NOT MEASUREMENT SENSITIVE

MIL-STD-1587D
21 June 2017
SUPERSEDING
MIL-HDBK-1587(USAF)
18 July 1996
MIL-STD-1587C(USAF)
21 July 1992

DEPARTMENT OF DEFENSE

DESIGN CRITERIA STANDARD

MATERIAL AND PROCESS REQUIREMENTS FOR AEROSPACE WEAPONS SYSTEMS

Reinstated after 21 June 2017 and may be used for new and existing designs and acquisitions.

AMSC 9823 AREA MFFP

FOREWORD

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

2. The purpose of this standard is to establish requirements for aerospace weapons systems.

3. Comments, suggestions, or questions on this document should be addressed to: Commander, Naval Air Warfare Center Aircraft Division Lakehurst, Route 547, Mail Stop 120-3, Joint Base MDL, NJ 08733-5100, or emailed to michael.sikora@navy.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil.

4. For guidance on the technical content of this document, contact the Commander, Naval Air Warfare Center, Aircraft Division (Code 4.3), 48066 Shaw Road, 2188 Patuxent River, MD 20670.

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TABLES

1. SCOPE

1.1 Scope. This standard establishes the requirements for materials and processes used during design and production of aerospace weapons systems. When used in conjunction with MIL-STD-1530, the other integrity program documents (MIL-STD-1798, MIL-HDBK-1783, 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. Authority to exceed or amend the requirements in this standard requires permission from the cognizant engineering authority (CEA) of the procuring activity.

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

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

FEDERAL STANDARD

FED-STD-191	-	Textile Test Methods

COMMERCIAL ITEM DESCRIPTIONS

A-A-59588	-	Rubber, Silicone
A-A-59877	-	Insulating Compound, Electrical, Embedding

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-6855	-	Rubber, Synthetic, Sheets, Strips, Molded or Extruded Shapes, General Specification for
MIL-PRF-8516	-	Sealing Compound, Synthetic Rubber, Electric Connectors and Electric Systems, Chemically Cured

MIL-S-9041	-	Sandwich Construction; Plastic Resin, Glass Fabric Base, Laminated Facings and Honeycomb Core for Aircraft Structural and Electronic Applications
MIL-PRF-23586	-	Sealing Compound, (With Accelerator), Silicone Rubber, Electrical
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 ºF (132 ºC)
MIL-DTL-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-A-46106	-	Adhesive-Sealants, Silicone, RTV, One Component
MIL-A-46146	-	Adhesives-Sealants, Silicone, RTV, Noncorrosive (for Use With Sensitive Metals and Equipment)
MIL-T-81556	-	Titanium and Titanium Alloys, Extruded Bars and Shapes, Aircraft Quality
MIL-DTL-83397	-	Rubber, Polyurethane, Castable, Humidity Resistant
MIL-PRF-83483	-	Antiseize Thread Compound, Molybdenum Disulfide-Petrolatum

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-129	-	Military Marking for Shipment and Storage
MIL-STD-810	-	Environmental Engineering Considerations and Laboratory Tests
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-1530	-	Aircraft Structural Integrity Program, (ASIP)
MIL-STD-1568	-	Materials and Processes for Corrosion Prevention and Control in Aerospace Weapons Systems
MIL-STD-1798	-	Mechanical Equipment and Subsystems Integrity Program

DEPARTMENT OF DEFENSE HANDBOOKS

MIL-HDBK-275	-	Guide for Selection of Lubricant Fluids and Compounds for Use in Flight Vehicles and Components
MIL-HDBK-838	-	Lubrication of Military Equipment
MIL-HDBK-1783	-	Engine Structural Integrity Program (ENSIP)
MIL-HDBK-6870	-	Nondestructive Inspection Program Requirements For Aircraft And Missile Materials And Parts
MIL-HDBK-83377	-	Adhesive Bonding (Structural) For Aerospace And Other Systems, Requirements For

JOINT SERVICE SPECIFICATION GUIDES

JSSG-2006	-	Aircraft Structures, General Specification
JSSG-2010	-	Crew Systems

(Copies of these documents are available online at http://quicksearch.dla.mil.)

2.2.2 Other Government documents and publications. The following other Government documents and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

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 these documents are available by email at engineering.standards@us.af.mil.)

AIR FORCE RESEARCH LABORATORY (AFRL)

Advanced Composite Repair Guide, AFWAL-TR-83-3092
Damage Tolerant Design Handbook, MCIC-HB-01
DOD/NASA Structural Composites Fabrication Guide, Vol I
DOD/NASA Structural Composites Fabrication Guide, Vol II
DOD/NASA Advanced Composites Design Guide, Vol I - Vol IV

(Copies of these documents are available online at https://www.dtic.mil.)

DEPARTMENT OF TRANSPORTATION

DOT/FAA/AR-MMPDS-	Metallic Materials Properties Development and Standardization

(Copies of the current edition of MMPDS may be obtained in several forms, as described in www.mmpds.org or by e-mail at bcommpds@battelle.org.)

