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MILITARY STANDARD

FASTENER SYSTEMS FOR AEROSPACE APPLICATIONS

FSC 53GP

DEPARTMENT OF DEFENSE
Washington, D C 20301

Fastener Systems for Aerospace Applications

MIL-STD-1515A

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

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

FOREWORD

The purpose of this document is to establish standardization in the selection, development, and use of aerospace fastening systems, including hole characteristics and inspection criteria. Existing fasteners cover a wide variety of configurations, sizes, materials, and finishes. Various aerospace fastener systems have common fastener needs but lack defined application exchangeability. This document provides contractual design requirements for proper selection and application of approved fastening systems. The basic objectives of this standard can be summarized as:

> To document selection and application information for approved fastening systems and procedures so the designer can achieve an optimum balance of performance, reliability, and exchangeability with minimum cost, logistic inventory and maintenance.

Selections and procedures are limited to those listed herein.

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INTRODUCTORY SECTION

SECTION 100 - GENERAL DESIGN REQUIREMENTS

* Requirement not yet published as of the date of this basic document.

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* Requirement not yet published as of the date of this basic document.

** Proposed Sections - Work to be initiated after sections 100 and 200 are completed.

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FASTENER SYSTEMS FOR AEROSPACE APPLICATIONS

1. SCOPE

1.1 Scope. This standard covers the methods of fastening, materials, finishes, test methods, and hole size and criteria of fasteners and fastening systems used in the design and construction of aerospace systems. In addition, it provides a comprehensive presentation of approved engineering practices, procedures, processes, and characteristics for fasteners.

1.2 Purpose. The purpose of this standard is to document selection and application information for approved fastening systems and procedures so the designer can achieve an optimum balance of performance, reliability, and exchangeability with minimum cost, logistic inventory, and maintenance.

2. APPLICABLE DOCUMENTS

2.1 Issues of Documents. The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of this standard to the extent specified herein.

STANDARDS

MILITARY

MS17855 Fasteners, Screw Threaded, Descriptive Factor Symbols and order of Notes for Engineering Documents for

2.2 Referenced Documents. A list of referenced documents is presented in the individual requirements contained in this standard. The applicable issues shall be those in effect on the date of the invitation for bids or request for proposal.

2.2.1 Nongovernment Documents. Nongovernment documents referenced herein show the specific issue applicable. Other revisions are not applicable.

2.2.2 Sources for Nongovernment Documents. Addresses for obtaining documents referenced herein but not obtainable from the Government are as follows:

AMS, AS, ARP, AIR, AMD
Society of Automotive Engineers, Inc.
400 Commonwealth Drive
Warrendale, PA 15096

ANSI
American National Standards Institute
1430 Broadway
New York, NY 10018

ASTM
American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103

NAS National Standards Association
1321 Fourteenth Street, NW
Washington, DC 20005

3. DEFINITIONS

3.1 Definitions Applicable to complete standard. The definitions provided in this document shall be for those special words, phrases, or usages which are peculiar to the fastenings area. This paragraph contains definitions (as defined above) for those words which are found in three or more requirements. Definitions for words used in only one or two requirements will be found with the particular requirement.

3.1.1 Airframe structure. In the context of this document, the airframe structure includes the fuselage, wing, and empennage.

3.1.2 Allowables. (See design allowables.)

3.1.3 Anchor nut (plate nut). A nut that resists turning during bolt installation by being attached to, or contained in, one or more of the parts being assembled.

3.1.4 Approved fastener. A fastener that is listed in this document.

3.1.5 Bearing face. (See bearing surface.)

3.1.6 Bearing surface. The load-carrying surface of a fastener or structural component.

3.1.7 Blind fastener. A fastenting system which is installed from one side of the structure.

3.1.8 Chamfer. A beveled surface on a component to facilitate entry of one part into the other. A beveled surface on a component to eliminate a sharp corner.

3.1.9 Critical application. Any application of a fastener where loss or failure of the fastener could cause one or more of the following:

a. Loss of aircraft.

b. Preclusion of continued flight and landing within the design limitations of the aircraft using normal pilot skill and strength.

c. Significant injury to the occupants of the aircraft or ground personnel.

d. Rendering of major subsystems or special mission systems inoperative or causing its destruction.

3.1.10 Design allowables. Tensile and shear ultimate strengths of fasteners and shear ultimate and yield strengths of mechanically fastened joints used for design of aircraft joint structures.

3.1.11 Fastening system. An installed fastener, its component parts, the geometry of the hole where it affects the performance of the system, and installation and removal tooling and procedures.

3.1.12 Grip or grip accommodation. The allowable variation of material thickness in which a specific fastener can function.

3.1.13 Impedance locking. A resistance that impedes disengagement of mating fastener components.

3.1.14 Locking device. A part or mechanism designed to prevent loss of preload or disengagement of a fastener.

3.1.15 Permanent fastener. A fastener which does not require removal to service or maintain the aircraft and that normally requires the destruction of the fastener or one of its components during removal.

3.1.16 Plate nut. (See anchor nut)

3.1.17 Self locking. An attribute of a fastener or fastener assembly having an integral locking element to impede relative rotation of mating components.

3.1.18 Shank. The untreaded portion of a fastener between the head and the threads, locking grooves, formed head, etcetera.

4. GENERAL STATEMENTS

4.1 Guidelines. A separate publication, "AMFRG Manual on Organization and Operations of the Aeromechanical Fastener Requirements Group for MIL-STD-1515", has been distributed to organizations participating in the preparation of MIL-STD-1515. This publication presents guidelines for the preparation and coordination of requirements for inclusion in this standard. These guidelines shall be followed for all requirement additions or changes and shall be revised as necessary by the preparing activity or his designee.

4.2 Application. The sections contained herein are intended to provide uniform requirements applicable to mechanical aerospace fasteners and shall be incorporated by reference in general and detail weapon systems and equipment specifications. If a requirement contained herein conflicts with a requirement in the general or detail weapon system or equipment specification, the weapon system or equipment specification shall take precedence. If a requirement listed in the contents has not been published but is referenced herein, it is not applicable and the requirements of the general or detail weapon system or equipment specification shall apply.

4.3 Descriptive factors and symbols. The descriptive factor symbols used in this standard shall be in accordance with MS17855.

5. NOTES

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

6. INTENDED USE AND GUIDANCE CRITERIA

6.1 Information and guidance. Paragraph 6 in all applicable requirements in this document presents information and guidance for use of that requirement or parts listed therein. The paragraph is not contractual.

Custodians:
Army - AV
Navy - AS
Air Force - 11

Reviewer Activities
Army - AR, MI
Navy -
Air Force - 10, 99
DLA - IS

Preparing Activity:
Air Force - 11

Project No. 5300-0039

SECTION 100 - GENERAL DESIGN REQUIREMENTS

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LUBRICATION

1. Purpose. This document establishes the requirements for the use of lubrication with mechanical fastener systems which are used in structural applications in the design, construction, and repair of aerospace/airframes, excluding propulsion systems. The purposes of lubrication in this requirement encompass wear reduction, prevention of lessening of galling and seizure, inhibiting fretting, aid in installing and removing fasteners, control of installaton torque or preload of joint, fastener system internal lubrication, and combinations of these factors. Lubrication of fasteners where the fastener acts as a bearing shaft is not covered by this document. Reference MIL-STD-1599 for appropriate bearing, equipment or functional systems specifications in this area.

1.1 Where appropriate military or industry documentation does not exist, this document establishes the requirements placed on the lubricant materials and the application to the fastener components. These materials requirements are included as addenda and will be deleted at such time as appropriate military or industry specifications are released.

1.2 Classification. Lubricant requirements discussed herein shall be identified by the type and class designation established in this paragraph. The categories of lubricants are reduced to four basic areas; solid or dry film, liquid film, metallic coatings, and lubricants involving encapsulation or transitions from liquid to solid or other peculiarities, herein called the Special Properties Lubricants. When lubricants are specified in MIL-STD-1515, the lowest level(s), types, and classes will be specified; for example, type I, class 2A-1, not simply type I, class 2. Type and class designations are intended for notation or reference on parts standards drawings or in procurement specifications. Addenda shall not be referenced in any other document or Requirement except Requirement 103.

1.2.1 Type I solid or dry film lubricants. Solid or dry film lubricants shall be one of the following classes as determined by this document and application conditions and must conform to the applicale noted military specification.

a. Class 1. Solid or Dry Film, General Purpose

(1) Class 1A - Air dry, unbonded lubricative powders.
None included at this time.

(2) Class 1B - Air dry, resin bonded, solid film lubricant
Class 1B1 - MIL-L-23398 -54°C to 260°C (-65°F to 500°F)

(3) Class 1C - Heat cured resin bonded solid film lubricant.
None included at this time.

(4) Class 1D - Inorganic binder, solid film, extreme environment
Class 1D1 - MIL-L-81329 184°C to 399°C (-300°F to 750°F)

b. Class 2. Solid or dry film, nongraphitic with no metallics

(1) Class 2A - Air cured, Corrosion inhibiting.
Class 2A1 - MIL-L-46147 -54°C to 121°C (-65°F to 250°F)

(2) Class 2B - Heat Cured, Corrosion inhibiting.
Class 2B1 - MIL-L-8937 -54°C to 260°C (-65°F to 500°F)
Class 2B2 - MIL-L-46010 -54°C to 260°C (-65°F to 500°F)

(3) Class 2C - Air or heat cured, extreme environment.
None included at this time.

c. Class 3. Solid or dry film, inert compounds. None included at this time.

d. Class 4. Special categories.

(1) Class 4A - Electrical insulation compounds
Class 4A1 - MIL-S-8660

1.2.2 Type II liquid film lubricants. Liquid film lubricants shall be one of the following classes as determined by this document and application conditions and must meet the requirements of addendum A to this requirement or applicable noted military specification.

a. Class 1. Liquid film fastener installation lubricants - organic:

(1) Class 1A
Class 1A1 - Cetyl alcohol. Cetyl alcohol shall meet all material and application requirements of addendum A and other requirements specifically noted in this document.

b. Class 2. Corrosion preventive compounds

(1) Class 2A
Class 2A1 - MIL-C-16173 (grade 1 or 2)

c. Class 3. Petrolatum and greases

(1) Class 3A
Class 3A1 - Petrolatum in accordance with VV-P-236
Class 3B1 - MIL-G-6032
Class 3C1 - MIL-G-4343

d. Class 4. Anti-seize compounds, Metallic

(1) Class 4A
Class 4A1 - White lead compound in accordance with MIL-L-25681
(2) Class 4B
Class 4B1 - Anti-seize compound in accordance with MIL-T-5542

(3) Class 4C
Class 4C1 - Anti-seize compound in accordance with MIL-T-83483

(4) Class 4D
Class 4D1 - Anti-seize compound in accordance with MIL-A-907

(5) Class 4E
Class 4E1 - Anti-seize compound in accordance with MIL-A-13881
Class 4E2 - Anti-seize compound in accordance with MIL-T-5544.

1.2.3 Type III metallic coatings. Metallic coatings intended for use as lubricants in the fastener system shall meet the requirements and specifications noted herein. Care should be exercised to assure that metallic coatings do not allow dissimilar metal/galvanic corrosion incompatibility with structural materials.

a. Class 1.

(1) Class 1A - Silver plating. Silver plating shall be in accordance with AMS 2412 for applications not exceeding 260°C (500°F) maximum.

(2) Class 1B - Silver plating. Silver plating shall be in accordance with AMS 2410 for applications not exceeding 518°C (965°F) maximum. May be used where class 1A is specified.

(3) Class 1C - Silver plating. Silver plating shall be in accordance with AMS 2411 for applications not exceeding 760°C (1400°F) maximum. May be used where classes 1A and 1B are specified.

1.2.4 Type IV special properties lubricants. Lubricants possessing special properties outside the scopes of types I, II, and III shall be one of the following classes as determined by this document and application conditions. No specific lubricants are included at this time.

1.2.5 Combination of lubricants. Types I, II, and III may be used in combination unless restricted for specific applications noted herein.

2. Documents applicable to requirement 103

VV-P-236	Petrolatum, Technical
MIL-A-907	Anti-seize Compound High Temperature
MIL-G-4343	Grease, Pneumatic Systems
MIL-T-5542	Thread Compound, Anti-seize and Sealing, Oxygen Systems
MIL-T-5544	Thread compound, Anti-seize, Graphite-petrolatum
MIL-G-5572	Gasoline, Aviation, Grades 80/87, 100/130, 115/145
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile, and Ordance
MIL-T-5624	Turbine Fuel, Aviation, Grades, JP-4 and JP-5
MIL-G-6032	Grease, Plug Valve, Gasoline and Oil Resistant
MIL-L-7808	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-A-8243	Anti-icing and Deicing - Defrosting Fluid
MIL-H-8446	Hydraulic Fluid, Nonpetroleum Base, Aircraft
MIL-S-8660	Silicone Compound

MIL-S-8802	Sealing Compound, Temperature-resistant, Integral Fuel Tanks and Fuel Cell Cavities, High-adhesion
MIL-L-8937	Lubricant, Solid Film, Heat Cured
MIL-A-13881	Anti-Seize Compound, Mica Base (For Threaded Fitting)
MIL-C-16173	Corrosion Preventive Compound, Solvent Cutback Cold-application
MIL-L-22851	Lubricating Oil, Aircraft Piston Engine (Ashless Dispersant)
MIL-L-23398	Lubricant, Solid Film, Air Drying
MIL-L-23699	Lubricating Oil, Aircraft Turbine Engines, Synthetic Base
MIL-L-25681	Lubricant, Molybdenum Disulfide, Silicone Base, High Temperature
MIL-L-46010	Lubricant, Solid Film, Heat Cured Corrosion Inhibiting
MIL-L-46147	Lubricant, Solid Film, Air-cured (Corrosion inhibiting)
MIL-L-81329	Lubricant, Solid Film Extreme Environment
MIL-T-83483	Thread Compound, Anti-seize, Molybdenum Disulphide-petrolatum
MIL-STD-1523	Age Control of Age-Sensitive Elastomeric Material
AMS 2410	Silver-Plating, Nickel Strike, High Bake
AMS 2411	Silver-Plating, High Temperature application
AMS 2412	Silver-Plating, Copper Strike, Low Bake

3. Definitions. Appropriate definitions are contained in the documents referenced in Section 2 of this requirement.

4. General Requirements

4.1 Compatibility

4.1.1 Fluid materials and coatings compatibility. For design purposes, lubricants may be considered compatible with all materials listed in table 103-I when an "X" appears in the applicale block.

4.1.2 Temperature limits. For design purposes, lubricants may be used where temperature limits are in accordance with table 103-II when an "X" appears in the applicable block.

4.1.3 Age control and relubriction. Lubricants which have a limited shelf life and require age control shall be controlled in accordance with MIL-STD-1523.

4.1.3.1 Fastener system internal lubricant. Multiple-piece fasteners, not normally disassembled, which utilize lubricants internally to assure the proper functioning of the fastener during installation shall not be relubricated without approval of the fastener manufacturer.

4.1.3.2 Fastener external lubricant. Fasteners utilizing type II lubricants for ease of installation or removal or for torque control may be relubricated with the same lubricant previously used.

4.1.4 Structural materials compatibility. For design purposes, lubricants may be considered compatible with all materials listed in table 103-III when an "X" appears in the applicale block. Others shall not be used in combination. Compatibility in this case is defined as not causing or contributing to stress corrosion, not leaving detrimental deposits, or hot reacting chemically with the material, such as galvanic corrosion.

4.2 Fastener system lubricants. Lubricants used on bolts, screws, pins, nuts, collars, washers, and other fastener elements shall follow the criteria specified herein when lubricants are used for general applications and for the specialied purposes noted in 4.3 and 5. In addition, lubricants must be one of the types and classes listed in 1.2 with the fluid compatibility, temperature limits, and structural materials compatibility of the application in accordance with tables 103-I, 103-II, and 103-III for all applications.

4.2.1 Fastener ease of insertion and removal. When this criterion is one of the intended purposes of the lubricant, the following requirements, restrictions, cautions, or allowances apply:

a. Caution. In interference-fit applications, lubricant shall permit full installation of the fastener without detriment to the hole or fastener. Minor scraping of plating from plated fastener is not considered detrimental in this regard.

b. Restriction. Type II lubricants shall not be the sole lubricant used on reusable fasteners when the pin element and nut or collar element are both stainless steel or titanium or a combination of the two.

4.2.2 Electrolytic corrosion barrier. When this criterion is a secondary purpose of the lubricant, the following requirements, restrictions, cautions, or allowances apply:

a. Restriction: Types I, II, and III are not considered sufficient for an electrolytic corrosion barrier and shall not be used as the sole barrier for this purpose regardless of metallic material combinations or environment.

b. Restriction: Type III coatings shall not be applied to titanium pins, nuts, or collars or be used in contact with titanium structure.

c. Requirement: All lubricated washers used in a system shall have lubricant which is compatible with the fastener components and sheet surfaces regardless of whether or not the washer will actually contact the components.

d. Requirement: See 5.1.2 for fastener system internal lubricants.

