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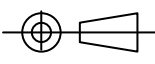
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FASTENER SYSTEMS FOR AEROSPACE APPLICATIONS



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FORM 09-01	THIRD ANGLE PROJECTION 	CUSTODIAN NATIONAL AEROSPACE STANDARDS COMMITTEE	REVISION 1
	PROCUREMENT SPECIFICATION NONE	TITLE FASTENER SYSTEMS FOR AEROSPACE APPLICATIONS	CLASSIFICATION STANDARD PRACTICE NAS 1515 SHEET 1 OF 95

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.

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

*** Denotes change from MIL-STD-1515A

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	206	24 June 1983 ***	Rivets, Solid
	207	*	Pins, Dowel, Taper, Spring
	208	12 July 1978	Spacers, Bushings, Sleeves
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	217	12 July 1978	Sandwich Construction Fasteners
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	220	12 July 1978	Pins, Quick Operating
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	222	(deleted)	Captive Screws
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	224	(deleted)	Fluid Sealing Fasteners

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** SECTION 800 APPLICATION REQUIREMENTS (PROPOSED)

*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.

*** Denotes change from MIL-STD-1515A

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

National Aerospace Standards

NASM17855 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:

SAE International

AMS, AS,
ARP, AIR,
AMD

Copies can be obtained from SAE International, 400 Commonwealth Dr., Warrendale, PA 15096-0001. www.sae.org

American National Standards Institute

ASQ

Copies can be obtained from the American Society for Quality, 600 North Plankinton Ave., Milwaukee, WI 53203. www.asq.org

ASTM International

ASTM

Copies can be obtained from ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959. www.astm.org

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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 fastening 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 is 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:
- Loss of aircraft.
 - Preclusion of continued flight and landing within the design limitations of the aircraft using normal pilot skill and strength.
 - Significant injury to the occupants of the aircraft or ground personnel.
 - 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.

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- 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 unthreaded portion of a fastener between the head and the threads, locking grooves, formed head, etc.

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 NASM1515. 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
- a. 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.
 - b. 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.
 - c. Section 100 Requirements apply only to Section 200 Structural fastener requirements (excluding subsequent proposed sections such as nonstructural, propulsion, etceteras, not published or in preparation).
- 4.3 Descriptive factors and symbols. The descriptive factor symbols used in this standard shall be in accordance with NASM17855.

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.
- 6.2 Implementation. This standard may not be applicable to programs in the experimental, developmental, exploration prototype, demonstration, validation program phases where the advantages of the standard will not be realized.

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SECTION 100 - GENERAL DESIGN REQUIREMENTS

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REQUIREMENT 103

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 or lessening of galling and seizure, inhibiting fretting, aid in installing and removing fasteners, control of installation 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-HDBK-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 NASM1515, 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 applicable 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-PRF-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-PRF-46147 -54 °C to 121 °C (-65 °F to 250 °F)
 - (2) Class 2B – Heat Cured, corrosion inhibiting.
Class 2B1 – ~~MIL-L-8937~~ AS5272, TYPE I -54 °C to 260 °C (-65 °F to 500 °F)
Class 2B2 – ~~MIL-PRF-46010~~ AS5272, TYPE II -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-8860~~ AS8860

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- 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-PRF-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~~ AMS-G-6032
Class 3C1 – ~~MIL-G-4343~~ AMS-G-4343
 - d. Class 4. Anti-seize compounds, Metallic.
 - (1) Class 4A
Class 4A1 – White lead compound in accordance with DOD-L-25681.
 - (2) Class 4B
Class 4B1 – Anti-seize compound in accordance with ~~MIL-T-5542~~ MIL-PRF-27617.
 - (3) Class 4C
Class 4C1 – Anti-seize compound in accordance with MIL-PRF-83483.
 - (4) Class 4D
Class 4D1 – Anti-seize compound in accordance with MIL-PRF-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~~ AMS2518.
- 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 AMS2412 for applications not exceeding 260 °C (500 °F) maximum.
 - (2) Class 1B – Silver plating. Silver plating shall be in accordance with AMS2410 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 AMS2411 for applications not exceeding 760 °C (1,400 °F) maximum. May be used where Classes 1A and 1B are specified.