FEDERAL AVIATION REGULATION (FAR)

FAR 25.853	-	Compartment Interiors Amendment 25-59 Appendix F, Part II, Flammability of Seat Cushions

(Copies of these documents are available online at http://www.faa.gov/.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

AMERICAN WELDING SOCIETY (AWS)

AWS C3.4M/C3.4	-	Specification for Torch Brazing
AWS C3.5M/C3.5	-	Specification for Induction Brazing
AWS C3.6M/C3.6	-	Specification for Furnace Brazing
AWS C3.7M/C3.7	-	Specification for Aluminum Brazing
AWS D1.1/D1.1M	-	Structural Welding Code Steel
AWS D1.2/D1.2M	-	Structural Welding Code Aluminum
AWS D17.1/D17.1M	-	Specification for Fusion Welding for Aerospace Applications
AWS D17.2/D17.2M	-	Specification for Resistance Welding for Aerospace Applications

(Copies of these documents are available online at http://www.aws.org.)

ASTM INTERNATIONAL

ASTM B265	-	Standard Specification for Titanium and Titanium Alloy Strip, Sheet, and Plate
ASTM E162	-	Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source

(Copies of these documents are available online at http://www.astm.org.)

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 15614-13	-	Specification and Qualification of Welding Procedures For Metallic Materials – Welding Procedure Test – Part 13: Upset (Resistance Butt) and Flash Welding

(Copies of this document are available online at http://www.iso.org.)

NATIONAL AEROSPACE STANDARD (NAS)

NAS 1514	-	Radiographic Standard for Classification of Fusion Weld Discontinuities

(Copies of this document are available online at http://www.aia-aerospace.org/standards.)

SAE INTERNATIONAL

SAE AMS2175	-	Castings, Classification and Inspection of
SAE AMS2300	-	Steel Cleanliness, Premium Aircraft-Quality, Magnetic Particle Inspection Procedure
SAE AMS2301	-	Steel Cleanliness, Aircraft Quality, Magnetic Particle Inspection Procedure
SAE AMS2303	-	Steel Cleanliness, Aircraft-Quality, Martenistic Corrosion-Resistant Steels Magnetic Particle Inspection Procedure
SAE AMS2430	-	Shot Peening Automatic
SAE AMS2750	-	Pyrometry
SAE AMS2759	-	Heat Treatment Steel Parts General Requirements
SAE AMS2770	-	Heat Treatment of Wrought Aluminum Alloy Parts
SAE AMS2771		Heat Treatment of Aluminum Alloy Castings
SAE AMS2772		Heat Treatment of Aluminum Alloy Raw Materials
SAE AMS3100	-	Adhesion Promoter for Polysulfide Sealing Compounds
SAE AMS3216	-	Fluorocarbon (FKM) Rubber High-Temperature - Fluid Resistant Low Compression Set 70 to 80
SAE AMS3218	-	Fluorocarbon (FKM) Rubber High-Temperature-Fluid Resistant Low Compression Set 85 to 95
SAE AMS3384	-	Rubber, Fluorocarbon Elastomer (FKM) 70 to 80 Hardness, Low Temperature Sealing Tg -22 °F (-30 °C) For Elastomeric Shapes or Parts in Gas Turbine Engine Oil, Fuel and Hydraulic Systems
SAE AMS3856	-	Cloth, Upholstery, Flame Resistant, Novoloid/Aramid, Waffle Type Weave
SAE AMS4900	-	Titanium Sheet, Strip, and Plate Commercially Pure Annealed, 55 ksi (379 MPa) Yield Strength - UNS R50550
SAE AMS4901	-	Titanium Sheet, Strip, and Plate Commercially Pure Annealed, 70.0 ksi (485 MPa) - UNS R50700
SAE AMS4902	-	Titanium Sheet, Strip, and Plate Commercially-Pure Annealed 40.0 ksi (276 MPa) Yield Strength - UNS R50400
SAE AMS4903	-	Titanium Alloy Sheet, Strip, and Plate 6Al - 4V Solution Heat Treated - UNS R56400
SAE AMS4904	-	Titanium Alloy Sheet, Strip, and Plate 6Al - 4V Solution Heat Treated and Aged - UNS R56400
SAE AMS4907	-	Titanium Alloy, Sheet, Strip, and Plate 6.0Al - 4.0V, Extra Low Interstitial Annealed - UNS R56401
SAE AMS4909	-	Titanium Alloy, Sheet, Strip, and Plate 5Al - 2.5Sn, Extra Low Interstitial Annealed - UNS R54521