4.2.3 Preload control. When the lubricant is used for the purpose of producing a controlled preload in the fastener system, the following requirements, restrictions, cautions, or allowances apply:

a. Requirements: Fasteners may be installed in the received condition. No lubricants shall be added prior to installation.

b. Allowances: Fasteners may be installed with the addition of wet sealant and/or wet primer. Note that torque-tension factor must be considered.

4.2.4 Repeated removal and reinstallation of fasteners. When this criteria is one of the requirements of the fastener system, the following requirements, restrictions, cautions, or allowances apply: None at this time.

4.3 Lubricated fastener requirements. Lubricated fastener and other fastening threaded components shall comply with the following requirements.

4.3.1 Structural fasteners

4.3.1.1 Permanent fasteners

4.3.1.1.1 Rivets. Rivets installed in clearance holes do not require lubrication. Rivets installed in interference fits may require lubrication.

4.3.1.1.2 Pins and collars

a. Straight shank interference pins and collars. Any type and class or combination thereof approved herein may be specified but parts shall be lubricated. Collars and pins do not require the same lubricant.

b. Straight shank noninterference pins and collars. Any type and class lubricant or combination thereof approved herein may be specified or parts may be unlubricated. Collars and pins do not require the same lubricant.

c. Tapered shank pins shall be lubricated with at least one of the lubricants specified herein.

4.3.1.2 Removable fasteners

4.3.1.2.1 Bolts and screws. Any type and class of lubricant or combination thereof approved herein may be specified or parts may be unlubricated.

4.3.1.2.2 Nuts. Any type and class of lubricant or combination thereof approved herein may be specified or parts may be unlubricated.

4.3.1.2.3 Nutplates. Any type and class of lubricant or combination thereof approved herein may be specified or parts may be unlubricated.

4.3.1.2.4 Inserts. Any type and class of lubricant or combination thereof approved herein may be specified or parts may be unlubricated.

4.3.1.2.5 Panel fasteners. Any type or class of lubricant or combination thereof approved herein may be specified or parts may be unlubricated.

4.3.2 Function systems attachment fasteners

4.3.2.1 Equipment attachment. Bolts, screws, nuts used to attach miscellaneous equipment to structure shall comply with the requirements of 4.3.1.2.1 and 4.3.1.2.2.

4.3.2.2 Tubing and wire bundle clamp fasteners. Fasteners used for attaching clamps for tubing and wire bundle support may not require lubrication.

4.3.2.3 Quick release fasteners. Panel fasteners and other quick release fasteners may not require lubrication.

4.3.2.4 Fluid systems fasteners

4.3.2.4.1 Couplings. Duct coupling and V-band coupling fasteners shall meet the requirements of 4.3.1.2.1 and 4.3.1.2.2.

4.3.2.4.2 Fluid systems. Fluid systems connection nuts shall utilize lubricants with fluid compatibility requirements of 4.1.1 and 4.1.2.

5. Detailed requirements. The following specific application allowances and restrictions shall be observed in the use of fasteners in the design of aerospace vehicles and equipment.

5.1 Specific system fluid compatibility. In addition to the requirements of Table 103-I, lubricants used on mechanical fasteners and threaded connections must be compatible with applicable fluids.

5.2 Electrical bonding or insulation. Fastener pins or bolts/screws intended to provide electrical continuity shall not be lubricated except with type III lubricant where applicable. Fastener systems intended to be insulated against electrical continuity shall be coated with type I class 4A insulating compound, unless a compatibility problem exists.

5.3 Application of lubricant to fastener elements. Lubricants shall be applied to fastener elements as specified in the applicable Military Specification or Addendum for types I, II, and IV and applicable specification for type III.

5.4 Reapplication of lubricant to fastener elements. Parts using type II lubricants may be relubricated. Sufficient drying time should be observed for assurance of proper torque-tension relationships.

5.5 Fastener system internal lubrication. Lubricants used for various purposes internally in the fastener system and which do not contact the structure must meet the requirements of this document except that electrolytic corrosion barrier properties apply only to the materials of the fastener components.

5.6 Change of lubricant. Where the lubricant is a necessary factor in the usage of a fastener system requiring qualification, the specified lubricant shall be used in the qualification testing of the system, and continued as part of the requirements of the qualified system. Any change of lubricant(s) type or class requires requalification of the system.

TABLE 103-I. Fluid Compatibility.

TYPE AND CLASS / MATERIAL	TYPE I						TYPE II											TYPE III		
	1B-1	1D-1	2A-1	2B-1	2B-2	4A-1	1A-1	2A-1	3A-1	3B-1	3C-1	4A-1	4B-1	4C-1	4D-1	4E-1	4E-2	1A	1B	1C
MIL-A-907																				
MIL-G-5572			X	X	X		0	0	0	X	0	0	0					X	X	X
MIL-H-5606			X	X	X		0	0	0	X		0	0					X	X	X
MIL-T-5624			X	X	X		0	0	0	X		0	0					X	X	X
MIL-L-7808			0	X	X		0	0	0			0	0					X	X	X
MIL-A-8243						X	0	X	X	X	X	X	X					X	X	X
MIL-H-8446			X	X	X	X	0	0	0	X		0	0					X	X	X
MIL-S-8802						X	X	X	X	X	X	X	X					X	X	X
MIL-C-16173			X	X	X	X	X	X	X	X	X	X	X					X	X	X
MIL-A-13881																				
MIL-G-21164																				
MIL-L-22851							0	0	0	X	0	0	0					X	X	X
MIL-L-23699			0	X	X		0	0	0			0	0					X	X	X
MIL-T-27730																				
Type II C1.1A-1																				
LPS No. 1																				

NOTES:
1. "X" in the block indicates that experience and/or testing concludes that in normal use, exposure of the lubricant to the fluid in the acceptable temperature range of the lubricant does not detrimentally affect the properties of the lubricant or contaminate the fluid.
2. "0" in the block indicates known incompatibility between the fluid and the lubricant.
3. Blank indicates unknown characteristics of the combination.

TABLE 103-II. Temperature Limits.

TYPE AND CLASS / TEMP. LIMITS	TYPE I						TYPE II											TYPE III		
	1B-1	1D-1	2A-1	2B-1	2B-2	4A-1	1A-1	2A-1	3A-1	3B-1	3C-1	4A-1	4B-1	4C-1	4D-1	4E-1	4E-2	1A	1B	1C
-54° to 38°C (-65° to 100°F)							X	X	X											
-65° to 250°F (-54° to 121°C)			X																	
-65° to 400°F (-54° to 204°C)						X				X	X									
-65° to 500°F (-54° to 260°C)	X			X	X													X		
-300° to 750°F (-184° to 399°C)		X																		
HIGHER RANGES											1400°F X (760°C)							965°F X (518°C)	1400°F X (760°C)	

NOTES:
1. "X" indicates lubricant is acceptable to the temperature limits indicated.
2. Blank indicates unknown or not applicable.
3. Lubricants may be detrimentally affected by extended exposure to temperature extremes.

TABLE 103-III. Metallic Material Compatibility.

METALLIC MATERIAL \ TYPE AND CLASS		TYPE I						TYPE II											TYPE III		
		1B-1	1D-1	2A-1	2B-1	2B-2	4A-1	1A-1	2A-1	3A-1	3B-1	3C-1	4A-1	4B-1	4C-1	4D-1	4E-1	4E-2	1A	1B	1C
ALUM. ALLOYS	2000 SERIES	X		X	X	X	X	X	X	X	X	X	X	X					0	0	0
	6000 SERIES	X		X	X	X	X	X	X	X	X	X	X	X					0	0	0
	7000 SERIES	X		X	X	X	X	X	X	X	X	X	X	X					0	0	0
ALLOY STEEL ---- CADMIUM PLATED		X		X	X	X	X	X	X	X	X	X	X	X					0	0	0
CORROSION RESISTANT STEEL	431	X		X	X	X	X	X	X	X	X	X	X	X					X	X	X
	410	X		X	X	X	X	X	X	X	X	X	X	X					X	X	X
	17-4PH	X		X	X	X	X	X	X	X	X	X	X	X					X	X	X
	A286	X		X	X	X	X	X	X	X	X	X	X	X					X	X	X
TITANIUM ALLOYS		X		X	X	X	X	X	X	X	X	X	X	X					0	0	0
GRAPHITE FIBERS																					
MAGNESIUM		X		X	X	X	X	X	X	X	X	X	0	0					0	0	0

NOTES:
1. "X" indicates that experience and/or testing concludes that no detrimental effects are caused by intimate contact of the lubricant with the material.
2. "0" indicates known detrimental conditions are caused by contact of the lubricant with the material.
3. Blank indicates unkown characteristics of the combination.

ADDENDUM A
LUBRICATION

LUBRICANT, CETYL ALCOHOL 1-HEXADECANOL APPLICATION TO FASTENERS

1. Purpose. This addendum covers the materials, processes, procedures, application and control of cetyl alcohol lubrication on mechanical fasteners.

2. Referenced document

P-D-680 Dry Cleaning Solvent

3. Material

3.1 Cetyl alcohol. National Formulary Grade $(CH_3)(CH_2)_{15}OH$) (flake or granular form), acid number 1.0 maximum hydroxyl number 218-238, melting point 45° - 51°C (113° - 124°F).

3.2 Solvent.

3.2.1 Petroleum base solvent in accordance with P-D-680 type II or equivalent.

3.2.2 Freon TB-1. Caution: Water on the surface of a Freon solution is not recommended in that with the presence of iron, over a period of time, corrosive hydrochloric acid will form.

4. Solution composition and preparation

4.1 Petroleum base solvent

4.1.1 Composition

4.1.1.1 For non-interference pins, bolts, and other externally threaded fasteners, the composition will normally be 1.0 to 1.25 pounds of cetyl alcohol per gallon of petroleum base solvent.

4.1.1.2 For interference-fit pins and bolts the composition will normally be 2.25 to 2.50 pounds of cetyl alcohol per gallon of petroleum base solvent.

4.1.1.3 For collars, nuts, and washers a composition of 0.25 to 0.75 pounds of cetyl alcohol per gallon of solvent may be sufficient.

4.1.2 Operating temperature. The operating temperature shall be in the range of 41° - 54°C (105° - 130°F). The lower end of the range is suggested for application of heavier coatings.

4.2 Freon TB-1

4.2.1 Composition 0.75 to 0.90 pounds cetyl alcohol per gallon of freon.

4.2.2 Operating temperature should be 33° - 37°C (92° - 98°F).

4.2.3 A 0.5 - 1.0 inch-thick layer of water on the surface of the solution is required to prevent loss of solvent.

5. Safety considerations

5.1 Caution. These mixtures have a relatively low flash point. Only equipment designed to handle volatile, inflammable liquids should be employed. Avoid prolonged breathing of solvent vapors.

6. Application

6.1 Parts shall be cleaned to remove all surface contaminants and foreign material. Parts shall be vapor degreased and immediately prior to first lubrication application.

6.2 Parts shall be packed or placed in small lots in perforated baskets and immersed into the solution and allowed to soak for two minutes after the parts have been immersed long enough to warm to solution operating temperature. Care shall be taken to insure that adequate circulation of lubricant is realized on all parts.

6.3 Parts shall be removed from solution, shaking off excess liquid and allowing to dry before handling. Parts may then be spread on wire rack or nonabsorbent surface to facilitate drying. Application of a centrifuge for the removal of excess solution may be required.

7. Controls. Controls shall be established to insure the cetyl alcohol content of the solution is within the range specified herein. The solution must be replaced with fresh solution at regular intervals to avoid excessive contamination.

8. General

8.1 Appearance

8.1.1 Cetyl alcohol lubricated parts are slippery to the touch.

8.1.2 Cetyl alcohol lubricated parts may have white film or frosty appearance which does not affect the performance of the lubricant, and shall not be a cause for rejection.

8.2 Use. Cetyl alcohol is to be applied on all parts as specified on the respective part drawing, standard or specification. Cetyl alcohol may also be used as an additional supplemental lubricant as allowed by the process specification, installation drawing, or appropriate technical orders.

DESIGN ALLOWABLES

1. Purpose. This requirement specifies where or how engineering criteria and requirements for design load allowables for fastener systems shall be obtained.

2. Documents applicable to Requirement 109

MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures

3. Design allowable loads. The design allowable loads shall be in accordance with MIL-HDBK-5.

3.1 Unavailable allowable loads. Where load or stress allowables are not contained in MIL-HDBK-5, they shall be obtained by test data in accordance with Chapter 9, Section 4, of MIL-HDBK-5, or by analysis or data acceptable to the procuring activity.

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TESTING

1. Purpose. This requirement shall establish engineering criteria and requirements for the testing of fasteners. These criteria and requirements may be limited by other documents which may take precedence over this military standard.

2. Documents applicable to Requirement 110.

MIL-STD-1312 *Fastener*, Test Methods

3. General. The proper selection of fasteners used in the design and construction of aerospace systems requires the evaluation and correlation of test data. This requirement establishes the methods for testing fasteners to determine their physical and mechanical properties. MIL-STD-1312 presents unified standard methods of testing, analysis of data and presentation of results for use in research, development, procurement, design selection, assembly, and maintenance. Unless otherwise specified in the applicable document these test methods shall be used. In case of conflict between the provisions of MIL-STD-1312 and the individual procedures in the specification for a particular item, the latter shall take precedence.

3.1 Test selection. In selecting the tests applicable to a fastener or fastener system, the fastener properties needed in the design must be determined. The appropriate test for each property of the fastener shall be specified. Care shall be taken to specify only those tests that are needed.

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SAFETY DEVICES AND ELEMENTS

1. Purpose. This requirement shall establish engineering criteria and requirements for the application of safety devices and elements. Selection may be further limited by other documents.

2. Documents applicable to Requirement 111.

MIL-N-8922	Nut, Self-Locking, Steel, 220 ksi F_{tu}, 450°F
MIL-F-8961	Fastener, Externally Threaded, 450°F and 1200°F, Self-Locking Design
MIL-N-8985	Nut, Self-Locking, Steel, 180 F_{tu}, 450°F
MIL-F-18240	Fastener, Externally Threaded, 250°F, Self-Locking Element For
MIL-N-25027	Nut, Self-Locking, 250°F, 450°F, and 800°F, 125 ksi F_{tu}, 60 ksi F_{tu}, and 30 ksi F_{tu}
MS15981	Fastener, Externally Threaded, Self-Locking Design and Usage Limitations For
MS18069	Compound, Adhesive, Aircraft Design and Usage Limitations for Threaded Components Retained or Sealed By
MS33540	Safety Wiring and Cotter Pinning, General Practices For
MS33588	Nut, Self-Locking, Aircraft Design and Usage Limitations of
MS33602	Bolt, Self-retaining, Aircraft Reliability and Maintainability Design and Usage Requirements For

3. General means of safetying. All threaded fasteners and other reusable fasteners shall be safetied. Self-locking fasteners are preferred over auxiliary devices (such as cotter pins, safety wire, tab washers, etcetera) and shall be used in accordance with MS15981 and MS33588. A self-locking element in accordance with MIL-F-8961 and MIL-F-18240 may be incorporated in externally threaded fasteners, and in accordance with MIL-N-25027, MIL-N-8922, and MIL-N-8985 for internally threaded fasteners. The locking element should be made of a low outgassing material for space applications.

3.1 Control systems. In the case of critical single-point linkages (flight, fuel controls, etcetera), they shall incorporate a self-retaining bolt in accordance with MS33602. Selection of self-retaining bolts shall be in accordance with Requirement 203.

3.2 Reusable fasteners. Except as specified in 3.1, each reusable bolt, nut, pin, or other fastener must incorporate two separate different types of locking devices, or elements, if --

its loss could preclude continued flight and landing within the design limitations of the aircraft using normal pilot skill and strength

or

its loss could result in reduction in pitch, yaw, or roll capability or response.

3.3 Safety wire and cotter pins. These are required only in cases where shearing or rupturing of material is required for safetying certain applications as noted in MS15981 (external threads), MS33588 (internal threads), and MS33602. When safety wire and cotter pins are required, they shall be used in accordance with MS33540.

3.4 Control cable and rod components. See Requirement 219.

3.5 Tab washers. The use of bend-tab washers is discouraged where breakage of the tabs would endanger the system. If a locking problem cannot be solved by more conventional means, tab wahers may be used. Provision must be made for locking to a keyway or adjacent structure.

