Packing Material Petroleum and Phosphate Ester Fluid Resistant
MIL-G-23983	- Gasket and Packing Material, Oil Resistant Rubber, Access Hull Applications
MIL-P-25732	- Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Limited Service at 275°F (135°C)
MIL-R-25897	- Rubber, Fluorocarbon Elastomer, High-Temperature, Fluid Resistant
MIL-R-25988	- Rubber, Fluorosilicone Elastomer, Oil-and-Fuel-Resistant, Sheets, Strips, Molded Parts, and Extruded Shapes
MIL-P-26536	- Propellant, Hydrazine
MIL-R-83248	- Rubber, Fluorocarbon Elastomer, High Temperature, Fluid and Compression Set Resistant
MIL-H-83282	- Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, NATO Code Number H-537
MIL-R-83285	- Rubber, Ethylene-Propylene, General Purpose
MIL-R-83412	- Rubber, Ethylene-Propylene, Hydrazine Resistant
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-R-83485	- Rubber, Fluorocarbon Elastomer, Improved Performance at Low Temperatures
MIL-R-83485/1	- Rubber, Fluorocarbon Elastomer, Improved Performance at Low Temperature, Sizes and Tolerances
MIL-P-87175	- Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Phosphonitrilic Fluoroelastomer
MIL-P-87175/1	- Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Grade 70, Sizes and Tolerances
MIL-P-87175/2	- Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Grade 80, Sizes and Tolerances

STANDARDS

MILITARY

MIL-STD-129	- Marking for Shipment and Storage
MIL-STD-190	- Identification Marking of Rubber Products
MIL-STD-417	- Classification System and Tests for Solid Elastomeric Materials
MIL-STD-1523	- Age Control of Age Sensitive Elastomeric Material
MS 3393	- Packing, Preformed, Straight Thread Tube Fitting Boss, Hydraulic, Minus 65 Deg. F to Plus 275 Deg. F
MS 9020	- Packing, Preformed - AMS 7271, 'O' Ring
MS 9021	- Packing, Preformed - AMS 7271, 'O' Ring
MS 9068	- Packing, Preformed - AMS 3304, 'O' Ring
MS 9241	- Packing, Preformed - Rubber, AMS 7272, 'O' Ring
MS 9355	- Packing, Preformed - AMS 7272, 'O' Ring
MS 9385	- Packing, Preformed - AMS 7267, Seal
MS 9386	- Packing, Preformed - AMS 7267, O-Ring
MS 9387	- Packing, Preformed - Seal

MIL-HDEK-692B

MS 9966 - Packing, Preformed - AMS 7273, Seal
 MS 9967 - Packing, Preformed - AMS 7273, O-Ring
 MS 9970 - Packing, Preformed - AMS 7279 O-Ring
 MS 24690 - Packing, Preformed - High Pressure Air Valve
 MS 28775 - Packing, Preformed, Hydraulic, +275°F, ('O' Ring)
 MS 28778 - Packing, Preformed, Straight Thread Tube Fitting Boss
 MS 28900 - Packing, Preformed, for Electrical Use
 MS 29512 - Packing, Preformed, Hydrocarbon Fuel Resistant, Tube Fitting, 'O' Ring
 MS 29513 - Packing, Preformed, Hydrocarbon Fuel Resistant, O-Ring
 MS 29561 - Packing, Preformed, 'O' Ring, Synthetic Lubricant Resistant
 MS 33666 - Packing Preformed Aeronautical Elastomeric, Range of Sizes
 MS 90064 - Packing, Preformed, Round (For Use With Waveguide Flanges and Dummy Loads)

ARMY-NAVY AERONAUTICAL

AN 6227 - Packing - 'O' Ring Hydraulic
 AN 6230 - Gasket - 'O' Ring Hydraulic
 AN 123851 thru
 AN 123950 - Packing, Preformed - AMS 7274, 'O' Ring
 AN 123951 thru
 AN 124050 - Seal - 'O' Ring, AMS 7270