SAE AMS4910	-	Titanium Alloy, Sheet, Strip, and Plate 5Al - 2.5Sn Annealed - UNS R54520
SAE AMS4911	-	Titanium Alloy, Sheet, Strip, and Plate 6Al - 4V Annealed - UNS R56400
SAE AMS4915	-	Titanium Alloy Sheet, Strip, and Plate 8Al - 1V - 1Mo Single Annealed - UNS R54810
SAE AMS4916	-	Titanium Alloy Sheet, Strip, and Plate 8Al - 1Mo - 1V Duplex Annealed - UNS R54810
SAE AMS4917	-	Titanium Alloy Sheet, Strip, and Plate 13.5V - 11Cr - 3.0Al Solution Heat Treated - UNS R58010
SAE AMS4918	-	Titanium Alloy, Sheet, Strip, and Plate 6AI - 6V - 2Sn Annealed - UNS R56620
SAE AMS4919	-	Titanium Alloy Sheet, Strip, and Plate 6AI - 2Sn - 4Zr - 2Mo - 0.08Si Duplex Annealed - UNS R54620
SAE AMS4921	-	Titanium Bars, Wire, Forgings, and Rings Commercially Pure 70 ksi (483 MPa) Yield Strength - UNS R50700
SAE AMS4939	-	Titanium Alloy Sheet, Strip, and Plate 3Al - 8V - 6Cr - 4Mo - 4Zr Solution Heat Treated - UNS R58640
SAE AMS4940	-	Titanium Sheet, Strip, and Plate Commercially Pure Annealed, 25.0 ksi (172 MPa) Yield Strength - UNS R50250
SAE AMS4970	-	Titanium Alloy Bars, Wire, and Forgings 7Al - 4Mo Solution and Precipitation Heat Treated - UNS R56740
SAE AMS4988	-	Titanium Alloy Sheet, Strip, and Plate 6Al - 6V - 2Sn Solution Heat Treated - UNS R56620
SAE AMS4989	-	Titanium Alloy Sheet, Strip, and Plate 3Al - 2.5V Annealed - UNS R56320
SAE AMS4990	-	Titanium Alloy Sheet, Strip, and Plate 6Al - 6V - 2Sn Solution Heat Treated and Aged - UNS R56620
SAE AMS5343	-	Steel, Corrosion Resistant, Investment Castings, 16CR - 4.1Ni - 0.28Cb(Nb) - 3.2 Cu, Homogenization, Solution, and Precipitation Heat Treated (H1000), 150 Ksi (1034 MPa) Tensile Strength 17-4
SAE AMS6900	-	Titanium Alloy Bars, Forgings and Forging Stock 5Al - 2.5Sn Annealed - UNS R54520
SAE AMS6901	-	Titanium Alloy Bars, Forgings, and Forging Stock 5Al - 2.5Sn, Extra Low Interstitial Annealed - UNS R54521
SAE AMS6905	-	Titanium Alloy Bars, Forgings and Forging Stock 6.0Al - 2.0Sn - 4.0Zr - 2.0Mo Duplex Annealed - UNS R54620
SAE AMS6906	-	Titanium Alloy Bars, Forgings, and Forging Stock 6.0Al - 2.0Sn - 4.0Zr - 6.0Mo Solution Heat Treated and Aged - UNS R56260
SAE AMS6907	-	Titanium Alloy Bars, Forgings and Forging Stock 6.0Al - 2.0Sn - 4.0Zr - 6.0Mo Duplex Annealed - UNS R56260
SAE AMS6910	-	Titanium Alloy Bars, Forgings and Forging Stock 8Al - 1Mo - 1V Duplex Annealed - UNS R54810

SAE AMS6915	-	Titanium Alloy Bars, Forgings and Forging Stock 7.0Al - 4.0Mo Annealed - UNS R56740
SAE AMS6920	-	Titanium Alloy Bars, Forgings and Forging Stock 3Al - 8V - 6Cr - 4Mo - 4Zr Solution Heat Treated - UNS R58640
SAE AMS6921	-	Titanium Alloy Bars, Forgings and Forging Stock 3Al - 8V - 6Cr - 4Mo - 4Zr Solution Heat Treated and Aged - UNS R58640
SAE AMS6925	-	Titanium Alloy Bars, Forgings and Forging Stock 13V - 11Cr - 3Al Solution Heat Treated - UNS R58010
SAE AMS6926	-	Titanium Alloy Bars, Forgings and Forging Stock 13V - 11Cr - 3Al Solution Heat Treated and Aged - UNS R58010
SAE AMS6930	-	Titanium Alloy Bars, Forgings and Forging Stock 6.0Al - 4.0V Solution Heat Treated and Aged - UNS R56400
SAE AMS6931	-	Titanium Alloy Bars, Forgings and Forging Stock 6.0Al - 4.0V Annealed - UNS R56400
SAE AMS6932	-	Titanium Alloy Bars, Forgings and Forging Stock 6.0Al – 4.0V Extra Low Interstitial Annealed - UNS R56401
SAE AMS6935	-	Titanium Alloy Bars, Forgings and Forging Stock 6.0Al – 6.0V – 2.0Sn Solution Heat Treated and Aged - UNS R56620
SAE AMS6936	-	Titanium Alloy Bars, Forgings and Forging Stock 6Al - 6V - 2Sn Annealed - UNS R56620
SAE AMS6940	-	Titanium Alloy Bars, Forgings and Forging Stock 3.0Al - 2.5V Annealed - UNS R56320
SAE AMS7259	-	Rubber: Fluorocarbon (FKM) High Temperature/Fluid Resistant, Low Compression Set / 85 to 95 Hardness, For Seals in Fuel Systems and Specific Engine Oil Systems
SAE AMS7276	-	Rubber: Fluorocarbon (FKM), High-Temperature-Fluid Resistant, Low Compression Set, For Seals In Fuel Systems and Specific Engine Oil Systems
SAE AMS7287	-	Fluorocarbon Elastomer (FKM) High Temperature / HTS Oil Resistant / Fuel Resistant, Low Compression Set / 70 to 80 Hardness, Low Temperature Tg -22 °F (-30 °C) For Seals in Oil / Fuel / Specific Hydraulic Systems
SAE AMS-A-21180	-	Aluminum-Alloy Castings, High Strength
SAE AMS-A-22771	-	Aluminum Alloy Forgings, Heat Treated
SAE AMS-C-7438	-	Core Material, Aluminum, for Sandwich Construction
SAE AMS-C-8073	-	Core Material, Plastic Honeycomb, Laminated Glass Fabric Base, for Aircraft Structural and Electronic Applications
SAE AMS-C-27725	-	Coating, Corrosion Preventative, for Aircraft Integral Fuel Tanks for Use to 250 °F (121 °C)
SAE AMS-F-7190	-	Forging, Steel, For Aircraft/Aerospace Equipment and Special Ordnance Applications
SAE AMS-H-81200	-	Heat Treatment of Titanium and Titanium Alloys
SAE AMS-P-5315	-	Acrylonitrile - Butadiene - (NBR) Rubber for Fuel-Resistant Seals 60 to 70
SAE AMS-P-5510	-	O-Ring, Preformed, Straight Thread Tube Fitting Boss,