3.6 Lock washers. Lock washers shall not be used to safety threaded parts.

3.7 Adhesive compounds. The use of adhesive compounds for safetying or retaining means shall be limited to applications where no other satisfactory means exists. If adhesive compounds are used, they shall be in accordance with MS18069.

RELEASE FOR USE OF NONAPPROVED FASTENERS

1. Purpose. Fastening systems, fasteners, and installation requirements identified and listed in the applicable requirements of this standard are approved and shall be given selection priority in new aerospace systems design. Those not listed as approved for use require a release for use by the procuring activity prior to incorporation into design, during development, or for use in assembly during production. This requirement establishes preparation and submission procedures for justification and engineering data necessary for the evaluation and use of fasteners not listed herein. It also establishes the point of contact for release requests.

2. Documents applicable to Requirement 112.

MIL-D-8706	Data and Tests, Engineering, Contract Requirements for Aircraft Weapon Systems
MIL-STD-143	Standards and Specifications, Order of Precedence for the Selection of
MIL-STD-965	Parts Control System

3. Procedures for use. When a determination has been made that a fastening system or fasteners not listed herein should be used, a request for release for use, with the justification and engineering data specified herein, shall be submitted to the procuring activity in accordance with the procedures of MIL-D-8706 and MIL-STD-965. When contracts do not call out any of the above-documented procedures, the requests shall be made to the procuring activity or contact points listed in Table 112-I in accordance with the procedures of MIL-STD-965, and the data requirements of 3.1 of this requirement. In all cases, the order of precedence for selection of standards and specifications shall be in accordance with MIL-STD-143.

3.1 Engineering data required. When applicable, the following engineering data shall be furnished for each fastener not listed herein for which release for use is requested.

a. The reason an approved fastener would not be a satisfactory selection to perform the function required by the design problem or application.

b. The specific materials from which the fastener is manufactured.

c. The specific plating, coatings, surface treatments, and lubricants, as applicable. These shall be completely identified.

d. Values for the physical and mechanical properties, and available installation performance requirements, and available structural design load allowable data.

e. An illustration of the fastener with the dimensions required to establish the geometrical material limits necessary for design selection and for determining exchangeability. (See Requirement 115). This includes the geometrical material limits of installation formed fasteners after installation and clearances required for installation.

f. The maximum weight limit per one hundred of the fasteners.

g. The design and usage limitations to be applied.

h. The installation or process instruction for the part.

3.2 Contract data requirements. Data specified in 3.1 will be listed directly on a DD Form 1423 incorporated into the contract.

TABLE 112-I. Request contact points

Department	Submit to	Action Required
Air Force	Aeronautical Systems Division ATTN: ENFEM Wright-Patterson AFB, OH 45433 Telephone: 513-255-4158	Disapprove or Release
Army	US Army Aviation R&D Command ATTN: DRDAV-EKS P. O. Box 209 - Main Station St. Louis, MO 63166 Telephone: 314-268-5791	Disapprove or Release
Navy	Naval Air Development Center ATTN: 6013 Warminster, PA 18974 Telephone: 215-441-2833	Review and Recommendation to NAVAIR
	Naval Air Systems Command ATTN: AIR-5303 Washington, DC 20361	Disapprove or Release
All Military Services DISC/MPCAG	Defense Industrial Supply Center ATTN: DISC-EPM Philadelphia, PA 19111 Telephone: 215-697-4395	Information and Recommendation

SUPERSEDES
REQUIREMENT I-13
2 October 1972

MIL-STD-1515A
REQUIREMENT 113
12 July 1978

IDENTIFICATION MARKING

1. Purpose. This requirement shall establish the methods and procedures for the identification marking of fasteners.

2. Documents applicable to Requirement 113.

MIL-STD-130	Identification Marking of U. S. Military Property
MIL-STD-1291	Identification Symbols For Aerospace Fastener Manufacturers
MIL-HDBK-131	Identification Markings for Fasteners
NAS 1347	Identification of Fasteners

3. Fastener marking. Approved fasteners shall be identification marked in accordance with the item, specification, standard, or part drawing. Other fasteners submitted for release shall be identification marked in accordance with MIL-HDBK-131 and NAS 1347. Fastener identification covered by NAS 1347, type IV markings are applicable for #10 diameter fasteners and larger only. All fasteners shall be marked with the actual manufacturer's name or manufacturer's identification symbol in accordance with MIL-STD-1291. Those manufacturers not listed in MIL-STD-1291 will be required to submit a symbol for approval.

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EXCHANGEABILITY

1. Purpose. This requirement shall govern the selection and use of exchangeable fasteners in the design and construction of aerospace mechanical systems and related subsystems.

2. Documents applicable to Requirement 115.

MIL-STD-100	Engineering Drawing Practices
MIL-STD-280	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms

3. Definitions of elements. Refer to MIL-STD-100 and MIL-STD-280 for definitions of appropriate elements.

4. Design tolerances. Provisions shall be made (during design selection and application) for dimensional, mechanical, and physical properties' tolerances, so that fasteners having dimensions and characteristics permitted by the fastener specification or drawing may be used without selection or departure from the specified equipment performance.

5. Use of approved fasteners. Approved fasteners, as defined in Section 3 of MIL-STD-1515, shall be used to the maximum extent practicable. When existing approved fasteners are not available and because of this, authority is granted by the procuring activity to substitute a nonapproved fastener, the equipment shall be designed so that the approved fastener can be used. When provision is made for the use of a substitute nonapproved fastener, the approved fastener shall be identified on the applicable documentation.

Choice of fasteners. The fastener having the broadest characteristics and tolerances that will fulfill the equipment performance requirements shall be used. However, if delays in development or production are caused by the procurement time required for such fasteners, approved or released substitute fasteners may be used, if the originally selected, approved, or released fastener is identified on the applicable documentation.

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THREAD SELECTION

1. Purpose. This requirement shall establish selection requirements for screw threads to be used in airframe and related systems design.

2. Documents applicable to Requirement 119.

MIL-S-7742	Screw Threads, Standard, Optimum Selected Series, General Specifications For
MIL-S-8879	Screw Threads, Controlled Radius Root With Increased Minor Diameter, General Specifications For

3. Requirements. Screw threads for fasteners shall conform to MIL-S-7742 or MIL-S-8879. The preferred diameter-pitch selection shall be used. Except for components or parts that are approved for use in Section 200, comply with the following:

a. MIL-S-8879 threads shall be used for all components or parts made of material with minimum ultimate tensile strength (F_{tu}) in excess of 150 ksi or with a minimum hardness greater than Rockwell C32 or equivalent.

b. MIL-S-8879 threads shall be used in applications where the operational temperatures exceed 232°/C (450°F), or are less than -78°C (100°F).

c. MIL-S-8879 threads shall be used in applications that specify fatigue strength or fracture critical parts.

d. MIL-S-8879 Class 3A threads shall be used for all externally threaded fasteners 0.164-inch diameter and larger.

e. MIL-S-8879 Class 3B threads shall be used for all internally threaded fasteners 0.164-inch diameter and larger.

f. Internal threads as specified in MIL-S-8879 may be used with external threads conforming with MIL-S-7742.

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THREADS IN BEARING

1. Purpose. This requirement shall establish requirements for threads in bearing in members joined with the fastener loaded in shear.

2. Documents applicable to Requirement 121.

Not Applicable.

3. Requirements. The shanks of all structural bolts in shear shall be of such length that no threads (including thread run out) are in bearing in sheets or fittings equal to or less than .080-inch thickness. In thicker sheets or fittings, a maximum of the thread run out (maximum of two thread pitches) is permitted in bearing. However, not more than 25 percent of the minimum thickness of the sheet or fitting shall have threads in bearing. The total load shall be assumed to be carried by the nonthreaded portion of the bolt and by the portion of the sheet or fitting bearing on the nonthreaded portion. Where the minimum grip of the proper length bolt is slightly greater than the thickness of material to be bolted, not more than two washers, including insulating washers (corrosion protection barriers), may be used to make up the difference.

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METRICATION AND METRIC FASTENERS

1. Purpose. This requirement identifies the military standard wherein the engineering criteria and requirements for metric mechanical fasteners and fastener systems are contained.

1.1 Metric fastener selection. The selection of metric fasteners and fastener systems for use in the design and construction of aerospace systems shall be made from DOD-STD-XXXX to be prepared as soon as metric items are available.

1.2 Unlisted metric fastener requirements. Metric fasteners and fastener systems not listed in DOD-STD-XXXX but which are required for use in design and construction of aerospace systems shall be approved in accordance with the procedures outlined in Requirement 112.

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SECTION 200 - STRUCTURAL FASTENER REQUIREMENTS

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SUPERSEDES
REQUIREMENT II-4
9 January 1976

MIL-STD-1515A
REQUIREMENT 204
12 July 1978

NUTS

1. Purpose. This requirement provides the criteria for selection of nuts established as approved hardware for use in airframe strucural joining.

2. Documents applicable to Requirement 204

FF-N-836	Nut, Square, Hexagon, Cap, Slotted, Castellated, Clinch, Knurled, and Welding
MIL-N-7873	Nut, Self-Locking, 1200°F
MIL-N-8922	Nut, Self-Locking, Steel, 220 ksi F_{tu}, 450°F
MIL-N-8984	Nut, Self-Locking, Steel, 260 ksi F_{tu}, 450°F
MIL-N-8985	Nut, Self-Locking, Steel, 180 ksi F_{tu}, 450°F
MIL-N-25027	Nut, Self-Locking, 250°F, 450°F, and 800°F, 125 ksi F_{tu}, 60 ksi F_{tu} and 30 ksi F_{tu}
MIL-STD-143	Standards and Specfications, Order of Precedence For the Selection of
AN256	Nut, Self-Locking, Right-Angle Plate
AN310	Nut, Plain, Castellated, Airframe
AN315	Nut, Plain, Airframe
AN316	Nut, Jam, Hexagon
AN320	Nut, Plain, Castellated, Shear
MS14144	Nut, Self-Locking, Lightweight, Castellated, 450°F
MS14145	Nut, Self-Locking, Lightweight, Thin Castellated, 450°F
MS14146	Nut, Self-Locking, Castellated, Hexagon, Counterbored, Captive Washer, 450°F
MS14156	Nut, Wheel, Self-Locking, Flanged, Steel, 180 ksi F_{tu}, 450°F, Spline Drive
MS14164	Nut, Wheel, Self Locking, Flanged, Steel, 220 ksi F_{tu}, 450°F, Spline Drive
MS17825	Nut, Self locking, Castelated, Hexagon, 250°F Non-metallic Insert
MS17826	Nut, Self-locking, Castellated, Hexagon, 250°F, Thin, Non-metallic Insert
MS20500	Nut, Self locking, Hexagon, 1200°F, 125 ksi F_{tu}
MS20501	Nut, Self Locking, Plate, Two Lug, 1200°F, 125 ksi F_{tu}
MS21042	Nut, Self Locking, 450°F, Reduced Hexagon, Reduced Height, Ring Base, Noncorrosion Resistant Steel (Asg)
MS21043	Nut, Self-locking, 800°F, Reduced Hexagon, Reduced Height, Ring Base, Corrosion Resistant Steel (Asg)
MS21044	Nut, Self Locking, Hexagon-regular Height, 250°F, 125 ksi F_{tu} and 60 ksi F_{tu} (Asg)
MS21045	Nut, Self Locking, Hexagon-regular Height, 450°F, 125 ksi F_{tu} (Asg)
MS21046	Nut, Self Locking Hexagon regular Height, 800°F, 125 ksi F_{tu} (Asg)
MS21047	Nut, Self-locking, Two Lug, Low Height, Steel, 125 ksi F_{tu}, 450°F
MS21048	Nut, Self-locking, Plate, Two Lug, Low Height, CRES, 125 ksi F_{tu}, 450°F
MS21049	Nut, Self-locking, Plate, Two Lug, 100° Countersunk, Low Height, Steel 125 ksi F_{tu}, 450°F
MS21050	Nut, Self-locking, Plate, Two Lug, 100° Countersunk, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F

MS21051	Nut, Self-locking, Plate, One Lug, Low Height, Alloy Steel, 125 ksi F_{tu}, 450°F
MS21052	Nut, Self-locking, Plate, One Lug, Low Height, CRES 125 ksi F_{tu}, 450°F and 800°F
MS21053	Nut, Self-locking, Plate, Alloy, One Lug, 100° Countersunk, Low Height, Steel, 125 ksi F_{tu}, 450°F
MS21054	Nut, Self-locking, Plate, One Lug, 100° Countersunk, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F (Asg)
MS21055	Nut, Self-locking, Plate, Corner, Low Height, Steel, 125 ksi F_{tu}, 450°F
MS21056	Nut, Self-locking, Plate, Corner, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F (Asg)
MS21057	Nut, Self-locking, Plate, Corner, 100° Countersunk, Low Height, Steel, 125 ksi F_{tu}, 450°F
MS21058	Nut, Self-locking, Plate, Corner, 100° Countersunk, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F (Asg)
MS21059	Nut, Self-locking, Plate, Two Lug, Floating, Low Height, Steel, 125 ksi F_{tu}, 450°F (Asg)
MS21060	Nut, Self-locking, Plate, Two Lug, Floating, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F (Asg)
MS21061	Nut, Self-locking, Plate, One Lug, Floating, Low Height, Steel, 125 ksi F_{tu}, 450°F (Asg)
MS21062	Nut, Self-locking, Plate, One Lug, Floating, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F (Asg)
MS21063	Nut, Self-locking, Channel, Floating, Low Height, Steel, 125 ksi F_{tu}, 250°F
MS21064	Nut, Self-locking, Channel, Floating, Low Height, Steel, 125 ksi F_{tu}, 450°F
MS21065	Nut, Self-locking, Chanel, Floating, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F
MS21066	Nut, Self-locking, Channel, 100° Countersunk, Floating, Low Height, Steel, 125 ksi F_{tu}, 250°F
MS21067	Nut, Self-locking, Channel, 100° Countersunk, Floating, Low Height, Steel, 125 ksi F_{tu}, 450°F
MS21068	Nut, Self-locking, Channel, 100° Countersunk, Floating, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F
MS21069	Nut, Self-locking, Plate, Two Lug, Reduced Rivet Spacing, Low Height, Steel, 125 ksi F_{tu}, 450°F
MS21070	Nut, Self-locking, Plate, Two Lug, Reduced Rivet Spacing, Low Height, CRES 125 ksi F_{tu}, 450°F and 800°F
MS21071	Nut, Self-locking, Plate, One Lug, Reduced Rivet Spacing, Low Height, Steel, 125 ksi F_{tu}, 450°F
MS21072	Nut, Self-locking, Plate, One Lug, Reduced Rivet Spacing, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F
MS21073	Nut, Self-locking, Plate, Corner, Reduced Rivet Spacing, Low Height, Steel 125 ksi F_{tu}, 450°F
MS21074	Nut, Self-locking, Plate, Corner, Reduced Rivet Spacing, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F
MS21075	Nut, Self-locking, Plate, Two Lug, Floating, Reduced Rivet Spacing, Low Height, Steel, 125 ksi F_{tu}, 450°F
MS21076	Nut, Self-locking, Plate, Two Lug, Floating, Reduced Rivet Spacing, Low Height, CRES 125 ksi F_{tu}, 450°F and 800°F
MS21077	Nut, Self-locking, Plate, Two Lug, Floating, Non-metallic Insert, Steel, 125 ksi F_{tu}, 250°F