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REQUIREMENT 103

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-PRF-907	Anti-seize Compound High Temperature
ASTM D 910	Standard Specification for Aviation Gasolines
AMS1424	Deicing/Anti-Icing Fluid, Aircraft SAE Type I
~~MIL-STD-1523~~	~~Age Control of Age Sensitive Elastomeric Material~~
J1899	Lubricating Oil, Aircraft Piston Engine, (Ashless Dispersant)
AMS2410	Silver-Plating, Nickel Strike, High Bake
AMS2411	Silver-Plating, High Temperature application
AMS2412	Silver-Plating, Copper Strike, Low Bake
AMS2518	Thread compound, Anti-seize, Graphite-petrolatum
~~MIL-G-4343~~	~~Grease, Pneumatic Systems~~
AMS-G-4343	Grease, Pneumatic Systems
AS5272	Lubricant, Solid Film, Heat Cured Corrosion Inhibiting
ARP5316	Storage of Elastomer Seals and Seal Assemblies Which Include an Elastomer Element Prior to Hardware Assembly
~~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 Ordnance
MIL-DTL-5624	Turbine Fuel, Aviation, Grades, JP-4 and JP-5
AMS-G-6032	Grease, Plug Valve, Gasoline and Oil Resistant, NATO Code Number G-363
~~MIL-G-6032~~	~~Grease, Plug Valve, Gasoline and Oil Resistant~~
MIL-PRF-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~~
AS8660	Silicone Compound NATO Code Number S-736
~~MIL-S-8802~~	~~Sealing Compound, Temperature resistant, Integral Fuel Tanks and Fuel Cell Cavities, High-adhesion~~
AMS-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-PRF-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-PRF-23699	Lubricating Oil, Aircraft Turbine Engines, Synthetic Base
DOD-L-25681	Lubricant, Molybdenum Disulfide, Silicone Base, High Temperature
MIL-PRF-27617	Grease, Aircraft And Instrument, Fuel and Oxidizer Resistant
~~MIL-PRF-46010~~	~~Lubricant, Solid Film, Heat Cured Corrosion Inhibiting~~
MIL-PRF-46147	Lubricant, Solid Film, Air-cured (Corrosion inhibiting)
MIL-PRF-81329	Lubricant, Solid Film Extreme Environment
MIL-PRF-83483	Thread Compound, Anti-seize, Molybdenum Disulfide-petrolatum

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REQUIREMENT 103

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 applicable block.
 - 4.1.2 Temperature limit. 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 relubrication. Lubricants which have a limited shelf life and require age control shall be controlled in accordance with ~~MIL-STD-1523~~ ARP5316.
 - 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 applicable 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 not 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 specialized 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. Cautions. 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. Restrictions. 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. Restrictions: 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. Restrictions: Type III coatings shall not be applied to titanium pins, nuts, or collars or be used in contact with titanium structure.

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- 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. Allowance: 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.

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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, NAS 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.

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TABLE 103-I – FLUID COMPATIBILITY

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
MIL-A-907																				
MIL-PRF-907																				
MIL-C-5572			X	X	X		O	O	O	X	O	O	O					X	X	X
MIL-H-5606			X	X	X		O	O	O	X		O	O					X	X	X
MIL-DTL-5624			X	X	X		O	O	O	X		O	O					X	X	X
MIL-PRF-7808			O	X	X		O	O	O			O	O					X	X	X
MIL-A-8243						X	O	X	X	X	X	X	X					X	X	X
AMS1424																				
MIL-H-8446			X	X	X	X	O	O	O	X		O	O					X	X	X
MIL-S-8802						X	X	X	X	X	X	X	X					X	X	X
AMS-S-8802																				
MIL-PRF-16173			X	X	X	X	X	X	X	X	X	X	X					X	X	X
MIL-A-13881																				
MIL-G-21164																				
MIL-L-22851							O	O	O	X	O	O	O					X	X	X
J1899																				
MIL-PRF-23699			O	X	X		O	O	O			O	O					X	X	X
MIL-T-27730																				
A-A-58092																				
Type II C1.1A-1																				
LPS No. 1																				

- (a) "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.
- (b) "O" in the block indicates known incompatibility between the fluid and the lubricant.
- (c) Blank indicates unknown characteristics of the combination.

TABLE 103-II – TEMPERATURE LIMITS

TEMP. LIMITS	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
-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												1,400 °F X (760 °C)							965 °F X (518 °C)	1,400 °F X (760 °C)

- (d) "X" indicates lubricant is acceptable to the temperature limits indicated.
- (e) Blank indicates unknown or not applicable.
- (f) Lubricants may be detrimentally affected by extended exposure to temperature extremes.

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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					O	O	O
	6000 SERIES	X		X	X	X	X	X	X	X	X	X	X	X					O	O	O
	7000 SERIES	X		X	X	X	X	X	X	X	X	X	X	X					O	O	O
ALLOY STEEL – CADMIUM PLATED		X		X	X	X	X	X	X	X	X	X	X	X					O	O	O
CRES	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					O	O	O
GRAPHITE FIBERS																					
MAGNESIUM		X		X	X	X	X	X	X	X	X	O	O						O	O	O

- (g) "X" indicates that experience and/or testing concludes that no detrimental effects are caused by intimate contact of the lubricant with the material.
- (h) "O" indicates known detrimental conditions are caused by contact of the lubricant with the material.
- (i) Blank indicates unknown characteristics of the combination.