		Type I Hydraulic (-65° to 160°F)
SAE AMS-P-83461	-	Packing, Preformed, Petroleum Hydraulic Fluid Resistant, Improved Performance at 275 Degrees F (135 Degrees C)
SAE AMS-QQ-A-367	-	Aluminum Alloy Forgings
SAE AMS-R-7362	-	Nitrile Rubber, Synthetic, Solid, Sheet, Strip and Fabricated Parts, Synthetic Oil Resistant
SAE AMS-R-83285	-	Rubber, Ethylene-Propylene, General Purpose -
SAE AMS-S-8802	-	Sealing Compound, Fuel Resistant, Integral Fuel Tanks and Fuel Cell Cavities
SAE ARP5316	-	Storage of Elastomer Seals and Seal Assemblies Which Include an Elastomer Element Prior to Hardware Assembly
SAE AS568	-	Aerospace Size Standard for O-Rings
SAE AS1933	-	Age Controls for Hose Containing Age-Sensitive Elastomeric Material
SAE AS3208	-	Packing, Preformed - AMS 7276 - Seal
SAE AS3209	-	Packing, Preformed - AMS 7276, 'O' Ring
SAE AS3581	-	Packing, Preformed - O-Ring Seal AMS 7259
SAE AS28775	-	Packing, Preformed - MS28775 O-Ring
SAE AS28778	-	O-Ring, Straight Thread Tube Fitting Boss, Molded From AMS-P-5510 Rubber
SAE AS29512	-	Hydrocarbon Fuel Resistant, Tube Fitting, O-Ring, Molded From AMS-P-5315 Rubber
SAE AS29513	-	Packing, Preformed, Hydrocarbon Fuel Resistant O-Ring
SAE AS29561	-	O-Ring, Synthetic Lubricant Resistant, Molded From AMS-R-7362 Rubber
SAE AS50881	-	Wiring Aerospace Vehicle
SAE AS81550	-	Insulating Compound, Electrical, Embedding, Reversion Resistant Silicone
SAE AS83461/1	-	M83461 O-Ring Molded From AMS-P-83461 Rubber
SAE AS83461/2	-	Straight Thread Tube Fitting Boss O-Ring Molded From AMS-P-83461 Rubber
SAE CMH-17-1G	-	Polymer Matrix Composites, Guide for Characterization of Structural Materials
SAE CMH-17-2G	-	Polymer Matrix Composites, Materials Properties
SAE CMH-17-3G	-	Polymer Matrix Composites, Materials, Usage, Design and Analysis

(Copies of these documents are available online at http://www.sae.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

3.1 Definitions. Definitions are in accordance with the documents listed in section 2.

4. GENERAL REQUIREMENTS

4.1 Material selection. The selection of materials and processes shall be the result of design studies for each system. The studies shall include all the relevant parameters specified by the contract, such as operational environments, performance, manufacturing capabilities, safety of flight structure, life cycle costs, and reliability and maintainability requirements. The studies shall determine the acceptable initial flaw types and size, defects, and tolerances associated with the manufacturing processes, fabrication, and assembly. The initial manufactured quality of the design shall meet the fatigue, rigidity, strength, durability, 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 DOT/FAA/AR-MMPDS 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 Department of Defense (DoD) weapons systems. Any use of these materials requires specific approval from the cognizant engineering authority of the procuring activity.

4.3 Material properties/fracture mechanics. Fracture mechanics analysis shall be in accordance with MIL-STD-1530 and MIL-STD-1798. Fracture mechanics analysis should also be in accordance with MIL-HDBK-1783. MCIC-HB-01 shall be used to establish material properties when conducting fracture mechanics analysis.