NON-GOVERNMENT PUBLICATIONS

SOCIETY OF AUTOMOTIVE ENGINEERS

AIR 786 - Elastomer Compatibility Considerations Relative to O-Ring and Sealant Selection
 AMS 2810 - Identification and Packaging Elastomeric Products
 AMS 2817 - Packaging and Identification, Preformed Packings
 AMS 3209 - Chloroprene Rubber - Weather Resistant, 65-75
 AMS 3210 - Chloroprene Rubber - Electrical Resistant, 65-75
 AMS 3226 - Nitrile Rubber - Hot Oil and Coolant Resistant - Low Swell, 45-55
 AMS 3237 - Butyl Rubber - Phosphate Ester Resistant, 35-45
 AMS 3238 - Butyl Rubber - Phosphate Ester Resistant, 65-75
 AMS 3239 - Butyl Rubber - Phosphate Ester Resistant, 85-95
 AMS 3243 - Chloroprene Rubber - Flame Resistant, 55-65
 AMS 3244 - Chloroprene Rubber - Flame Resistant, 65-75
 AMS 3248 - Synthetic Rubber-Phosphate Ester Resistant, Ethylene Propylene Type, 55-65
 AMS 3249 - Synthetic Rubber-Hydrazine-Base-Fluid Resistant, Ethylene Propylene Type, 75-85
 AMS 3304 - Silicone Rubber - General Purpose, 65-75
 AMS 3305 - Silicone Rubber - General Purpose, 75-85
 AMS 3348 - Silicone Rubber - 1150 psi, High Resiliency, 25-35
 AMS 3349 - Silicone Rubber - 1100 psi, High Resilience, 65-75
 AMS 3356 - Silicone Rubber - Lubricating Oil & Comp. Set Resistant, Elect. Grade, 55-65

MIL-HDBK-692B

- AMS 7260 - Rings, Packing-Nitrile Rubber, Fuel & Low Temp. Resistant, 70-80
- AMS 7261 - Rings, Sealing, Phosphonitrilic Fluoroelastomer, High-Temperature-Fluid Resistant, FZ Type
- AMS 7261/1 - Rings, Sealing, Phosphonitrilic Fluoroelastomer, High-Temperature-Fluid Resistant, 65-75, FZ Type
- AMS 7261/2 - Rings, Sealing, Phosphonitrilic Fluoroelastomer, High-Temperature-Fluid Resistant, 75-85, FZ Type
- AMS 7261/3 - Rings, Sealing, Phosphonitrilic Fluoroelastomer, High-Temperature-Fluid Resistant, 85-95, FZ Type
- AMS 7262 - Rings, Sealing, Ethylene Propylene Rubber, Phosphate Ester, Hydraulic Fluid Resistant, 85-95
- AMS 7266 - Rings, Sealing-Fluorosilicone Rubber, General Purpose, High Temperature, Fuel and Oil Resistant, 65-75
- AMS 7267 - Rings, Sealing-Silicone Rubber, Ht. Resistant, Low Compression Set, 70-80
- AMS 7268 - Rings, Sealing-Silicone Rubber, Low Compression Set, Non-Oil Resistant, 65-75
- AMS 7269 - Rings, Sealing, Silicone Rubber - Low Out-Gassing Space and Vacuum Service, 45 - 55
- AMS 7270 - Rings, Sealing-Nitrile Rubber, Fuel Resistant, 65-75
- AMS 7271 - Rings, Sealing-Nitrile Rubber, Fuel & Low Temp. Resistant, 60-70
- AMS 7272 - Rings, Sealing-Nitrile Rubber, Synthetic Lubricant Resistant, 65-75
- AMS 7273 - Rings, Sealing-Fluorosilicone Rubber, High Temperature Fuel and Oil Resistant, 70-80
- AMS 7274 - Rings, Sealing-Synthetic Rubber, Oil Resistant, 65-75
- AMS 7276 - Rings, Sealing, Fluorocarbon Rubber, High Temperature-Fluid Resistant, Very-Low Compression Set, FKM Type, 70-80
- AMS 7279 - Rings, Sealing - Fluorocarbon Rubber, High Temp. Fluid Resistant, 85-95
- AMS 7280 - Rings, Sealing - Fluorocarbon Rubber, High Temp. Fluid Resistant, Low Compression Set, FKM Type, 70-80
- AS 568A - Aerospace Size Standard for O-Rings
- J 120A - Recommended Practice for Rubber O-Rings for Automotive Seal and Packing Applications

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

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NATIONAL AEROSPACE STANDARD

NAS 617 - Packing, Preformed, Straight Thread Tube Fitting Boss, Synthetic
Lubricant Resistant