MS21078	Nut, Self-locking, Plate, Two Lug, Non-metallic Insert, Steel, 125 ksi F_{tu}, 250°F
MS21079	Nut, Self-locking, Gang Channel, Non-metallic Insert, 125 ksi F_{tu}, 250°F
MS21080	Nut, Self-locking, Plate, One Lug, Non-metallic Insert, Steel 125 ksi F_{tu}, 250°F
MS21081	Nut, Self-locking, Plate, Corner, Non-metallic Insert, Steel, 125 ksi F_{tu}, 250°F
MS21082	Nut, Self-locking, Plate, One Lug, Floating, Non-metallic Insert, Steel 125 ksi F_{tu}, 250°F
MS21083	Nut, Self-locking, Hexagon, Nonmetallic Insert, Low Height, 250°F
MS21084	Nut, Self-locking, Steel, 220 ksi F_{tu}, 450°F, Flanged, MS 33787 Wrenching Element
MS21085	Nut, Self-locking, Steel, 260 ksi F_{tu}, 450°F, Flanged, MS 33787 Wrenching Element
MS21086	Nut, Self-locking, Plate, Side by Side Reduced Rivet Spacing, Low Height, Steel 125 ksi F_{tu}, 450°F
MS21087	Nut, Self-locking, Plate, Side by Side Reduced Rivet Spacing, Low Height, CRES, 125 ksi F_{tu}, 450°F and 800°F
MS21133	Nut, Self-locking, Steel, 180 ksi F_{tu}, 450°F, Flanged, MS33787 Wrenching Element
MS21224	Nut, Self-locking, Castellated, Hexagon, Counterbored, Assembled Washer, 250°F, Non-metallic Insert (For Self Retaining Bolts)
MS21244	Nut, Castellated, Hexagon, Counterbored
MS21245	Nut, Self-Locking, Hexagon, Thin, 450°F, 70 ksi F_{tu}
MS27130	Nut, Plain, Blind, Rivet-flat and Countersunk Head, Open End
MSFC 10M90001	Requirements and Procedures for Contamination Control Due to Vacuum Outgassing
NAS 577	Nut, Self Locking, Barrel Floating (Note: Code "X" not approved for general use.) (14 June 74)
NAS 1291	Nut, Self-Locking, Hexagonal, Low Height, Lightweight, 450°C, 800°F* (Ref. 7)
NAS 1329	Nut, Blind Rivet, Flat Head, Internal Thread, Nonlocking (Free Running) or Self-Locking (14 June '74)
NAS 1330	Nut, Blind, Rivet, Countersunk Head, Internal Thread, Nonlocking (Free Running) or Self-Locking (14 June '74)
NAS 1473	Nut, Self-locking, Plate, Two Lug, Cap, Floating, Self-Sealing (14 June '74)
NAS 1474	Nut, Self-locking, Plate, Two Lug, Cap Floating, Reduced Rivet Spacing, (14 June '74)
NAS 1770	Nut, Self-Locking, Plate, Two Lug, Low Height, Counterbored, 160 ksi, 450°F, 800°F* (Oct '74)
NAS 1771	Nut, Self-Locking, Plate, One Lug, Low Height, Counterbored, 160 ksi, 450°F, 800°F* (Oct., '74)
NAS 1772	Nut, Self-Locking, Plate, Corner, Low Height, Counterbored, 160 ksi, 450°F, 800°F* (Oct., '74)
NAS 1773	Nut, Self-locking, Plate, Two Lug, Low Height, Counterbored, Floating, 160 ksi, 450°CF, and 800°F* (Oct., '74)

NAS 1774	Nut, Self-Locking, Plate, One Lug, Low Height, Counterbored, Floating, 160 ksi, 450°F and 800°F* (Oct '74)
NAS 1775	Nut, Self-Locking, Plate, Two Lug, Low Height, Counterbored, Reduced Rivet Spacing, 160 ksi, 450°F, 800°F* (Oct '74)
NAS 1776	Nut, Self-Locking, Plate, One Lug, Low Height, Counterbored, Reduced Rivet Spacing, 160 ksi, 450°F, 800°F* (Oct '74)
NAS 1777	Nut, Self-Locking, Plate, Corner, Low Height, Counterbored, Reduced Rivet Spacing, 160 ksi, 450°F, 800°F* (Oct '74)
NAS 1778	Nut, Self-Locking, Plate, One Lug, Low Height, Counterbored, Side by Side, 160 ksi, 450°F, 800°F* (Oct '74)
NAS 1779	Nut, Self-Locking, Plate, Two Lug, Low Height, Counterbored, Floating, Reduced Rivet Spacing, 160 ksi, 450°F, 800°F* (Oct '74)
NAS 1780	Nut, Self-Locking, Plate, Two Lug, Low Height, 100° Countersunk 160 ksi, 450°F, 800°F (Oct '74)
NAS 1781	Nut, Self-Locking, Plate, One Lug, Low Height, 100° Countersunk, 160 ksi, 450°F, 800°F* (Oct '74)
NAS 1782	Nut, Self-Locking, Plate, Corner, Low Height, 100° Countersunk, 160 ksi, 450°F, 800°F* (Oct '74)
NAS 1783	Nut Assembly, Self-Locking, Gang Channel, Low Height, Counterbored, 160 ksi, 250°F, 450°F, 800°F* (Oct '74)
NAS 1784	Nut Assembly, Self-Locking, Gang Channel, Low Height, Countersunk, 160 ksi, 250°F, 450°F, 800°F* (Oct '74)
NAS 1789	Nut, Self-Locking, Plate, Side by Side, Floating, Low Height, Reduced Rivet Spacing, C Bored, 160 ksi, 450°F, 800°F
NAS 3350	Nuts, Self-Locking, 450°F, High Quality* (Rev. 1)

*No Acceptance Notice.

3. Procurement specification provisions. Fasteners in the category established by this requirement shall conform to the documents specified in 2.

4. Design and usage limitations. Fasteners in the category established by this requirement shall be subject to the following design and usage limitations:

a. At joints in control systems at single attachments or where loss of the bolt would affect safety or flight unless the threaded parts are held by a positive locking device that requires shearing or rupture of materials before torsional loads would relieve the initial stresses of the assembly.

b. On any externally threaded part that serves as an axis of rotation for another part unless there are no possible torsional loads which can be applied to either the externally or internally threaded part in such a manner as to relieve the initial stresses of the assembly, or unless the threaded parts are held by a positive locking device that requires shearing or rupture of material before torsional loads would relieve the initial stresses of the assembly. Example: Pulleys, cranks, levers, linkages, hinge pins, and cam followers.

c. With bolts or screws on jet engine aircraft in locations where the loose nut, bolt or screw could fall or be drawn into the engine air intake duct.

d. With bolts, screws, or studs to attach access panels, doors or to assemble any parts that are routinely disassembled prior to or after each flight.

e. Bolts, studs, or screws must extend through the self-locking nut for a length equivalent of two threaded pitches. This length includes the chamfer.

f. Self-locking nuts which are attached to the structure shall be attached in a positive manner to eliminate the possibility of their rotation or misalignment when tightening is to be accomplished by rotating the bolts or screws. The manner of attachment shall permit removal without injury to the structure and permit replacement of the nuts. When projection spot-welding is used for attaching plate nuts, control shall be maintained in order that removal, by drilling out the welds, permits replacement with drilled plate nuts.

g. Self-locking nuts that have been reworked or reprocessed shall not be used by contractors or field maintenance personnel of the services.

h. Cadmium plated self-locking nuts shall not be used in contact with titanium and titanium alloy bolts, screws or studs and in application where the operating temperatures exceed 450°F.

i. Silver plated self-locking nuts shall not be used in contact with titanium and titanium alloy bolts, screws or studs in application where the operating temperatures exceed 600°F.

j. Silver plated self-locking nuts shall not be used with silver plated bolts.

5. Design selection and approved call out. Fasteners in the category established by this requirement shall be selected from and specified by part numbers listed in Section 2.

6. Intended use and guidance criteria. Table 204-I is presented as an aid in the selection of nuts.

6.1 General criteria notes.

a. The ultimate stress classification (ksi) of nuts listed corresponds with the ultimate strength level of the mating externally threaded fastener. The ultimate stress classification of nuts listed is a guide, and generally obtained when tested with bolts having a minimum tensile strength greater than the rated tensile strength of the nut. Consult specific standards for ultimate tensile values and details.

b. Where possible and practicable, mating parts (except where flush head bolts or anchor nuts are used) should have similar external wrenching configurations.

c. When outgassing characteristics are a requirement, refer to Requirements 102 and 103 and Marshall Space Flight Center document 10M90001.

d. Cadmium-plated nuts shall not be used in space vehicle components or systems. Nuts that are lubricated with dry film lubricants may be used in space applications provided the lubricant has been approved as meeting the outgassing requirements.

TABLE 204-I. Aid in the selection of nuts

Ultimate Tensile Stress, ksi	Drawing Number	Procurement Specification	Material	Temperature Limitation, °F	Coating or Plating	Remarks
			Plain (Nonself-Locking)			
55	AN315	FF-N-836	Aluminum	250	Anodized	
55	AN316	FF-N-836	Steel	450	Cadmium	
110	AN315	FF-N-836	Steel	450	Cadmium	
110	AN315	FF-N-836	CRES	450	Passivated	
			Plain Castellated (Nonself-Locking)			
29	AN320	FF-N-836	Aluminum	250	Anodized	
55	AN320	FF-N-836	Steel	450	Cadmium	
55	AN320	FF-N-836	CRES	450	Passivated	
55	AN310	FF-N-836	Aluminum	250	Anodized	
110	AN310	FF-N-836	Steel	450	Cadmium	
110	AN310	FF-N-836	CRES	450	Passivated	
			Plain-Castellated and Counterbored (Nonself-Locking)			
60	MS21244	FF-N-836	Steel	450	Cadmium	
60	MS21244	FF-N-836	A 286 CRES	450	Passivated	
			Plain (Self-Locking)			
30	MS21083	MIL-N-25027	Aluminum	250	Anodized	
60	MS21044	MIL-N-25027	Aluminum	250	Anodized	
60	MS21083	MIL-N-25027	Steel	250	Cadmium	
60	MS21083	MIL-N-25027	CRES	250	Passivated	
80	MS21045	MIL-N-25027	Steel	450	Cadmium	
80	MS21245	MIL-N-25027	Steel	450	Cadmium	
125	MS21043	MIL-N-25027	A 286 CRES	800	Silver	
125	MS21044	MIL-N-25027	Steel	250	Cadmium	
125	MS21044	MIL-N-25027	CRES	250	Passivated	
125	MS21045	MIL-N-25027	Steel	450	Cadmium	
125	MS21045	MIL-N-25027	CRES	450	Passivated	

TABLE 204-I. Aid in the selection of nuts Continued

Ultimate Tensile Stress, ksi	Drawing Number	Procurement Specification	Material	Temperature Limitation, °F	Coating or Plating	Remarks
			Plain (Self-Locking) Continued			
125	MS21046	MIL-N-25027	CRES	800	Silver	
125	MS20500	MIL-N-7873	CRES	1200	Silver	
125	NAS 1291	MIL-N-25027	A 286 CRES	450/800	Dry Film/ Silver	
160	MS21042	MIL-N-25027	Steel	450	Cadmium	
180	MS21133	MIL-N-8985	Steel	450	Cadmium	
180	MS14156	MIL-N-8985	Steel	450	Cadmium	Spline Drive Wheel
220	MS21084	MIL-N-8922	Steel	450	Cadmium	Spline Drive
220	MS14164	MIL-N-8922	Steel	450	Cadmium	Spline Drive Wheel
260	MS14164	MIL-N-8922	Steel	450	Cadmium	
260	MS21085	MIL-N-8984	Steel	450	Cadmium	Spline Drive
			Castellated (Self-Locking)			
35	MS17826	MIL-N-25027	Steel	250	Cadmium	
60	MS14145	MIL-N-25027	Steel	450	Cadmium	
95	MS17825	MIL-N-25027	Steel	250	Cadmium	
125	MS14144	MIL-N-25027	Steel	450	Cadmium	
			Castellated and Counterbored (Self-Locking)			
60	MS14146	MIL-N-25027	Steel	450	Cadmium	
60	MS21224	MIL-N-25027	Steel	250	Cadmium	

TABLE 204-I. Aid in the selection of nuts Continued

Ultimate Tensile Stress, ksi	Drawing Number	Procurement Specification	Material	Temperature Limitation, °F	Coating or Plating	Remarks
			Self-Locking Plate and Channel			
125	MS20501	MIL-N-7873	CRES	1200	Silver	2 Lug
125	MS21047	MIL-N-25027	Steel	450	Cadmium	2 Lug, Low Height
125	MS21048	MIL-N-25027	CRES	450	Passivated/ Dry Film	2 Lug, Low Height
125	MS21048	MIL-N-25027	CRES	800	Silver	2 Lug, Low Height
125	MS21049	MIL-N-25027	Steel	450	Cadmium	2 Lug, Countersunk
125	MS21050	MIL-N-25027	CRES	450	Passivated/ Dry Film	2 Lug, Countersunk
125	MS21050	MIL-N-25027	CRES	800	Silver	2 Lug, Countersunk
125	MS21051	MIL-N-25027	Steel	450	Cadmium	1 Lug, Low Height
125	MS21052	MIL-N-25027	CRES	450	Passivated/ Dry Film	1 lug, Low Height
125	MS21052	MIL-N-25027	CRES	800	Silver	1 Lug, Low Height
125	MS21053	MIL-N-25027	Steel	450	Cadmium	1 Lug, Countersunk
125	MS21054	MIL-N-25027	CRES	450	Passivated/ Dry Film	1 Lug, Countersunk
125	MS21054	MIL-N-25027	CRES	800	Silver	1 Lug, Countersunk
125	MS21055	MIL-N-25027	Steel	450	Cadmium	Corner, Low Height
125	MS21056	MIL-N-25027	CRES	450	Passivated/ Dry Film	Corner, Low Height
125	MS21056	MIL-N-25027	CRES	800	Silver	Corner, Low Height
125	MS21057	MIL-N-25027	Steel	450	Passivated/ Dry Film	Corner, Countersunk
125	MS21058	MIL-N-25027	CRES	450	Cadmium	
125	MS21058	MIL-N-25027	CRES	800	Silver	Corner, Countersunk

TABLE 204-I. Aid in the selection of nuts Continued

Ultimate Tensile Stress, ksi	Drawing Number	Procurement Specification	Material	Temperature Limitation, °F	Coating or Plating	Remarks
			Self-Locking Plate and Channel Continued			
125	MS21059	MIL-N-25027	Steel	450	Cadmium	2 Lug, Floating
125	MS21060	MIL-N-25027	CRES	450	Passivated/ Dry Film	2 Lug, Floating
125	MS21060	MIL-N-25027	CRES	800	Silver	2 Lug, Floating
125	MS21061	MIL-N-25027	Steel	450	Cadmium	1 Lug, Floating
125	MS21062	MIL-N-25027	CRES	450	Passivated/ Dry Film	1 Lug, Floating
125	MS21062	MIL-N-25027	CRES	800	Silver	1 Lug, Floating
125	MS21063	MIL-N-25027	Steel	250	Cadmium	Aluminum Channel
125	MS21064	MIL-N-25027	Steel	450	Cadmium	CRES Channel
125	MS21065	MIL-N-25027	CRES	450	Passivated/ Dry Film	CRES Channel
125	MS21065	MIL-N-25027	CRES	800	Silver	CRES Channel
125	MS21066	MIL-N-25027	Steel	250	Cadmium	Aluminum Channel, Countersunk
125	MS21067	MIL-N-25027	Steel	450	Cadmium	CRES Channel, Countersunk
125	MS21068	MIL-N-25027	CRES	450	Passivated/ Dry Film	CRES Channel, Countersunk
125	MS21068	MIL-N-25027	CRES	800	Silver	CRES Channel, Countersunk
125	MS21069	MIL-N-25027	Steel	450	Cadmium	2 Lug, Reduced Spacing
125	MS21070	MIL-N-25027	CRES	450	Passivated/ Dry Film	2 Lug, Reduced
125	MS21070	MIL-N-25027	CRES	800	Silver	2 Lug, Reduced Spacing
125	MS21072	MIL-N-25027	CRES	450	Passivated/ Dry Film	1 Lug, Reduced Spacing
125	MS21072	MIL-N-25027	CRES	800	Silver	1 Lug, Reduced Spacing
125	MS21073	MIL-N-25027	Steel	450	Cadmium	Corner, Reduced Spacing

TABLE 204-I. Aid in the selection of nuts Continued

Ultimate Tensile Stress, ksi	Drawing Number	Procurement Specification	Material	Temperature Limitation, °F	Coating or Plating	Remarks
			Self-Locking Plate and Channel Continued			
125	MS21074	MIL-N-25027	CRES	450	Passivated/ Dry Film	Corner, Reduced Spacing
125	MS21074	MIL-N-25027	CRES	800	Silver	Corner, Reduced Spacing
125	MS21075	MIL-N-25027	Steel	450	Cadmium	2 Lug, Floating Reduced Spacing
125	MS21076	MIL-N-25027	CRES	450	Passivated/ Dry Film	2 Lug, Floating Reduced Spacing
125	MS21076	MIL-N-25027	CRES	800	Silver	2 Lug, Floating Reduced Spacing
125	MS21077	MIL-N-25027	Steel	250	Cadmium	Nylon Insert, 2 Lug
125	MS21078	MIL-N-25027	Steel	250	Cadmium	Non-metallic Insert, 2 Lug
125	MS21079	MIL-N-25027	Steel	250	Cadmium	Nylon Insert, Channel
125	MS21080	MIL-N-25027	Steel	250	Cadmium	Nylon Insert, 1 Lug
125	MS21081	MIL-N-25027	Steel	250	Cadmium	Nylon Insert, Corner
125	MS21082	MIL-N-25027	Steel	250	Cadmium	Nylon Insert, 1 Lug, Floating
125	MS21086	MIL-N-25027	Steel	450	Cadmium	Side-by-Side Reduced Spacing
125	MS21087	MIL-N-25027	CRES	450	Passivated/ Dry Film	Side-by-Side Reduced Spacing
125	MS21087	MIL-N-25027	CRES	800	Silver	Side-by-Side Reduced Spacing
125	NAS 1473	MIL-N-25027	Steel	225	Cadmium	Self Sealing
125	NAS 1473	MIL-N-25027	CRES	450	Silver	Self Sealing
125	NAS 1474	MIL-N-25027	Steel	225	Cadmium	Self Sealing
125	NAS 1474	MIL-N-25027	CRES	450	Silver	Self Sealing
	AN256	MIL-N-25027	Aluminum	250	Anodized	Right Angle
	AN256	MIL-N-25027	Steel	250	Cadmium	Right Angle