4.4 Disclosure of materials. Proposed materials and processes shall be selected from existing DoD or non-Government standards body (AMS, etc.) specifications. Selected materials and processes shall have been approved under the technical proposal (see 6.4). A technical proposal shall contain:

a. Information identifying operating environment and loading conditions.
b. List of materials and processes.
c. Rationale and materials process selection

4.5 Contractor-prepared specifications. If a material or process not covered by an existing military or non-Government standards body (AMS, etc.) specification is to be used, a specification containing rationale and tests to be performed shall be prepared in accordance with DI-MFFP-82119 for the procuring agency's engineering authority approval (see 5.2.1.4.2 and 6.3).

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 1/	
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

1/ Shall 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 thickness. The minimum thickness of material permissible for structural applications (except sandwich constructions) 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 AFSC 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 alloy, raw materials, parts, and castings shall be in accordance with SAE AMS770, SAE AMS2771, SAE AMS2772. In all cases, maximum thickness for heat treatment shall be controlled to ensure that the 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 that do not result in detrimental residual stresses or losses in mechanical properties or lead to stress corrosion sensitivity of structurally critical parts, as defined by the cognizant engineering authority, or lead to stress corrosion sensitivity of the part. Shot peen forming is permissible. Adequate controls shall be maintained to ensure 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 SAE AMS2300 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 SAE AMS2301 cleanliness requirements. Ferromagnetic corrosion resistant steels shall meet SAE AMS2303 cleanliness requirements. Compositions shall be selected which have ductile to brittle temperature measured by impact that are below any temperature that the part will experience in service.

5.1.3.1 Heat treatment. Heat treatment shall be accomplished in accordance with SAE AMS2759 or methods recognized therein. The equipment and controls shall comply with SAE AMS2750. 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 SAE AMS2430 all parts that 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 centimeter (0.0015 inch) based on pre-shot peened dimensions shall be permissible.

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

5.1.3.4 Forming or straightening of steel parts. All precautions shall be taken to minimize warping during heat treatment of steel parts. Non-destructive inspections (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 (1370 MPa) UTS shall be hot formed or straightened within a temperature range from the tempering temperature to 28 ºC (50 ºF) below the tempering temperature.

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	9N1-4Co 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 shall be approved by the procuring agency.

5.1.3.5 Decarburization. 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 inch) 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, as approved by the engineering authority.

5.1.3.6 Carburization. Minimum carburization of fully hardened steel parts shall be a prime objective. Furnace atmospheres shall not increase the carbon content of surface zones above the maximum for the respective composition. 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. 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 a carbide reamers having a sufficient number of flutes to avoid chattering. The documents controlling such techniques shall specify a final sizing pass with minimal radial loads, speed and feed rates, coolant flow rates, tool life limits, inspection techniques, and other requirements necessary to ensure the production of holes of high quality, smooth bore surfaces, and free from “hard spots” and microcracks. Tooling and processes used shall be approved by the procuring activity’s engineering authority. 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 that 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. Carbine 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 not be used unless approved by the procuring activity’s engineering authority. 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 ºC (1000 ºF). Exception is made for castings which may be aged at 501.5 ±9.4 ºC (935 ±15 ºF), for fasteners that may be used in the H950 condition, and for springs that have optimum properties at the CH 900 condition. H950 shall not be used for 17-4 PH or 15-5 PH alloys.

5.1.4 Titanium.

5.1.4.1 Forgings. All titanium bar and forging stock, as applicable, shall be in accordance, with SAE AMS4921, SAE AMS4970, SAE AMS6900, SAE AMS6901, SAE AMS6905, SAE AMS6906, SAE AMS6907, SAE AMS6910, SAE AMS6915, SAE AMS6920, SAE AMS6921, SAE AMS6925, SAE AMS6926, SAE AMS6930, SAE AMS6931, SAE AMS6932, SAE AMS6935, SAE AMS6936, SAE AMS6940 and shall meet 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, as applicable, shall be in accordance, with ASTM B265, SAE AMS4900, SAE AMS4901, SAE AMS4902, SAE AMS4903, SAE AMS4904, SAE AMS4907, SAE AMS4909, SAE AMS4910, SAE AMS4911, SAE AMS4915, SAE AMS4916, SAE AMS4917, SAE AMS4918, SAE AMS4919, SAE AMS4939, SAE AMS4940, SAE AMS4988, SAE AMS4989, SAE AMS4990 and shall provide the quality, properties and processing to meet its intended use.

5.1.4.3 Extrusions. All titanium extruded bars, rods, or special shaped sections shall be in accordance with MIL-T-81556 and shall meet the metallurgical and structural properties required to support reliability and durability requirements of the weapon system.

5.1.4.4 Heat treatment. Heat treatment of titanium shall be in accordance with SAE AMS-H-81200.

5.1.5 Beryllium. All beryllium and beryllium containing alloys shall be used in accordance with MIL-STD-1568. 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 shall be demonstrated using preproduction tests under simulated service loading conditions and environments. Load paths shall 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 shall be considered during fabrication, assembly, and in service usage and maintenance of beryllium parts.

5.1.6 Other metals. Magnesium alloys shall not be used in accordance with MIL-STD-1568. Nickel base alloys and copper base alloys may be used. Other commonly used metals may be used if approved by the procuring activity. Where design trade studies show the desirability for the use of less common metals other than those discussed herein procuring activity's engineering authority approval for use shall be obtained (see 6.5).