(Application of copies should be addressed to the National Standards
Association, Inc., 1321 Fourteenth Street, N. W., Washington, DC 20005.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM 13-413001-20 - Influence of Organic Liquids on Rubber Materials

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

MIL-HDBK-692B

SECTION 1. SCOPE

1.1 Scope. This handbook lists the currently available types of O-rings for which military or nationally recognized technical society specifications exist, and indicates the environments to which each type of O-ring is resistant. Plastic or metal O-rings, O-rings fabricated from rubber in combination with other materials, and ring shaped packings and gaskets with other than round cross sections are not included. Information relative to the effect of a particular fluid on various elastomers is not included in this handbook (see 3).

MIL-HDBK-692B

SECTION 2. USE OF HANDBOOK

2.1 Selection table. It is most important that users of this handbook understand the make-up of the selection table. The table is not intended to be a complete list of O-ring uses. The table is a compilation of the requirements cited by the referenced O-ring specifications. For example, for specification MIL-P-5315, the chart lists "-65 to +158" under "Air" and "+158" under "ASTM Reference Fuel B." These entries mean that Specification MIL-P-5315 contains tests and requirements for rubber O-rings at -65°F in air, at +158°F in air and at +158°F in Reference Fuel B. These table entries do not necessarily imply that MIL-P-5315 O-rings are unsuited for use at temperatures higher than 158°F in either air or fuel.

2.1.1 Inactive specifications. Specifications MIL-P-5516, MIL-R-25897, and MIL-STD-417 are inactive for new designs. They have been left in the table selection for reference purposes only. For new design consult Cancellation Notices of the applicable specification for replacement document.

2.2 Table objective. The fact that the selection table does not in all cases provide information concerning the maximum resistance of O-rings to various combinations of temperature and environment should not detract from its usefulness. The table can well serve to fulfill its prime objective, namely, to lead the designer or engineer from a particular group of desired properties to one or more O-ring specifications which cover these properties.

2.3 Example. The following example illustrates the method of selecting a specification under which O-rings, suitable for use in a particular application, may be procured.

- a. It is desired to obtain O-rings which can withstand exposure in air over the range -40 to +257°F and which are resistant to petroleum base oils over the same temperature range.
- b. The O-ring selection table lists five types of O-rings which meet the air service temperature requirement. (SAEJ120R Class 1, AMS 7270, AMS 7274, AMS 3226, and MIL-R-7362, Type 1).
- c. MIL-R-7362, Type 1 would not be selected because it contains no numerical values in the table under "Petroleum Base Oils", indicating no such test was performed. The superscript "a" in the table indicates the temperature, in degrees F, at which specification tests are performed.
- d. The selection of one of the four applicable specifications should be made on the basis of the other requirements contained in the specifications, as shown in the selection table. For example, if high tensile strength is desired, AMS 7270 or AMS 7274 should be chosen. If performance tests are required, SAEJ120R, Class 1 should be selected.

MIL-HDBK-692B

SECTION 3. COMPATIBILITY OF ELASTOMERS IN SERVICE FLUIDS

3.1 Service fluids. Military usage of fluids is so wide and varied that it is beyond the scope of this handbook to include usage data. However, two excellent sources of information on the compatibility of elastomers in various fluids can be found in Aerospace Information Report (AIR 786) and American Society for Testing and Materials Handbook (ASTM 13-413001-20).

MIL-HDBK-692B

SECTION 4. ADDITIONAL INFORMATION

4.1 Source of information. For those cases where more information is desired than is furnished in the selection table, the user is encouraged to contact Committee G-4 on Elastic Seals of the Society of Automotive Engineers or the O-ring Division of the Rubber Manufacturers Association. Additional sources of information are provided in the Appendix to this handbook.

MIL-HDBK-692B

SECTION 5. METRIC EQUIVALENTS.

$$\text{Degree Celsius (C}^\circ\text{)} = \frac{\text{degree F}-32}{1.8}$$

$$1 \text{ pound per square inch (psi)} = 6.894 \text{ Kilo pascal (KPa)}$$

Custodian:

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Preparing activity:

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User Activities:

Army - MD, ME

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MIL-HDBK-692B

APPENDIX

Additional Sources of Information
on O-Rings

Availability

Department of the Army Supply Manual
SM 9-C5330-SL, Volumes 1-A through 1-I
(Descriptions are provided for the more
than 10,000 rubber O-rings stocked by
the Department of Defense).