TABLE 204-I. Aid in the selection of nuts Continued

Ultimate Tensile Stress, ksi	Drawing Number	Procurement Specification	Material	Temperature Limitation, °F	Coating or Plating	Remarks
		Self-Locking Plate and Channel Continued				
160	NAS 1770	NAS 3350	Steel	450	Cadmium	2 Lug, Low Height
160	NAS 1770	MIL-N-25027	CRES	800	Silver	2 Lug, Low Height
160	NAS 1771	MIL-N-25027	CRES	800	Silver	1 Lug, Low Height
160	NAS 1771	NAS 3350	Steel	450	Cadmium	Corner, Low Height
160	NAS 1772	NAS 3350	Steel	450	Cadmium	1 Lug, Low Height
160	NAS 1772	MIL-N-25027	CRES	800	Silver	Corner, Low Height
160	NAS 1773	NAS 3350	Steel	450	Cadmium	2 Lug, Floating
160	NAS 1773	MIL-N-25027	CRES	800	Silver	2 Lug, Floating
160	NAS 1774	NAS 3350	Steel	450	Cadmium	1 Lug, Floating
160	NAS 1774	MIL-N-25027	CRES	800	Silver	1 Lug, Floating
160	NAS 1775	NAS 3350	Steel	450	Cadmium	2 Lug, Reduced Spacing
160	NAS 1775	MIL-N-25027	CRES	800	Silver	2 lug, Reduced Spacing
160	NAS 1776	NAS 3350	Steel	450	Cadmium	1 Lug, Reduced Spacing
160	NAS 1776	MIL-N-25027	CRES	800	Silver	1 Lug, Reduced Spacing
160	NAS 1777	NAS 3350	CRES	450	Cadmium	Corner, Reduced Spacing
160	NAS 1777	MIL-N-25027	CRES	800	Silver	Corner, Reduced Spacing
160	NAS 1778	NAS 3350	Steel	450	Cadmium	1 Lug, Side-by-Side Reduced Spacing
160	NAS 1778	MIL-N-25027	CRES	800	Silver	1 Lug, Side-by-Side Reduced Spacing
160	NAS 1779	NAS 3350	Steel	450	Cadmium	2 Lug, Floating, Reduced Spacing

TABLE 204-I. Aid in the selection of nuts Continued

Ultimate Tensile Stress, ksi	Drawing Number	Procurement Specification	Material	Temperature Limitation, °F	Coating or Plating	Remarks
			Self-Locking Plate and Channel Continued			
160	NAS 1779	MIL-N-25027	CRES	800	Silver	2 Lug, Floating, Reduced Spacing
160	NAS 1780	NAS 3350	Steel	450	Cadmium	2 Lug, Low Height Countersunk
160	NAS 1780	MIL-N-25027	CRES	800	Silver	2 Lug, Low Height Countersunk
160	NAS 1781	NAS				
3350	Steel	450	Cadmium	1 Lug, Low Height		Countersunk
160	NAS 1781	MIL-N-25027	CRES	800	Silver	1 Lug, Low Height Countersunk
160	NAS 1782	NAS 3350	Steel	450	Cadmium	Corner, Low Height Countersunk
160	NAS 1782	MIL-N-25027	CRES	800	Silver	Corner, Low Height, Countersunk
160	NAS 1783	NAS 3350/	Steel/	250	Cadmium/ Dry Film	Aluminum Channel, Counterbore
160	NAS 1783	NAS 3350/ MIL-N-25027	Steel/CRES	450	Cadmium/ Dry Film	CRES Channel, Counterbore
160	NAS 1784	MIL-N-25027	CRES	800		CRES Channel, Counterbore
160	NAS 1784	NAS 3350/ MIL-N-25027	Steel/CRES	250	Cadmium/ Dry Film	Aluminum Channel Countersunk
160	NAS 1784	NAS 3350/ MIL-N-25027	Steel/CRES	450	Cadmium/ Dry Film	CRES Channel, Countersunk
160	NAS 1784	MIL-N-25027	CRES	800	Silver	CRES Channel, Countersunk
160	NAS 1789	NAS 3350	Steel	450	Cadmium/ Dry Film	Side-by-Side, Floating
160	NAS 1789	MIL-N-25027	CRES	800	Silver	Reduced Spacing

TABLE 204-I. Aid in the selection of nuts Continued

Ultimate Tensile Stress, ksi	Drawing Number	Procurement Specification	Material	Temperature Limitation, °F	Coating or Plating	Remarks
			Miscellaneous Nuts (Self-Locking Barrel)			
160	NAS 577	MIL-N-25027	Steel	450	Cadmium	Use with NAS 578 retainer. Code "I" not approved for general use.
			Nut, Blind Rivet			
645	NAS 1329	None	6053-T4 Aluminum	250	Anodized	Was blind rivet nuts are not controlled by the Military.
90	NAS 1329	None	1180 or 1110 Steel	450	Cadmium	
125	NAS 1329	None	430 CRES	600	Passivated	Use only self-locking and closed-end types.
160	NAS 1329	None	4037 Steel	450	Cadmium	
45	NAS 1330	None	6053-T4 Aluminum	250	Anodized	
90	NAS 1330	None	1108 or 1110 Steel	450	Cadmium	
125	NAS 1330	None	430 CRES	600	Passivated	
160	NAS 1330	None	4037 Steel	450	Cadmium	
60	MS27130	None	6053-T4 Aluminum	250	Anodized	
115	MS27130	None	1108 or 1110 Steel	450	Cadmium	
130	MS27130	None	430 CRES	600	Passivated	
100	MS27130	None	Brass	250		

INSERTS, SCREW THREAD

1. Purpose. This requirement establishes engineering criteria and requirements for use and selection of screw thread inserts.

2. Documents Applicable to Requirement 205.

MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification For
MIL-I-45932/1	Insert, Screw Thread, Thin Wall, Locked In
MIL-I-45932/2	Insert, Screw Thread, Thin Wall, Locked In, Nonmetallic Locking Element (-60°F to +250°F)
MIL-I-45934/1	Insert, Screw Thread, Keyring Locked, Self-Looking and Nonself-Locking, 125 ksi F_{tu}
MIL-I-45934/2	Insert, Screw Thread, Keyring Locked, Self-Locking and Nonself-Locking, 180 ksi F_{tu}
MIL-I-45934/3	Insert, Screw Thread, Keyring Locked, Self-Locking and Nonself-Locking, 220 ksi F_{tu}
MS21209	Insert, Screw Thread, Coarse and Fine, Screw-Locking, Helical Coil, CRES
MS51830	Insert, Screw Thread, Locked In, Key Locked, Regular Duty
MS51831	Insert, Screw Thread, Locked In, Key Locked, Heavy Duty
MS51832	Insert, Screw Thread, Locked In, Key Locked, Extra-Heavy Duty
MS51990	Ring, Lock, Serrated
MS51991	Insert, Screw Thread, Locked In, Ring Locked, Serrated
MS51993	Insert, Screw Thread, Locked In, Ring Locked, Serrated, High Strength
MS51997	Ring, Lock, Serrated - High Strength
MS122076 through MS122275	Insert, CRES Helical Coil, Coarse Thread
MS124651 through MS124850	Insert, CRES Helical Coil, Fine Thread

3. Classification.

3.1 Type I, helical coil wire type. Selection of inserts shall be made from part number shown on the following Military standards:

MS21209
MS122076 through MS122275
MS124651 through MS124850

3.2 Type II, solid bushing type. Selection of inserts shall be made from part numbers shown on the following Military specifications and standards:

MIL-I-45932/1	MS51830
MIL-I-45932/2	MS51831
MIL-I-45934/1	MS51832
MIL-I-45934/2	MS51990
MIL-I-45934/3	MS51991
	MS51993
	MS51997

4. General. The following requirements shall apply:

a. Insure that the internal threads of the assembled insert will accept parts externally threaded to MIL-S-8879.

b. Design shall consider sufficient edge distance to permit drilling and tapping for the next larger size insert.

5. Design and usage limitations. For aerospace vehicles, screw thread inserts shall be restricted to those referenced in this document and shall be subject to the following limitations:

a. In the design selection of inserts, consideration shall be given to the axial load-carrying capabilities of the installed insert in a specific parent material.

b. Inserts shall not be used in critical applications without prior approval of the procuring activity.

c. Inserts shall be installed in a manner to eliminate their rotational displacement when installing or removing the externally threaded part.

d. Self-locking inserts shall not be used as follows:

(1) At joints in control systems, at single attachments, or where loss of the bolt would affect safety of flight.

(2) On any externally threaded part that serves as an axis of rotation for another part unless the externally threaded part is held by a positive locking device that requires shearing or rupture of material before torsional loads would be applied to the externally threaded part in such a manner as to relieve the initial stress of the assembly.

(3) At any single bolted structural joint which serves as a primary load path, the failure of which would endanger the safety of personnel or would render the equipment inoperative or cause its destruction.

(4) Where the prevailing locking torque falls below the minimum specified in the respective performance specifications.

(5) Fasteners used in conjunction with self-locking inserts shall be selected and located by design to provide full thread pitches that engage the complete insert locking device and insure the required assembly strength.

e. Silver-plated inserts shall not be used in titanium housings or in conjunction with titanium bolts or screws.

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SPACERS, BUSHINGS, AND SLEEVES

1. Purpose. This requirement shall establish engineering criteria and requirements for the use of spacers, bushings, and sleeves in mechanical fastening systems.

2. Documents applicable to Requirement 208.

NAS 42	Spacers rivet (14 June '74)
NAS 43	Spacers, Screw and Bolt (14 June '74)
NAS 75	Bushing, Plain, Press-Fit (14 June '74)
NAS 76	Bushing plain, Press-fit, Bronze (14 June '74)
NAS 77	Terminal, Chain To Cable (For Swaging)
NAS 537	Bushing-plain, Press-Fit, Undersize Inside Diameter (14 June '74)
NAS 538	Bushing, Flanged, Press-Fit, Undersize Inside Diameter (14 June '74)
NAS 1056	Spacer, Sleeve-Rivet, High-Temperature, Nonmagnetic (14 June '74)
NAS 1057	Spacer, Sleeve-Screw and Bolt, High-Temperature, Nonmagnetic (14 June '74)

3. Definitions

3.1 Spacer

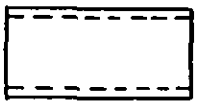
3.1.1 Spacer, plate. An item having a solid (unlaminated) cross section of any shape, including round, and designed to maintain a predetermined distance between assembled parts. (Also see Requirement 210.)

3.1.2 Spacer, sleeve. A tubular-shaped item with a round or hexagon peripheral shape having two flat bearing surfaces perpendicular to the axis of the centrally located hole and designed to maintain a predetermined distance between assembled parts.

3.1.3 Spacer, stepped (sleeve). A rigid, cylindrical item having one or more internal counterbores and internal steps on either or both sides. It is used in mechanical, electrical, or optical devices to maintain a predetermined distance between assembled parts.

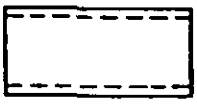
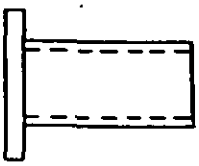
3.1.4 Spacer, ring. Essentially a sleeve spacer except that the diameter of the centrally located hole exceeds 75 percent of the outside diameter and the thickness is less than 25 percent of the outside diameter.

TABLE 208-I. Applications for spacers.

Type of Spacer	Part Number	Material	Code	Type of Fastener	Nominal Diameter, inch
Rivet 	NAS 42	2024-T3/T4 4130 8630	DD HT HT	Rivet	3/32 through 3/8
	NAS 1056	CRES 303A CRES A-286 INCONEL X	C E K		
Bolt 	NAS 43	2024-T3/T4 4130 8630	DD HT HT	Bolt	#4 through 1.00
	NAS 1057	CRES 303A CRES A-286 INCONEL X	T W		

NOTE: Use for spacing sheets, wire bundle clams, etcetera. Do not use NAS 43 or NAS 1057 for pulley guards.

TABLE 208-II. Applications for bushings

Type of Bushing	Part Number	Material	Code	Type of Fastener	Nominal Diameter inch
Plain, Press Fit 	NAS 75	4130 8630	None None	Bolt	#10 through 1-1/4
	NAS 76	Aluminium Bronze	None		
	NAS 537	4130 8630 Aluminium Bronze	None None B		
Flanged, Press Fit 	NAS 77	4130 8630 Aluminium Bronze	None None A	Bolt	#10 through 1-1/4
	NAS 538	4130 8630 Aluminium Bronze	None None B		

NOTE: These bushings are intended for reaming after installation.

3.2 Bushings

3.2.1 Bushing, plain. A replaceable part, cylinerical in shape, hollow, and designed primarily to be inserted in a hole to reduce the effective inside diameter of the hole and to protect the body structure about the hole from damage.

3.2.2 Bushing, electrical conductor. An item of metal or insulating material having a smooth exterior to prevent damage to the insulation of the wire or cable passing through a panel(s).

3.3 Sleeves

3.3.1 Sleeve, fastener. A tubular-shaped, unthreaded item with or without a flange at one end and designed primarily to be inserted in a fastener hole to reduce the effective inside diameter of the hole and to protect the body structure about the hole from damage corrosion. The length must exceed 25 percent of the outside diameter. Wall thickness is .015 inch or less, normally running .006 inch to .009 inch.

3.3.2 Sleeve, tapered, fastener. A truncated cone-shaped metal item, tapered through its entire length, with a centrally located hole. It may be split longitudinally through the wall paralled to its axis. It is designed primarily to be inserted in a hole to reduce the effective inside diameter of the hole and to protect the body structure about the hole from damage and corrosion. The length must exceed 25 percent of the outside diameter. Wall thickness is .015 inch or les, normally running .006 inch to .009 inch.

4. Application. Tables 208-I and 208-II present applications for spacers and bushings.

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WASHERS

1. Purpose. This requirement shall establish engineering criteria and requirements for the use of washers in mechanical fastening systems.

2. Documents applicable to Requirement 209.

AN960	Washer, Flat
AN961	Washer, Flat, Electrical
AN970	Washer, Flat, For Wood
AN975	Washer, Taper-Pin
AND10476	Washer, Limitations on Usage of Lock
MS15795	Washer, Flat, Metal, Round, General Purpose (In/mm)
MS19070	Washer, Key Retaining, Ball and Roller Bearing, Regular Series
MS21299	Washer, Countersunk and Plain, For Use With Bolts and Nuts Up to and Including 260 ksi F_{tu}
MS27183	Washer, Flat-Round, Steel, Cadmium Plated, General Purpose
NAS 460	Washer, Tab-Type*
NAS 549	Washer, Nonmetallic, Insulating, Electrical*
NAS 620	Fastener, Titanium Alloy Procurement Specification
NAS 1197	Washer, 5052 Aluminum Alloy
NAS 1252	Washer, 7075 Aluminum Alloy, Flat
NAS 1515	Washers, Plastic and Synthetic Rubber*
NAS 1587	Washers, Plain and Countersunk, 1200°F

3. Definition

3.1 Washer, plain

3.1.1 Washer, plain, flat. A solid, flat, circular item having two smooth parallel bearing surfaces and a single hole which is centrally located.

3.1.2 Washer, plain, flat, recessed. A solid, flat, circular item having two smooth parallel bearing surfaces and a hole which is centrally located. One or both bearing surfaces are broken by a counterbore, countersink, or similar recess.

3.2 Washer, lock. See 4.2.

3.2.1 Washer, lock, tooth, internal/external. A circular item with a centrally located hole. Its edges and two bearing surfaces are so designed that applied pressure brings into play the spring tension and frictional locking principle which resists the tendency toward turning.

3.2.2 Washer, lock, split. A circular item with a centrally located hole. Its two parallel bearing surfaces are divided along the radius leaving a fissure across the rim from the outer circumference to the washer hole. The fissure is never as large as the washer hole diameter.

*no acceptance notice

3.3 Washer, special purpose.

3.3.1 Washer, self-aligning (convex/concave). A circular item with a centrally located hole. One bearing surface is smooth and flat. The other bearing surface is smooth and raised (convex) or recessed (concave) to form a curved or spherical contour. One of each type is used together to achieve a self-aligning function.