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 it is proposed to use materials or processes for which only a limited amount of data or experience is available approval for use shall be obtained from the procuring activity's engineering authority (see 6.6).

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 shall 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 ºC (250 ºF), 176 ºC (350 ºF), 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 SAE CMH-17-1G and SAE CMH-17-3G.

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 SAE CMH-17-1G and SAE CMH-17-3G.

5.2.1.4.1 Material property design allowables. The material property design allowables, as necessary, according to a material characterization and design allowable substantiation plan shall be developed. This plan shall be subject to review and approval by the procuring activity's engineering authority. 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 same 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 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. shall be evaluated. During production, material properties shall be verified periodically by testing of materials processed during a production run. The effects upon the design allowables of impact damage and repairs shall be evaluated. Some material property design allowable can be obtained from SAE CMH-17-2G.

5.2.1.4.2 Specifications. Specifications for the material and processes to be employed are required.

5.2.1.4.2.1 Material specification. A material specification shall be established in accordance with DI-MFFP-82119 (see 6.3). The material specification shall contain requirements and criteria (typically by mechanical, chemical or thermal analysis) required for approval of materials supplied by material vendors to be used in a particular aerospace application. The specification as a minimum 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, the range of test results that are needed for the incoming material to be acceptable for manufacturing, and conformance inspections for individual purchase lots of incoming material after that material has been approved. 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 the 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.

5.2.1.4.2.2 Process specification. A process specification shall be established in accordance with DI-MFFP-82119 (see 6.3). The process specification shall provide for and specify all processes that are essential to fabrication or procurement of a product or material, particularly the processing of the raw material or perform into the final part form ready for trim and assembly. Process 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 range. Adequate process controls and 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, and warming from freezer to room temperature in a package to avoid condensation on the material itself.

5.2.1.4.3 Joining and fastening. 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 shall 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 over-torqued 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 specified in 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 shall be kept to a minimum (e.g., substitute dry film mold release).

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, on 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 fiberglass cloth. Selection of metals, in general, shall be so as to prevent dissimilar metal contact specified in MIL-STD-889.

5.2.1.4.4 Repairability. The selection of materials and processes shall be compatible with system repair and maintenance requirements. The selection of materials and processes shall facilitate identification of repair concepts that meet or exceed repair requirements. Repairs that include bolt hole quality, size of repairs, multiple repairs, skill level, required support, repair time, and equipment shall be substantiated. 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 materials 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, AFWAL-TR-83-3092.

5.2.1.4.5 Supportability. Composites shall be supportable and correlated with mechanical property design allowable data when selecting materials.

5.2.1.4.6 Electrical/electromagnetic behavior. Material characteristics shall be evaluated 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 in accordance with SAE AS1933 and SAE ARP5316. 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 of cured elastomers shall not exceed 38 ºC (100 ºF) and shall not exceed 55 ºC (125 ºF).

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 that does not exceed 26 ºC (80 ºF). Some specific materials may require storage at reduced temperatures and these materials shall be given such storage as recommended by the manufacturer. Materials requiring reduced temperature storage shall be avoided 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 nine months at less than 26 ºC (80 ºF) and the materials remain suitable for use. A policy of first in, first out shall be maintained. If materials become overage, tests approved by the procuring activity's engineering authority 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. These include commercial adhesives/sealants and those in accordance with MIL-A-46106. These materials can cause corrosion to electronic materials, such as copper wire, aluminum connectors, steel containers, and cadmium plated surfaces. These materials shall not be specified 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 ¼ 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. Alcohol liberating sealants should be used in preference to the acetic acid liberating sealants.

5.2.2.2 O-rings. Dimensions and tolerances for all o-rings shall be in accordance with SAE AS568. O-rings conforming to the following specifications should be used:

System	**Materials Specification**	**Applicable drawing**
Fuel Lubricating oil	SAE AMS-P-5315 (Buna N)	SAE AS29512, SAE AS29513
	MIL-R-25988 (Fluorosilicone)	MIL-R-25988/1, /2, /3, & /4
	(Fluorocarbon elastomers)	
	SAE AMS7276	SAE AS3208, SAE AS3209
	SAE AMS7259	SAE AS3581
	SAE AMS3216	-------
	SAE AMS3218	-------
	SAE AMS-R-7362 (Buna N)	SAE AS29561
Hydraulic		
	(Fluorosilicone)	
	MIL-R-25988	MIL-R-25988/1, /2, /3 & /4
	SAE AMS-P-83461 (Buna N)	SAE AS83461/1
	MIL-P-25732 (Buna N)	SAE AS28775
	SAE AMS-P-5510 (Buna N)	SAE AS28778
		SAE AS83461/2

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

Specification	Material
MIL-PRF-6855	Buna N, Neoprene, and Buna S
SAE AMS-R-7362	Buna N
MIL-DTL-25988	Fluorosilicone
SAE AMS7276	Fluorocarbone elastomer
SAE AMS7259	Fluorocarbone elastomer
SAE AMS3216	Fluorocarbone elastomer
SAE AMS3218	Fluorocarbone elastomer
SAE AMS-R-83285	Ethylene-propylene
MIL-DTL-83397	Polyurethane
SAE AMS3384	Low Temp Fluoroelastomer
SAE AMS7287	
A-A-59588	Silicone

5.2.2.4 Potting compounds. The potting compounds in accordance with one of the following specifications shall be used:

Specification	Material
MIL-PRF-8516	Polysulfide
A-A-59877	Epoxy
MIL-PRF-23586	Silicone
MIL-M-24041	Polyurethane
SAE AS81550	Silicone

Other materials than those meeting the above specifications may be used if approved by the procuring activity.