Cost

Department of the Army Supply Manual
SM 9-C5330-SL, Vol. 2.

Design and Material Selection

- MIL-H-5440, "Hydraulic Systems, Aircraft Types I and II, Design and Installation, Requirements For."
- MIL-F-5509, "Fittings, Flared Tube, Fluid Connection."
- MIL-P-5514, "Gland Design; Packings, Hydraulic, General Requirements For."
- MIL-P-5518, "Pneumatic Systems, Aircraft; Design, Installation, and Data Requirements For."
- MIL-HDBK-149, "Rubber and Rubber-Like Materials."
- MIL-HDBK-212, "Gasket Materials (Nonmetallic)."
- NAVSHIPS 93793, "O-Ring Seals For Submarine Antenna Systems Applications."
- Machine Design, published by the Penton Publishing Company, "The Seals Book".
- SAE AIR 786, "Elastomer Compatibility Considerations Relative to "O" Ring and Sealant Selection."
- SAE AIR 851A, "O-Ring Tension Testing Calculations."
- SAE AIR 1707, "Patterns of O-Ring Failure."
- SAE ARP 979, "Backup Rings and Special Sealing Devices, Performance Qualification Testing for."
- SAE ARP 1231, "Gland Design, Elastomeric O-Ring Seals, General Consideration."
- SAE ARP 1232, "Gland Design, Elastomeric O-Ring Seals, Static Radial."

MIL-HDBK-692B

ASD Technical Report 61-234, "Handbook of Design Data of an Elastomeric Material Used in Aerospace systems."

"Seals", Lubrication, Vol. XLIX, No. 8, published by Texaco, Inc.

"The Seals Book", Machine Design, published by the Penton Publishing Company.

WADC Technical Report 59-786, "Design Data For O-Rings and Similar Elastic Seals."

Inspection

MIL-STD-413, "Visual Inspection Guide For Elastomeric O-Rings."

SAE AS 708, "O-Ring Packings and Gaskets, Top Quality Visual (TVQ) - Surface Inspection Guide and Acceptance Standards" (Inactive for new Design).

SAE AS 871A, "Manufacturing and Inspection Standards For Preformed Packings (O-Rings)."

RMA, "O-Ring Inspection Guide, Surface Imperfection Control" -1974 Ed. Rubber Manufacturers Assn., 1901 Pennsylvania Ave. N. W., Washington, DC 20006¹/₂.

Pneumatic Applications

SAE ARP 820, "O-Ring Packings, 3000 psi Hydraulic Service, Physical and Performance Tests for Type II (-65 to +275° F)."

Size

SAE AS 568A, "Aerospace Size Standard for O-Rings."

Storage Life

MIL-HDBK-695, "Rubber Products, Shelf Storage Life."

Air Force Technical Manual T.O. 00-20-K-7, 15 March 1974, "Inspection and Age Control."

Air Force Technical Manual AFML-TR-67-235, "Literature Survey on the Effects of Long Term Shelf Aging of Elastomeric Materials."

MIL-HDBK-692B

The American Society of Mechanical Engineers, Paper Number 61-AV26,
"Missile System Elastomers - Predicting Field Life Expectancies."

Army Ballistic Missile Agency Standard 29, "Rubber Synthetic and Related
Items, Age Control of."

Department of the Army Supply Bulletin SB5-60, "Deteriorating Items."

National Aeronautics and Space Administration, MSFC-STD-105, "Synthetic
Rubber, Age Control of."

1/Reference may be made to handbooks supplied by members of the Rubber
Manufacturers Association, O-Ring Division.

MIL-HDBK-692B

O-RING SELECTION GUIDE

[illegible]

a. The ambient values to the tests are the temperatures at which the qualification tests are performed
b. DA R - Grain Size
c. Values "as determined" at the O-rings were submitted for qualification approval
d. Specification is inclusive for new design. Consult Generation notes 1 for replacement materials

*AS 355 is listed only as a recommended chemical reagent. Its use is not required by any of the specifications.
 †This is the maximum burner test (ASTM D355-6). The actual test temperature is not known.

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL*(See Instructions - Reverse Side)*

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