3.3.2 Washer, tab (key). A circular item having two parallel bearing surfaces. The outside and inside edges have one or more protuberances (tabs). The edges or tabs may be prebent at any angle to the bearing surface. The tabs may be fitted into keyways in adjacent material or bent over after application to hold or lock one or more items.

3.3.3 Washer, dimpled (100°). A circular item that is flush-flanged and of a cone or disk shape with a centrally located hole.

3.3.4 Washer, kit, preload indicating (PLI). The kit consists of two concentric steel rings of rectangular cross section that are sandwiched between two close-tolerance plain washers. The inner ring is higher than the outer ring so that when load is applied, the inner ring deforms and binds the outer ring thus indicating that the proper preload has been achieved.

4. Application. See Table 209-I.

4.1 Washer, plain. Used under nut to protect surface from damage and to reduce the stress of the joint by increasing the bearing area. May be used to accommodate variations in grip length. Should be used to avoid electrolytic corrosion by preventing contact of dissimilar metals. (See Requirement 104)

4.2 Washer, lock. Warning: Do not use lock washers in airframe or space vehicles. (See Requirement 111)

4.3 Washer, special purpose. See individual parts document for application data.

4.4 Cadmium-plated washers. Cadmium-plated washer shall not be used in space applications.

4.5 Washer, recessed. It is standard design practice to use countersunk washers, or countersunk bolt holes under high-strength (160 ksi and above) protruding head bolts for clearance of the head-to-shank fillet radius.

4.6 Washer, nonmetallic. Nonmetallic washers used in space applications shall be approved as meeting the applicable outgassing requirements.

TABLE 209-I. Application of washers.

Washer		Function			Use (Tensile Strength of Fastener)			
Part Number	Material	Bearing	Lock	Electrical Insulation	Nonstructural	160-180 ksi	220-260 ksi	280 and higher ksi
Plain Washers								
AN960	Aluminum Alloy Brass Steel CRES	X X X X			X X X X	 X X		
AN961	Brass	X			X			
AN970	Steel	X			X			
MS15795	Aluminum Alloy Brass Nickel Copper CRES	X X X X			X X X X			
MS21299	Steel	X				X	X	
MS27183	Steel	X			X			
NAS 549	Fiber Phenol Melamine Epoxy			X X X X	X X X X			
NAS 620	Aluminum Alloy Brass Steel CRES	X X X X			X X X X			
NAS 1197	Aluminum Alloy	X			X			
NAS 1252	Aluminum Alloy	X			X	X		
NAS 1515	Silicone Synthetic Rubber Buna N Nylon Chloroprene Butyl Kel-F Teflon			X X X X X X X X	X X X X X X X X			
NAS 1587	CRES	X				X		
Recessed Washers								
AN 975	Steel	X			X			
NAS 1587	CRES	X				X		
Special Pupose Tab Washers								
MS19070	Steel CRES	X X			X X			
NAS 460	Steel	X			X			

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SUPERSEDES
REQUIREMENT II-10
15 August 1973

MIL-STD-1515A
REQUIREMENT 210
12 July 1978

SHIMS

1. Purpose. This requirement shall establish engineering criteria and requirements for the use of shims in mechanical fastening systems.

2. Documents applicable to Requirement 210.

MIL-S-22499	Shim Stock, Laminated
NAS 463	Shim, Anchor Nut, Plain
NAS 500	Shim Anchor Nut, Countersunk
NAS 1195	Shim, Miniature Anchor Nut

3. Definitions

3.1 Shim. A thin flat metal or nometallic item of various peripheral shapes having a solid or laminated cross section. It is designed to maintain a predetermined distance between two surfaces.

3.2 Shim, stock, laminated. A ferrous or nonferrous product of rectangular cross section throughout. It is composed of strips or sheets alternating with layers of adhesive binder to form a unit structure which can be reduced in thickness by peeling off one or more layers. It may be all laminated or partly solid and partly laminated. All laminations must be of the same thickness in any one unit.

3.3 Shim, nut plate. A ferrous or nonferrous product of cross section to approximate the appropriate plate nut shape.

4. Application

4.1 Shim stock, laminated. Laminated shim stock shall be in accordance with MIL-S-2499. It is available as shown in tables 210-I and 210-II.

Classes:
1 - .002 Laminations
2 - .003 Laminations

Types:
I - All laminations
II - One-half solid stock
III - Three-fourths solid stock

Compositions:
1 - Aluminum Alloy
2 - Brass
3 - Corrosion-Resisting Steel
4 - Carbon steel

4.2 Shims, nut plate

4.2.1 Shims for fixed and floating nut plates. Shims of various configurations in accordance with NAS 463 are available in corrosion-resistant steel, 5052, 2014, 2024, and 7075 aluminum alloy materials for fastener sizes ranging from #4 through 9/16 inch and shim thicknesses from 0.016 through 0.090 inch.

TABLE 210-I. Construction and dimensions.

Nominal Size* Inch	Class I (.002 Laminations)			Class 2 (.003 Laminations)		
	Type I	Type II	Type III	Type I	Type II	Type III
	Applicable Compositions					
.006	1,2,3,4			1,2,3,4		
.008	1,2,3,4					
.010	1,2,3,4					
.012	1,2,3,4			1,2,3,4		
.015	1,2,3,4			1,2,3,4		
.016	1,2,3,4			1,2,3,4		
.020	1,2,3,4			1,2,3,4		
.021	1,2,3,4			1,2,3,4		
.032	1,2,3,4			1,2,3,4		
.033	1,2,3,4			1,2,3,4		
.048	1,2,3,4			1,2,3,4		
.062	1,2,3,4	1,2		1,2,3,4	1,2	
.063	1,2,3,4	1,2		1,2,3,4	1,2	
.078	1,2,3,4	3		1,2,3,4		
.080	1,2,3,4	3		1,2,3,4		
.093	1,2,3,4	1,2		1,2,3,4	1,2	
.094	1,2,3,4	1,2		1,2,3,4	1,2	
.109					1	
.121		1	1		1	1
.125	1,2,3,4	1,2,3,4	1,2	1,2,3,4	1,2,3,4	1,2
.156	1,2,3,4			1,2,3,4		
.166	1,2,3,4	1,2		1,2,3,4	1,2	
.187	1,2,3,4	1,2		1,2,3,4	1,2	
.190	1,2,3,4	1,2	1	1,2,3,4	1	
.233			1			1
.250	1,2,3,4		1	1,2,3,4		1
.251	1,2,3,4		1	1,2,3,4		1
.375	1,2,3,4		1	1,2,3,4		1
.376	1,2,3,4		1	1,2,3,4		1

* Total thickness.

TABLE 210-II. Lateral dimensions.

Dimensions		Applicable Compositions
Width, inches	Length, inches	
8	24	2
8	48	2,4
12	48	2
A20	48	1,3,4
24	48	1,3,4

Compositions: 1 - Aluminum Alloy
2 - Brass
3 - Corrosion-Resisting Steel
4 - Carbon Steel

4.2 Shims, nut plate

4.2.1 Shims for fixed and floating nut plates. Shims of various configurations in accordance with NAS 463 are available in corrosion-resistant steel, 5052, 2014, 2024, and 7075 aluminum alloy materials for fastener sizes ranging from #4 through 9/16 inch and shim thicknesses from 0.016 through 0.090 inch.

4.2.2 Shims for countersunk nut plates. Shims of various configurations in accordance with NAS 500 are available in corrosion-resistant steel, 5052, 2014, 2024, and 7075 alumium alloy materials for fastener sizes ranging from #8 through 1/4 inch and shim thicknesses from 0.080 through 0.125 inch.

4.2.3 Shims for miniature fixed and floating nut plates. Shims of various configurations in accordance with NAS 1195 are available in corrosion-resistant steel, 5052, 2014, 2024, and 7075 aluminum alloy materials for fastener sizes ranging from #4 through 3/8 inch and shim thicknesses from 0.016 through 0.063.

4.3 Application notes

4.3.1 Shim stock, laminated. The laminated shim stock covered by MIL-S-22499 is intended for use in assemblies to provide adjustment of fits and alignment of component parts of the assembly by peeling off one or more laminations. Caution is advised in the use of excessive thickness, particularly at elevated temperatures, because of the possibility of loss of bolt preload.

4.3.2 Shim plate nut. Generally used with nut plates to increase material thickness to accommodate excess grip length of bolts. To avoid installation errors when attaching a panel which is normally removed for routine maintenance, one length of bolt should be used. The designer must, in this case, utilize the shim to accommodate varying thicknesses of material to be found in the structure surrounding the panel. (NOTE: Newer plate nut designs are available in which the use of these shims is eliminated. This is achieved by having graduated counterbore depths in the cylindrical portion of the nut element. This type of nut plate provides the effect of shimming at less weight and production installation cost.)

4.3.3 Cadmium plated materials. Do not use cadmium-plated plate nut shims or cadmium-plated carbon steel shim stock in space applications.

SUPERSEDES
REQUIREMENT 11-13
15 August 1973

MIL-STD-1515A
REQUIREMENT 213
12 July 1978

BLIND FASTENERS

1. Purpose. This requirement shall establish criteria for the design application of blind fasteners for use in aerospace mechanical structures. It includes blind fastener systems which shall be in accordance with documents shown in 2. Fasteners not listed may be used subject to approval by the procuring activity.

2. Documents applicable to Requirement 213.

MIL-R-8814	Rivet, Blind, Nonstructural-type (Asg)
MIL-F-8975	Fastener, Blind, High Strength, Pull Type, Positive Mechanical Lock, Corrosion and Heat Resistant Steel
MIL-F-81177	Fastener, Blind, High Strength, Pull Type, Positive Mechanical Lock
MS20426	Rivet, Solid, Countersunk 100° Precision Head, Aluminum and Aluminum Alloy
MS20470	Rivet, Solid-universal Head, Aluminum and Aluminum Alloy
MS20604	Rivet, Blind, Nonstructural, Universal Head, Class 1
MS20605	Rivet, Blind, Nonstructural, 100° Flush Head, Class 2
MS21140	Fastener, Blind, High Strength, Pull Type, Positive Mechanical Lock, 100° Flush Head, Corrosion Resistant Steel, 95 ksi Fsu
MS21141	Fastener, Blind, High Strength, Pull Type, Positive Mechanical Lock Protruding Head, Corrosion Resisting Steel, 95 ksi Fsu
MS24694	Screw, Machine, Flat Countersunk Head, 100°, Structural, Cross Recessed, UNC-3A and UNF-3A
MS90353	Rivet, Blind, High Strength, Pull Type, Positive Mechanical Lock, 100° Flush Head, Alloy Steel, 112 ksi Fsu
MS90354	Rivet, Blind, High Strength, Pull Type, Positive Mechanical Lock, Protruding Head, Alloy Steel, 112 ksi Fsu
MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures
NAS 618	Fastener, Recommended Shank, Hole and Head-to-Shank Fillet Radius, Limits For
NAS 1097	Rivet, Solid 100° Flush Shear Head, Aluminum Alloy
NAS 1398	Rivet, Blind, Protruding Head, Locked Spindle* (Rev. 3)
NAS 1399	Rivet, Blind 100° Flush Head, Locked Spindle* (Rev. 3)
NAS 1400	Rivet, Blind, Self-Plugging, Mechanically Locked Spindle* (Rev. 3)
NAS 1699	Fastener, Blind, Internally Threaded, External Sleeve, General Purpose, Protruding Head
NAS 1670	Fastener, Blind, Internally Threaded, External Sleeve, General Purpose, Flush Head
NAS 1671	Fastener, Blind, Internally Threaded, External Sleeve, High Temperature, Protruding Head,
NAS 1672	Fastener, Blind, Internally Threaded, External Sleeve, High Temperature, Flush Head,
NAS 1673	Fastener, Blind, Internally Threaded, External Sleeve, Lightweight, Protruding Head
NAS 1674	Fastener, Blind, Internally Threaded, External Sleeve, Lightweight, Millable Head
NAS 1675	Fastener, Blind, Internally Threaded, External Sleeve
NAS 1738	Rivet, Blind, Protruding Head, Mechanically Locked Spindle, Bulbed

NAS 1739	Rivet, Blind, 100° Flush Head, Mechanically Locked Spindle, Bulbed
NAS 1740	Rivet, Blind, Self-Plugging, Mecanically Locked Spindle, Bulbed
NAS 1900	Rivet, Blind, General Purpose, Bulbed, Self-Plugging, Mechanically Locked Spindle* (April 72)
NAS 1919	Rivet, Blind, General Purpose, Bulbed Protruding Head, Mechanically Locked Spindle* (April 72)
NAS 1921	Rivet, Blind, General Purpose, Bulbed, 100° Flush Head, Mechanically Locked Spindle* (Rev. 1)

* No Acceptance Notice.

3. Requirements.

3.1 Blind sheet thickness. When using NAS 1398 and NAS 1399 fasteners, the minimum blind side sheet thickness shall be as shown in table 213-I.

3.2 Dimpled assembly. Fastener holes shall be drilled or reamed to final size after dimpling.

3.3 Head configuration. Head configuration may be eight protruding head or countersunk head. The countersunk head shall be 100° including angle designs of one of three head styles in accordance with dimensions shown on either MS20426, MS24694, or NAS 1097 and referenced in table 213-II. The preferred protruding-head configuration shall be in conformance with MS20470. Other protruding-head designs are acceptable where described in documents included in 2.

3.4 Hole size. Fasteners shall be capable of obtaining functional characteristics when installed in hole sizes listed in table 213-III on the same line with the shank diameter.

3.5 Shear strength. Fasteners are rated by the shear strengths shown in their applicable specifications. These are ultimate shear strengths when tested in steel plates in accordance with the specifications. For standardization, newly developed fasteners shall meet the shear strengths of the applicable document for one of the levels shown in table 213-IV.

3.6 Design limitations. Blind fasteners shall not be used under the following conditions:

a. In engine inlet areas

b. In fluid tight areas

c. In control surface hinges, hinge brackets, auxiliary control brackets, wing attach fittings, landing gear fittings, or other heavily stressed locations.

3.6.1 Additional limitations. In addition to the limitations above, hollow fasteners shall not be used under the following conditions:

a. In surfaces which enclose a pressurized area

b. In surfaces which enclose areas requiring moisture proofing

c. In fuel areas requiring sealing.

TABLE 213-I. Minimum blind sheet thickness for NAS 1398/NAS 1399*.

Rivet	Shank Material	Blind Sheet Material			
		Aluminum			Ti-6A1-4V
		6061-T6	2024-T3	7075-T6	Annealed
B4	5056-F	.032	.032	.032	.016
B5	Aluminum	.032	.032	.032	.016
B6		.040	.040	.032	.016
B8		.050	.050	.032	.020
D4	2017-T4	.040	.032	.032	.016
D5	Aluminum	.040	.032	.032	.016
D6		.040	.040	.032	.016
D8		.040	.040	.032	.020
M4	Monel	.025	.025	.025	.016
M5		.032	.032	.032	.016
M6		.050	.050	.050	.016
M8		.063	.063	.063	.020
C4	A-286	.032	.025	.025	.016
C5		.032	.032	.032	.016
C6		.040	.040	.040	.025
C8		.050	.050	.050	.032

* The minimum thickness in a column may be used for other sheet materials having an equal or higher F_{tu} value.

TABLE 213-II. Maximum theoretical head diameters.

Diameter Dash Number (Nominal Shank Diameter)		MS20426	MS24694	NAS1097
-4	(.125)	.229	—	.196
-5	(.156)	.290	.332	.247
-6	(.188)	.357	.385	.302
-8	(.250)	.480	.507	.395
-10	(.312)	.568	.635	—
-12	(.375)	.698	.762	—

TABLE 213-III. Hole sizes.

Diameter Dash Number	Fastener Shank Diameter	Hole Size
-3	*.092 - .097	*.097 - .101
-4	.123 - .128 *.124 - .128 .139 - .143	.129 - .134 *.129 - .132 .143 - .146
-5	.154 - .159 *.155 - .159 .162 - .164 .1625 - .1645 .172 - .176	.160 - .166 *.160 - .164 .164 - .167 .165 - .168 .176 - .180
-6	.185 - .190 *.186 - .190 .197 - .199 .200 - .204	.192 - .198 *.192 - .196 .199 - .202 .205 - .209
-8	.248 - .253 *.249 - .253 .258 - .260	.256 - .263 *.256 - .261 .260 - .263
-10	.3095 - .3115 +*.3095 - .3120 .310 - .312	.312 - .315 +*.3125 - .3165 .312 - .315
-12	.372 - .374 +*.3720 - .3745 .3725 - .3745	.374 - .377 +*.375 - .379 .375 - .378
-14	+*.4345 - .4370 .435 - .437	+*.4375 - .4425 .437 - .441
-16	+*.4970 - .4995 .496 - .499	+*.500 - .505 .500 - .504

* To be used for newly developed fasteners. Other fastener diameters in table 213-II and their respective holes may be used on newly developed fasteners for replacing existing fasteners during the interim while the diameters marked * are becoming standardized in new design.