5.2.2.5 Integral fuel tank sealing. Integral fuel tank sealing shall be accomplished by the use of sealant in accordance with SAE AMS-S-8802. When non-curing 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 advantageous when applying curing type sealant over polyurethane coating conforming to SAE AMS-C-27725. While the sealant will adequately adhere to new polyurethane coating, as the coating becomes older, obtaining 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. Adhesion promoter in accordance with SAE AMS3100 shall be used prior to sealing over SAE AMS-C-27725 polyurethane coating. MIL-STD-1568 shall be used for sealing other than fuel tanks.

5.2.3 Foamed plastics. Foamed plastics can absorb moisture 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. The design shall be thoroughly tested to ensure adequate sealing, provide resistance to vibration and acoustic noise, and shall be validated by tests.

5.2.4 Flexible and semi-flexible 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. Background information for the design and selection of materials for aircraft cabin interiors to minimize fires and emission of smoke and toxic fumes is found in JSSG-2010. Certain components are exempt from the FAA Amendment 25-61 fire standards (e.g., 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 shall pass the FAR 25.853 tests, including the Bunsen burner test, the flash resistance test, and the ASTM E162 radiant panel test. Any material that is used on material aircraft cabin interior design that has not been certified by the FAA testing requirements shall be self-extinguishing and meet the following requirements, when tested in accordance with FED-STD-191, Method 5903.

After flame time (seconds, maximum)
Single 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 that meet the flame resistance and smoke generation requirements of the respective material types, as specified in SAE AMS3856. For carpeting, material used shall not meet a maximum average of 75, when tested in accordance with ASTM E162. Any cabin furnishings, upholstery fabrics, and carpeting materials used that contain wool shall 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 FED-STD-191 testing requirements stated herein.

5.2.4.1 Aircraft seats. Materials used for aircraft seats shall pass the following test(s): outermost covering used to cover ejection seats shall be tested in accordance with

FED-STD-191, Method 5903 (vertical burn test) and shall meet the after flame time, after glow time, and char length requirements specified in 5.2.4. Non-ejection crew and passenger seating shall 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 seats shall pass their respective flame retardancy test requirements before and after 10 dry cleanings as specified in FED-STD-191, Method 5509 or launderings as specified in FED-STD-191, Method 5518. Test samples shall be determined individually as well as the average value.

5.2.5 Lubricants and working fluids. Lubricants include lubricating oils, greases, solid film lubricants, and anti-seize compounds. Fluids include hydraulic fluids, coolants, and heat transfer fluids. The selection of fluids and lubricants should refer to MIL-HDBK-838 and MIL-HDBK-275. Lubricants or anti-seize compounds containing graphite shall not be used, except for use on aircraft engine spark plugs and threaded fasteners and fittings where temperatures are expected to be above 410 ºC (800 ºF). Graphite containing lubricants may be safely 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 shall not be used in contact with these metals. Instead, molybdenum disulfide based anti-seize compounds such as MIL-PRF-83483 shall be used but only up to 410 ºC (800 ºF). 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 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, SAE CMH-17-2G should be used for guidance in selecting materials and designing transparencies (windshields, canopies, etc.). As a general guide for the critical area of 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 or abrasion environments. Protection can be accomplished by laminating a thin sheet or either as-cast acrylic or glass to the exterior polycarbonate surfaces by means of a compatible, non-plasticized interlayer material. Polyvinyl butyral (PVB) interlayer material shall 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") shall not be used to protect the exterior surface of aircraft transparency enclosures. They will either lose adhesion or 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 SAE CMH-17-2G. If appropriate, hole drilling procedures are not used, the integrity of the transparency can be very seriously degraded. Crazes can easily be induced that 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 that 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 in accordance with 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 SAE AS50881 shall be used to ensure long term insulation performance.

5.2.8 Tape. Tapes shall be selected that 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 Hydroscopic materials. Non-wicking, non-hygroscopic 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 or 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 or non-government standards. Other corrosion preventive compounds shall be approved by the cognizant engineering authority of 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 that 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 weapons systems. In most cases, part procurements and manufacturing processes are controlled by manufacturer 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 that provide repeatable quality and properties of materials that are 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 SAE AMS-F-7190 for steel, SAE AMS-A-22771 or SAE AMS-QQ-A-367 for aluminum, and SAE AMS4921, SAE AMS4970, SAE AMS6900, SAE AMS6901, SAE AMS6905, SAE AMS6906, SAE AMS6907, SAE AMS6910, SAE AMS6915, SAE AMS6920, SAE AMS6921, SAE AMS6925, SAE AMS6926, SAE AMS6930, SAE AMS6931, SAE AMS6932, SAE AMS6935, SAE AMS6936, SAE AMS6940 for titanium or industry 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 productions forgings shall be sectioned and etched to show the grain flow pattern and to determine mechanical properties at critical design points. This sectioning shall be repeated after any major change in the forging technique. The internal grain flow shall be such that the principal stresses are in the direction of flow as limited by forging techniques. The pattern shall be free from re-entrant or sharply folded flow lines.