+ In accordance with NAS 618.

TABLE 213-IV. Shear strength.

Document Tabulating Shear Strength	Shear Strength PSI Reference
NAS 1400, Type B	30,000
NAS 1400, Type D	38,000
NAS 1675, Class 3	46,000
NAS 1400, Type M	55,000
NAS 1400, Type C	75,000
MIL-F-8975	95,000
MIL-F-81177	112,000
MIL-HDBK-5 Table 8.1.5a	125,000
MIL-HDBK-5 Table 8.1.5a	132,000

3.7 Hole filling and non-hole-filling fasteners. Some blind fasteners are hole filling, due to shank expansion, or due to installation in interference holes. The hole-filling fasteners can pick up load before non-hole-filling fasteners, if both are in the same pattern. The two shall not be mixed in the same pattern unless the loading difference is acceptable.

3.8 Grip increments. Grip increments for newly developed blind fasteners shall be as follows:

Material Thickness to be Joined (Grip)	Grip Dash Number
*.000 - .062	-1
.062 - .125	-2
.125 - .188	-3
.188 - .250	-4

* Minimum permissible grip may be greater than .000 for some fasteners.

4. Design and usage limitations. Design and usage limitations shall be as specified in Requirement 118.

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PANEL FASTENERS

1. Purpose. This requirement establishes and defines the basic design and engineering requirements for the use of quick-operating fastener assemblies for attaching structural load-carrying and nonstructural panels, inspection doors, quickly detachable plates, control and instrument panels, and equipment rack systems.

1.1 Classification. Panel fasteners shall be of the following types and classes.

Type I - Structural (high-strength, stressed-panel fasteners)
Type II - Nonstructural
Type III - Nonstructural strip instrument panel fasteners.

Class 1 - Floating receptacle
Class 2 - Rigid receptacle.

2. Documents applicable to Requirement 215.

QQ-P-35	Passivation Treatments for Corrosion-Resisting Steel
QQ-P-416	Plating, Cadmium (Electrodeposited)
MIL-D-1000	Drawing, Engineering, and Associated List
MIL-C-5541	Chemical Conversion Coatings on Aluminum and Aluminum Alloys
MIL-S-8879	Screw Threads, Controlled Radius Root With Increased Minor Diameters, General Specification For
MIL-L-8937	Lubricant, Solid-Film, Heat-Cured
MIL-L-46010	Lubricant, Solid-Film, Heat-Cured, Corrosion-Inhibiting
MIL-C-81562	Coating, Cadmium, and Zinc (Mechanically Deposited)

3. Design and construction. Types I and II fasteners shall be of the stud-receptacle design and shall be so constructed that neither the stud assembly nor the receptacle assembly can be inadvertently disassembled during normal flight or vehicle operation. Types I and II fasteners shall provided for retention of the stud in the outer sheet when disengaged from receptacle. Type III fasteners shall be of the stud-strip receptacle type and shall be such that, when the fastener is unlocked or open, the stud assembly is retained by the case panel and receptacle strip is retained by the rack structure support.

3.1 Material. The material shall be of aircraft quality, suitable for the type and class intended.

3.2 Stud assembly. The stud assembly configuration shall employ a shear bushing, sleeve bolt, retainer ring, and other components.

3.2.1 Driving recess. The recess in the head of the stud or sleeve bolt shall be limited to those specified in MIL-STD-1515, Requirement 120, except that type I fasteners shall be hex type. The recess torque capability shall not be less than the values specified on the manufacturer's part drawing.

3.2.1.1 Type III fasteners. The driving means shall be a slot, and with the fasteners in the locked or installed position, shall be in line with the long axis of the receptacle strip to indicate engagement of the fastener components.

3.2.2 Head flushness

3.2.2.1 Type I fasteners. Flush-head studs or sleeve bolts and grommets shall be capable of being installed flush with the outer panel within ±0.015 inch when installed in any grip within the grip range of the fastener. In designs utilizing a shear bushing type component, the stud head shall be flush with the top of the shear bushing within ±0.015 inch when seated.

3.2.2.2 Type II fasteners. Flush-head studs shall be capable of being installed flush with the surface of the outer panel within ±0.015 inch when installed in the nominal grip for which the fasteners are intended. In designs utilizing a bushing or grommet type component, the stud head shall be flush with the top of the bushing or grommet within ±0.015 inch when installed in nominal grip and locked.

3.2.3 Locking. Stud locking of types II and III fasteners shall be accomplished within approximately 1/4 turn of rotation (for rotary types) after engagement with the locking means of the receptacle.

3.3 Receptacle assembly

3.3.1 Type I fasteners. The receptacle shall be either of the floating style (class 1) having a minimum radial float of 0.020 inch, or of the rigid style (class 2) having no radial float.

3.3.2 Type II fasteners. The receptacle shall be either of the floating style (class 2) having a minimum radial float of 0.030 inch, or of the rigid style (class 2) having no radial float.

3.3.3 Installation. The receptacle shall be attachable by means of rivets, unless otherwise specified. If weld projections are specified, the spacing of the projects shall be the same as specified for the rivet holes. Sheet preparation for production installations shall be determined by the design requirements of the application.

3.3.3.1 A counterbore in either facing surface of the panel or substructure shall be capable of containing the retaining ring, when used, without pinching or cocking. In no case shall the formed-in-place gasket substitute for a spacer or counterbore.

3.3.3.2 Type III fasteners. The nut (receptacle) strip shall provide for mounting holes and receptacle holes at multiple intervals of 0.375 ±0.002 inch.

3.4 Threads. Threads, where employes, shall be single, double, or quadruple lead depending upon the specific manufacturer's design, as specified in MIL-S-8879. Internal threads, in the area of self-locking, shall be deformed or displaced in any manner in order to meet the self-locking and reuse requirements of the design.

3.5 Protective treatments. Components of alloy steel shall be cadmium plated as specified in QQ-P-416, type II, class 2, or MIL-C-81562, type II, class 2. Aluminum alloy parts shall be anodized as specified in MIL-C-5541.

Corrosion-resistant materials shall be passivated as specified in QQ-P-35 or shall be provided with a finish compatible with the environmental and temperature requirements of the particular application.

3.6 Lubrication. Dry-film lubricants, when required, shall be as specified in MIL-L-8937 or MIL-L-46010.

3.7 Size limitation. Type I panel fasteners shall be limted to the 3/8 inch nominal size only.

4. Performance characteristics. The minimum performance criteria for panel fasteners are dictated by requirements of the individual airframe design. Definition of application requirements shall determine the tests for the fastener manufacturer or airframe manufacturer to substantiate required attributes. The tests could include, but are not limited to, the following:

a. Locking and unlocking torque
b. Prevailing torque
c. Torque out
d. Stud or sleeve bolt push out
e. Receptacle push out
f. Sheet pull up
g. Simulated installation without and with hold mismatch
h. Curved sheet installation
i. Sealing
j. Endurance or reusability
k. Vibration
l. Elevated temperature
m. Corrosion resistance.

5. Mechanical properties. The mechanical properties of a panel fastener assembly are not only the strength capability of the individual components, but also a function of the strength and thickness of the panel material. Consequently, the end use shall also influence the tests established by the manufacturer or user. Tests shall be performed using sheet materials as defined in the design application. Tests for mechanical properties could include, but are not limited to, the following:

a. Shear, both rated and ultimate
b. Tensile, both rated and ultimate
c. Shear fatigue
d. Tension-tension fatigue

6. Notes

6.1 Interchangeability. All parts that have the same manufacturer's part number shall be directly and completly interchangeable with each other, with respect to installation and performance. Changes in manufacturer's part number shall be governed by the drawing number requirements as specified in MIL-D-1000.

6.2 Anodic coating for aluminum components is preferred; however, chemical conversion coating as specified in MIL-C-5541 may be used in areas not subject to corrosive environments.

6.3 Marking. Except where limited by configuration, the stud and receptacles shall be marked with the manufacturer's identification. In addition, the stud shall be identified with the grip length.

RETAINING RINGS

1. Purpose. This requirement shall establish engineering criteria and requirements for the use of tapered and uniform retaining rings with rectangular and beveled cross section.

2. Documents applicable to Requirement 216.

GGG-P-480	Pliers, Retaining Ring, Hog Ring Staple (Upholsterer S), Brake Repair Brake Spring) and Hose Clamp (Wire)
MIL-R-21248	Rings, Retaining (Tapered and Reduced Section)
MIL-R-27426	Ring, Retaining, Spiral (Uniform Cross Section)
MS3215	Ring, Retaining, External, E. Reinforced (Reduced Section Type)
MS3216	Ring, Retaining, External, Prong Lock (Reduced Section Type)
MS3217	Ring, Retaining, External, Heavy Duty (Tapered Section Type)
MS16624	Ring, Retaining, External, Basic (Tapered Section Type)
MS16625	Ring, Retaining, Internal, Basic (Tapered Section Type)
MS16626	Ring, Retaining, External, Inverted (Tapered Section Type)
MS16627	Ring, Retaining, Internal, Inverted (Tapered Section Type)
MS16628	Ring, Retaining, External, Bowed (Tapered Section Type)
MS16629	Ring, Retaining, External, Bowed (Tapered Section Type)
MS16630	Ring, Retaining, External, Beveled (Tapered Section Type)
MS16631	Ring, Retaining, External, Beveled (Tapered Section Type)
MS16631	Ring, Retaining, Internal, Beveled (Tapered Section Type)
MS16632	Ring, Retaining, External, Crescent (Tapered Section Type)
MS16633	Ring, Retaining, External, E (Reduced Section Type)
MS16634	Ring, Retaining, External, Bowed E (Reduced Section Type)
MS90707	Ring, Retaining, External, Grip
MS90708	Ring, Retaining, External, Interlocking

3. General. Tapered, uniform and reduced section type retaining rings shall conform to the requirements of MIL-R-21248 and MIL-R-27426, and selection should be made from the specifications and standards listed in 2.

4. Design and tests

a. In all critical applications, performance tests are required.

b. Design of shafts or housings and grooves for retaining rings shall be in accordance with conditions specified in the applicable Military standards.

c. Requirements for checking proper ring assembly (dimension K) on the applicable Military standard shall be adhered to.

d. When retaining rings are used in seal assemblies, the assembly shall not be designed so that deflection of the retaining ring under load will reduce the extent to which the seal is compressed or squeezed.

e. Retaining rings shall not be used in applications that subject them to shock loads unless the installation has been tested for these shock loads and fatigue life and proven to be satisfactory.

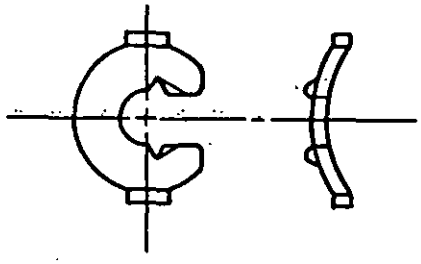
f. Cadmium-plated steel rings shall not be used at temperatures in excess of 232°C (450°F).

g. Corrosion-resistant steel rings shall not be used at temperatures in excess of 353°C (700°F).

5. Tools. Retaining ring pliers and other specifically designed installation tooling shall be used for installation and removal of retaining rings in accordance with Federal Specification GGG-P-480.

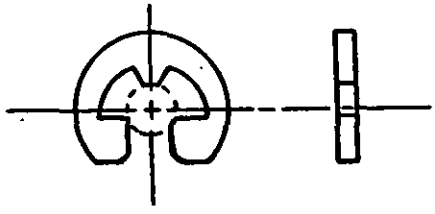
6. Retaining ring selection and intended use. Retaining rings shall be selected and specified by part number from the following listed standards or specifications:

MS3215 — Ring, Retaining, External, E. Reinforced (Reduced Section Type)



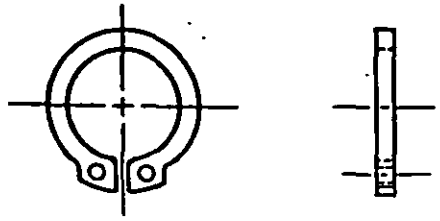
Intended use: To provide unusually large shoulders for positioning and maintaining machine components on shafts. They are applied radially and withstand strong pushout forces resulting from heavy vibrations and shock loads, high rotational speeds, or relative rotation between the retained parts. They are of further advantage where axial assembly of a retaining ring is not possible and where fast assembly for mass production lines is essential.

MS3216 - Ring, Retaining, External, Prong-Lock (Reduced Section Type)



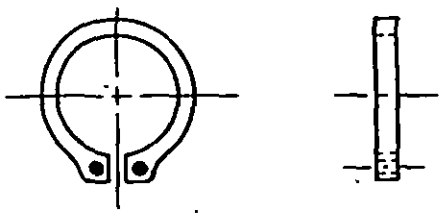
Intended use: To provide large shoulders for positioning and maintaining machine parts. They are applied radially and are locked positively in their grooves by means of two prongs extending from the inner circumference to the open end. They withstand high thrust loads and relative rotation between the retained parts. Their bowed construction provides resilient end-play take up in axial direction; however, they are not intended to take axial loads.

MS3217 - Ring, Retaining, External, Heavy Duty (Tapered Section Type)



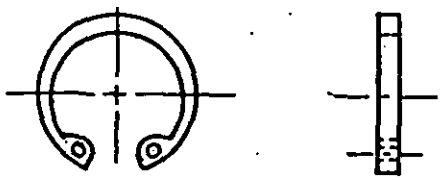
Intended use: To provide large shoulders for positioning and retaining machine components under heavy loading conditions on shafts, even if components to be secured have large corner radii or chamfers abutting the rings. They withstand comparatively heavy lock loads and high rotational speeds. They eliminate the need for separate thrust washers.

MS16624 - Ring, Retaining, External, Basic (Tapered Section Type)



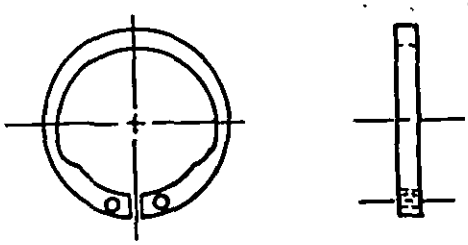
Intended use: To provide shoulders for positioning and retaining machine components on shafts. Tapered design principle permits rings to maintain practically constant circularity and pressure against bottom of groove, counteracting considerable centrifugal force. Rings for shaft diameters over 4 inches are specially dimensioned to maintain balance in rotation.

MS16625 - Ring, Retaining, Internal, Basic (Tapered Section Type)



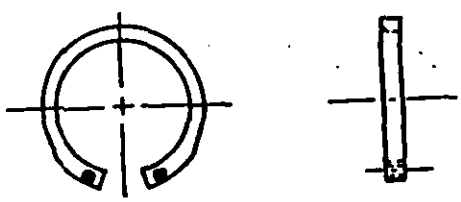
Intended use: To provide shoulders for positioning and retaining machine components in housings (bores). Tapered design principle permits rings to maintain constant circularity and pressure against bottom of groove.

MS16626 - Ring, Retaining, External, Inverted (Tapered Section Type)



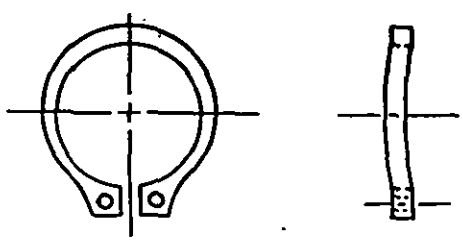
Intended use: To provide uniform protruding shoulders for positioning and retaining machine components on shafts. Tapered design principle permits rings to maintain practically constant circularity and fit securely against bottom of groove, counteracting considerable centrifugal force. Especially suited for locating and retaining machine parts having curved abutting surface.

MS16627 - Ring, Retaining, Internal, Inverted (Tapered Section Type)



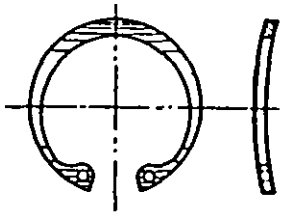
Intended use: To provide uniform protruding shoulders for positioning and retaining machine components in housings (bores). Tapered design principle permits rings to maintain practically constant circularity and fit securely against bottom of the groove. Especially suited for locating and retaining machine parts having curved abutting surfaces.