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 industry accepted practices. 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 inch) of material removal for aluminum and 0.0038 cm (0.0015 inch) for steels.

5.3.2 Castings. Castings shall be classified and inspected in accordance with SAE AMS2175. Structural castings shall be in accordance with SAE AMS-A-21180, SAE AMS5343, or equivalent as specified by the procuring activity. Design criteria shall be governed by JSSG-2006.

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 in accordance with the requirements of the AWS D1.1/D1.1M and AWS D1.2/D1.2M. For critical flight hardware, welded joints shall be designed within the allowables and guideline requirements of DOT/FAA/AR-MMPDS. Welds in parts subject to fatigue loading or high stresses shall be fully heat treated after welding where possible. Heated metal shall be protected from contaminants whose presence would lead to defects or detrimental conditions not subsequently removable by chipless machining or polishing. This precaution shall be 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 AWS D17.2/D17.2M, ISO 15614-13, AWS D17.1/17.1M, and AWS D1.1/D1.1M is required as applicable. Weld quality shall conform to a designated class of NAS 1514. Weld tests and operator qualification shall conform to AWS D17.1/17.1M.

5.3.3.1 Weld repair. Weld repair is limited to the repair of welding of defects in a production fusion weld revealed by inspection and repair shall 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 material or process specification.

5.3.4 Brazing. Brazing shall be in accordance with AWS C3.4M/C3.4, AWS C3.5M/C3.5, AWS C3.6M/C3.6 and AWS C3.7M/C3.7. 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 DOT/FAA/AR-MMPDS. Tension loaded joints require the approval of procuring activity. Metals not covered by the AWS specifications herein shall not be brazed without prior approval of brazing process by the procuring activity’s engineering authority.

5.3.5 Adhesive bonding. For adhesive bonding MIL-HDBK-83377 should be used.

5.3.6 Soldering. For electrical, the soldering IPC J-STD-00X series of standards should be used.

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 SAE AMS-C-7438 and shall be of the corrosion resistant type. For sandwich construction using plastic honeycomb core and facings, 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 SAE AMS-C-8073. Design of structural sandwich assemblies shall be guided by MIL-HBDK-17-1. 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 lead tested in accordance with MIL-HDBK-83377. Other core materials or designs for which the above specifications do not apply, require approval of the cognizant engineering authority of the procuring activity (see 6.7).

5.3.8 Material inspection. Unless otherwise specified in the contract, inspection shall be performed during and after fabrication to ensure that the system can perform its intended function for its intended life without structural failure. MIL-HDBK-6870 provides inspection guidance.

6. NOTES

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

6.1 Intended use. This design standard provides design criteria that provides timely and comprehensive consideration during systems design of the limitation of materials and processes and of the lessons learned over the years from military-unique operational systems worldwide. The standard employs military-unique design criteria and considerations that exceed commercial design practices in order to meet the military rigors and environment that the operational systems encounter. 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 Acquisition requirements. Acquisition documents should specify the title, number, and date of this standard.

a. Title, number, and date of this standard.

b. If required, technical proposal (see 4.4 and 6.4)

6.3 Associated Data Item Descriptions (DIDs). This standard has been assigned an Acquisition Management Systems Control number authorizing it as the source document for the following DIDs. When it is necessary to obtain the data, the applicable DID must be listed on the Contract Data Requirements List (DD Form 1423).

Paragraph #	DID Title	Applicable DID
5.2.1.4.2.1, 5.2.1.4.2.2	Program-Unique Material or Process Specification	DI-MFFP-82119

The above DID was current as of the date of this standard. The ASSIST database should be researched at (http://quicksearch.dla.mil) to ensure that only current and approved DIDs are cited on the DD Form 1423.

6.4 Technical proposal. Technical proposal information must be provided to the procuring agency's engineering authority for review and possible approval (see 4.4 and 6.2).

6.5 Less common metals. Trade studies, together with the design properties, proposed processing, finishing, and manufacturing must be provided to the procuring activity's engineering authority for review and possible approval.

6.6 Less common nonmetallic materials. Background data must be provided to the procuring activity's engineering authority for review and possible approval.

6.7 Other core materials. Approval of other core materials requires that a test program be developed to substantiate the structural and environmental suitability for the system intended use.

6.8 Subject term (key word) listing.

Aircraft
Composites
Lessons learned
Material and process
Material selection
Metals
Properties
Nonmetals

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

CONCLUDING MATERIAL

Custodians:
Army - MI
Navy - AS
Air Force - 20

Preparing activity:
Navy-AS
(Project MFFP-2017-002)

Review activities:
Army - AR, AV, MR
Navy - CH, EC, MC. SA
Air Force - 11

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.