MS16628 - Ring, Retaining, External, Bowed (Tapered Section Type)



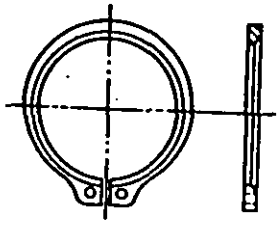
Intended use: To provide shoulders for positioning and retaining machine components on shafts. The rings are bent like a bow out of plane. Free ends and opposite edge abut machine part, mid-section of rings abuts outer groove wall. The ring will counteract considerable centrifugal forces. Ring will take up end play resiliently.

MS16629 - Ring, Retaining, External, Bowed (Tapered Section Type)



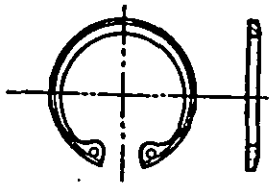
Intended use: To provide shoulders for positioning and retaining machine components in housings (bores). The rings are bent like a bow out of plane. Free ends and opposite edge abut outer groove wall. Mid-section of ring abuts machine part. Ring will take up end play resiliently.

MS16630 - Ring, Retaining, External, Beveled (Tapered Section Type)



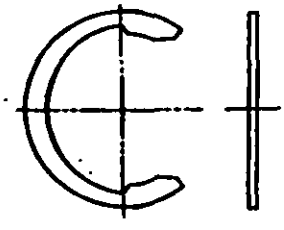
Intended use: To provide shoulders for positioning and retaining machine components on shafts. Tapered design principle permits rings to maintain practically constant circularity within the limits of expansion in normal use. The rings with bevel in inner circumference and when spring into groove with tapered outer wall corresponding to ring bevel, will self adjust and provide secure pressure fit axially to take up end play. The ring will counteract considerable centrifugal forces and will be secure against high rpm's.

MS16631 - Ring, Retaining, Internal, Beveled (Tapered Section Type)



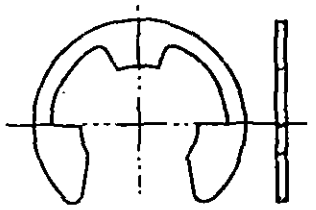
Intended use: To provide shoulders for positioning and retaining machine components in housings. Tapered design principle permits ring to maintain practically constant circularity. The rings with bevel on outer circumference and when sprung into groove with tapered outer wall corresponding to ring bevel will self adjust and provide secure pressure fit axially to take up end play.

MS16632 - Ring, Retaining, External, Crescent (Tapered Section Type)



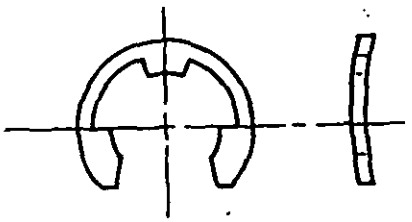
Intended use: To provide shoulders for positioning and maintaining machine parts on shafts which are axially inaccessible in assembly. They are applied radially and, because of deep grooves, have high thrust capacity. They are of advantage where fast assembly for mass production lines is essential and where comparatively small clearance diameters are desirable.

MS16633 - Ring, Retaining, External, E (Reduced Section Type)



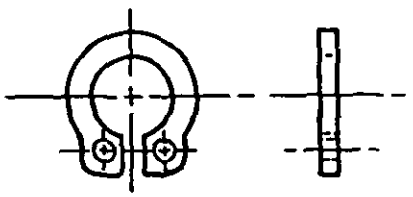
Intended use: To provide unusually large shoulders for positioning and maintaining machine components on shafts. They are applied radially and withstand considerable thrust load. They are advantageous where axial assembly of a retaining ring is not possible and where fast assembly for mass production lines is essential.

MS16634 - Ring, Retaining, External, Bowed E (Reduced Section Type)



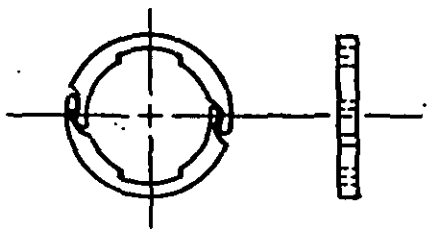
Intended use: To provide unusually large shoulders for positioning and maintaining machine components on shafts. They are applied radially and withstand considerable thrust load. The rings are bent like a bow out of plane. Free ends and opposite ends abut the machine part, midsection of ring abuts outer groove wall. Ring will take up end play resiliency. They are of advantage where axial assembly of a bowed retaining ring is not possible.

MS90707 - Ring, Retaining, External, Grip



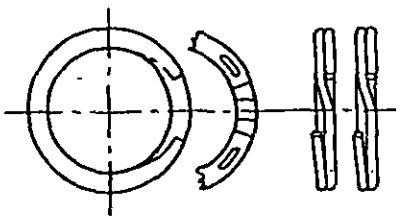
Intented use: To provide shoulders for positioning and retaining machine components on ungrooved shafts, tubes, bosses, studs, et cetera. Friction force caused by heavy spring pressure of ring on shaft makes fastener secure against axial displacement from either direction under moderate thrust or vibration. The rings are adjustable on the shaft and are reusable following disassembly. The rings will withstand high rotational speeds.

MS90708 - Ring, Retaining, External, Interlocking



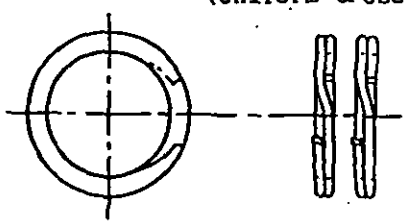
Intended use: To provide high circular shoulders for positioning and retaining machine components on shafts. The identical semicircular halves held together by the interlocking prongs form a balanced ring concentric with the shaft which will withstand high rotational speeds.

MIL-R-27426, Type A, Class 1 - Ring, Retaining, Spiral, External, Light Series (Uniform Cross Section)



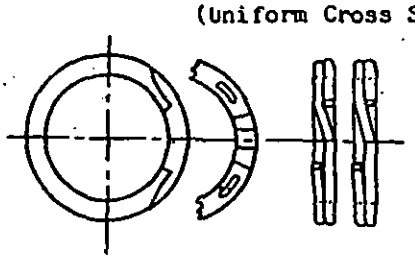
Intended use: To provide shoulders for positioning and retaining components on shafts. Provides a continuous uniform retaining shoulder. No special tools required to install or remove rings. Moderate thrust capacity.

MIL-R-27426, Type A, Class 2 - Ring, Retaining, Spiral, External, Heavy Series (Uniform Cross Section)



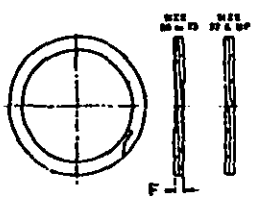
Intended use: To provide shoulders for positioning and retaining components on shafts. Provides a continuous uniform retaining shoulder. No special tools required to install or remove rings. High thrust capacity.

MIL-R-27426, Type B, Class 1 - Ring, Retaining, Spiral, Internal Light Series (Uniform Cross Section)



Intended use: To provide shoulder for positioning and retaining components in housing or bores. Provides a continuous uniform retaining shoulder. No special tools required to install or remove rings. Moderate thrust capacity.

MIL-R-27426, Type B, Class 2 - Ring, Retaining, Spiral, Internal, Heavy Series (Uniform Cross Section)



Intended use: To provide shoulder for positioning and retaining components in housing or bores. Provides a continuous uniform retaining shoulder. No special tools required to install or remove rings. High thrust capacity.

SANDWICH CONSTRUCTION FASTENERS

1. Purpose. This requirement defines the basic requirements for fasteners specifically designed for use in sandwich-type panels. It is limited to fasteners including studs, through-type sleeves, and female-threaded elements specifically designed to provide load-carrying capability in sandwich-type structures.

2. Documents applicable to Requirement 217.

MIL-S-8879	Screw Threads, Controlled Radius Root With Increased Minor Diameter, General Specification For
MIL-N-25027	Nut, Self-Locking, 250°F, 450°F, and 800°F, 125 Ksi F_{tu}, 60 ksi F_{tu}, and 30 ksi F_{tu}

3. Definitions

3.1 Sandwich construction. Composite assemblies composed of a minimum of two face sheets separated by, but attached to, a core or filler material capable of carrying the shear and compression force required to cause the composite to act as a single member.

3.2 Footprint area. The area of contact between the potting compound and the inside surface of the face skin(s). An increase in the footprint area reduces the loading-per-unit area, thus higher tension and shear loads are obtainable.

3.3 Sandwich panel fasteners. Fasteners installed mechanically, bonded to, or potted into, the sandwich structure which provide a means of transmitting axial or shear loads into the panel. In some configurations, they also provide column strength in the fastener area.

3.3.1 Mechanically installed. Fasteners featuring mechnical means of transmitting loads to each skin.

3.3.1.1 Nonremovable without damage (mechanically installed). Fasteners which are destroyed upon removal or whose removal causes physical damage to the sandwich construction.

3.3.1.2 Removable, without damage, (mechanincally installed). Fasteners capable of disassembly and are reusable.

3.3.2 Bonded. Fasteners which utilize a bond film between the insert, the skin(s), or the core material, either chemically or thermally activated, for reduction of the fastener.

3.3.2.1 Nonremovable, without damage (bonded). Fasteners capable of being removed without physical damage to the sandwich construction.

3.3.3 Potted in. Fasteners which utilize an agent, usually an epoxy-type compound, chemically or thermally activated to solidify between the insert, the core material, and the skin(s), thereby providing retention of the fastener. Since removability of this type fastener is a function of the potting compound, the fastener itself is not defined as removable without damage, or nonremovable, without damage.

3.3.4 Welded or brazed. Fasteners which utilize a welding or brazing operation to permanently attach the fastener to the sandwich structure.

3.3.5 Clearance, hole type. Permanently installed nonthreaded inserts designed to transmit axial and shear loads from a fastener into a structure of sandwich construction.

3.3.6 Internally threaded type. Permanently installed threaded inserts, designed to transmit axial and shear loads from a fastener into a structure of sandwich construction.

3.3.6.1 Blind type. An insert which does not extend through the sandwich panel. It is blind in the sense that it does not penetrate the face sheet on the side opposite to the installation hole.

3.3.6.2 Fixed. An insert having a threaded element which, once installed does not provide radial movement.

3.3.6.3 Floating. An insert having a threaded element, usually a multi-piece part, which allows a radial movement of the threaded element prior to loading.

3.3.7 Studs. Inserts having threaded or nonthreaded elements protruding from the face skin(s), permanently installed, and designed to transmit axial and/or shear loads into or through sandwich structure.

3.4 Permanently installed. An insert is considered permanently installed when the removal of the same would necessitate use of an oversize replacement and repair to the sandwich structure.

4. Installation and performance

4.1 Installation procedure. Refer to the fastener manufacturer's recommended installations specifications.

4.2 Performance characteristics. The methods used to transmit loads into and out of sandwich structure are important. As a result, design-allowable loads must be substantiated by test. The test procedures established by the fastener manufacturer and users should be followed. Tension, shear, and torque tests are generally conducted and only the parameters of the end use should be considered.

4.2.1 Other limitations. Panel service environmental requirements dictate the fastener selection and installation method.

4.2.2 Performance requirements of fastener. MIL-N-25027 applies to the fastener for self-locking torque (as installed and reusability as applicable.) Axial tensile, shear, and torque-out strengths are a function of the strength of the panel, design of the insert, and the amount of grip between the insert and panel (mechanical) or footprint area (potted or bonded). Therefore, the ultimate load-carrying capability of the insert shall be based on the design requirements of the specific application and verified by tests.

4.2.3 The thread form shall be in accordance with MIL-S-8879 and modified as necessary by construction and self-locking requirements.

5. General

5.1 Application. Variations in sandwich structure are unlimited. Face skin may vary in thickness from several thousandths of an inch to .250 inch or more. They may be metallic or nonmetallic. Core may be honeycomb of various cell sizes and materials, homogeneous materials, or any other material of various configurations capable of transmitting loads to the outer skins.

5.1.1 Special applications. Many nonmetallic face skins cannot be dimpled. Metallic face skins over .032-inch thick are generally machine countersunk when a mechanical fastener and a flush surface are required. It is also difficult to have a mechanical fastener grip nonmetallic face skins. Certain face skins such as titanium and aluminum alloy 7075 may not be dimpled. Epoxies with densities varying from about 35 pounds to 125 pounds per cubic foot are available. Application should be coordinated between fastener manufacturers and the sandwich panel user.

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CONTROL CABLE AND CONTROL/STRUCTURAL ROD COMPONENTS; FASTENING AND SAFETYING

1. Purpose. This requirement establishes engineering criteria and requirements for the selection and attachment of terminals (fittings) to cable, the fastening of control cable fittings together, the attachment of end fittings to control rods, and the safetying of control cable fittings and control rods. In addition, the requirements for the bolts or screws supporting pulleys, fairleads, actuators, tension regulators, rod ends, hinges, and other control system components are established. This requirement does not establish selection criteria for control cable systems with respect to sizing, locating, tensioning, actuating, or pulley and fairlead selection and use.

1.1 Exceptions. With respect to structural and control rods, this requirement does not cover material, wall thickness, diameter, sizing, tensile or compressive strength, or other factors in the selection of the rod itself.

2. Document applicable to Requirement 219.

MIL-STD-1599	Bearings, Controls Systems Components, and Associated Hardware used in the Design and Construction of Aerospace Mechanical Systems and Subsystems.

3. Control cable and control and structural rod components; fastening and safetying. See MIL-STD-1599 for criteria and requirements for the selection and attachment of terminals (fittings) to cable, the fastening of control cable fittings and control rods. Also, for requirements for the bolts or screws supporting pulleys, fairleads, actuators, tension regulators, rod ends, hinges, and other control system components, see MIL-STD-1599.

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PINS, QUICK-OPERATING

1. Purpose. This requirement shall establish engineering criteria and requirements for the application of quick-operating pins. This requirement shall apply to positive-locking, quick-operating pins.

2. Documents applicable to Requirement 220.

MIL-P-23460	Pin, Quick-release, Self-retaining, Positive-locking
MS17984	Pin, Quick Release, Self-retaining, Positive Locking, Single Acting, Button Handle
MS17985	Pin, Quick Release, Self-retaining, Positive Locking Single-Acting, (T) Handle
MS17986	Pin, Quick Release, Self-Retaining, Positive Locking, Single-Acting (L) Handle
MS17987	Pin, Quick Release, Positive Locking, Single Acting Ring Handle
MS17988	Pin, Quick Release, Positive Locking, Double-Acting, (T) Handle
MS17989	Pin, Quick Release, Positive Locking, Double-Acting, (L) Handle (Asg)
MS17990	Pin, Quick Release, Positive Locking, Double-Acting, Ring Handle (Asg)
NAS 618	Fastener, Recommended Shank, Hole and Head To Shank Fillet Radius Limits for

3. Classification. Quick-Operating pins shall be of the following types:

Type I -- Positive locking pins, single-acting. Pins can only be installed or removed by pushing a button in the head which allows the balls to retract into the pin body (see figure 220-1).

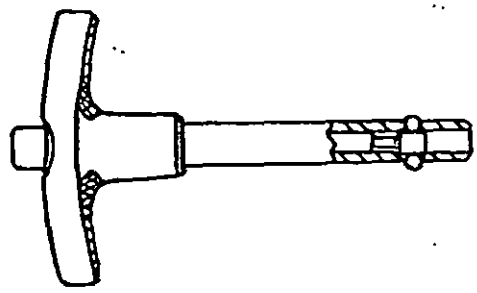

FIGURE 220-1. Single acting, positive locking pins.

Type II -- Positive-locking pins, double-acting. Pins can only be removed by pushing or pulling the handle in the head which allows the balls to retract into the pin body (see figure 220-2).

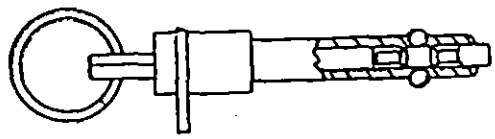

FIGURE 220-2. Double acting, positive locking pins.

4. General. Quick-operating, positive-locking pins are primarily designed to be used in applications that require double shear strength capabilities combined with quick-disconnect features. Pins shall be capable of withstanding tension loads as listed in MIL-P-23460. The specific shear and tension load capabilities are a function of the material being attached, hole size, and hardness of application material. MIL-P-23460 gives double shear and tensile rating in steel application.

5. Application. Typical applications are quick attachment and removal of ground support equipment and attaching warning streamers to critical joints.

SECTION 300 - NONSTRUCTURAL FASTENER REQUIREMENTS

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SECTION 400 - PROPULSION SYSTEMS FASTENER REQUIREMENTS

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SECTION 500 - HYDRAULIC SYSTEMS FASTENER REQUIREMENTS

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SECTION 600 - ELECTRICAL/ELECTRONIC FASTENER REQUIREMENTS

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SECTION 700 - SUBSYSTEMS/AUXILIARY FASTENER REQUIREMENTS

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