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REQUIREMENT 103

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 MIL-PRF-680 Dry Cleaning Solvent
3. Material
 - 3.1 Cetyl alcohol. National Formulary Grade ($\text{CH}_3(\text{CH}_2)_{15}\text{OH}$) (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 MIL-PRF-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 .25 to .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 .75 to .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 .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.

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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 allowed to dry before handling. Parts may then be spread on wire rack or nonabsorbent surface to facilitate drying. Application of a centrifuge for 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.

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REQUIREMENT 109

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
MMPDS Metallic Materials and Elements for Aerospace Vehicle Structures
3. Design allowable loads. The design allowable loads shall be in accordance with MMPDS.
- 3.1 Unavailable allowable loads. Where load or stress allowables are not contained in MMPDS, they shall be obtained by test data in accordance with Chapter 9, Section 7, of MMPDS, or by analysis or data acceptable to the procuring activity.

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REQUIREMENT 110

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 standard.
2. Documents applicable to Requirement 110

NASM1312 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. NASM1312 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 NASM1312 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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REQUIREMENT 111

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**

NASM8922	Nut, Self-Locking, Steel, 220 ksi F_{tu} , 450 °F
MIL-F-8961	Fastener, Externally Threaded, 450 °F and 1200 °F, Self-Locking Design
NASM8985	Nut, Self-Locking, Steel, 180 °F, 450 °F
MIL-DTL-18240	Fastener, Externally Threaded, 250 °F, Self-Locking Element For
NASM25027	Nut, Self-Locking, 250 °F, 450 °F, and 800 °F, 125 ksi F_{tu} , 60 ksi F_{tu} , and 30 ksi F_{tu}
NASM15981	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
NASM33540	Safety Wiring and Cotter Pinning, General Practices for
NASM33588	Nut, Self-Locking, Aircraft, Reliability and Maintainability Usage Requirements for
NASM33602	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, etc.) and shall be used in accordance with NASM15981 and NASM33588. A self-locking element in accordance with MIL-F-8961 and MIL-DTL-18240 may be incorporated in externally threaded fasteners, and in accordance with NASM25027, NASM8922, and NASM8985 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, etc.), they shall incorporate a self-retaining bolt in accordance with NASM33602. 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: (1) its loss could preclude continued flight and landing within the design limitations of the aircraft using normal pilot skill and strength, or (2) 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 NASM15981 (external threads), NASM33588 (internal threads), and NASM33602. When safety wire and cotter pins are required, they shall be used in accordance with NASM33540.
 - 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 washers 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.

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REQUIREMENT 112

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-HDBK-965 Acquisition Practices for Parts Management
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-HDBK-965. When contracts do not call out any of the above-documented procedures, the requests shall be made to or contact points listed in Table 112-I, through the procuring activity in accordance with Procedure I of MIL-HDBK-965, and the data requirements of 3.1 of this requirement.
- 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. 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. Contract data requirements shall include the data specified in 3.1.

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REQUIREMENT 112

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

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REQUIREMENT 113

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-HDBK-57	Identification Symbols for Aerospace Fastener Manufacturers
MIL-HDBK-131	Identification Markings for Fasteners
NAS1347	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 NAS1347. Fastener identification covered by NAS1347, 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-HDBK-57. Those manufacturers not listed in MIL-HDBK-57 will be required to submit a symbol for approval.

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REQUIREMENT 115

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, mechanicals, 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 NASM1515, 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.
6. ~~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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REQUIREMENT 119

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
AS8879 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 AS8879. 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. AS8879 threads shall be used for all components or parts made of material with minimum ultimate tensile strength (F) in excess of 150 ksi or with a minimum hardness greater than 32 HRC or equivalent.
 - b. AS8879 threads shall be used in applications where the operational temperatures exceed 232 °C (450 °F), or are less than -78 °C (-108 °F).
 - c. AS8879 threads shall be used in applications that specify fatigue strength or fracture critical parts.
 - d. AS8879 Class 3A threads shall be used for all externally threaded fasteners .164 inch diameter and larger.
 - e. AS8879 Class 3B threads shall be used for all internally threaded fasteners .164 inch diameter and larger.
 - f. Internal threads as specified in AS8879 may be used with external threads conforming with MIL-S-7742.

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REQUIREMENT 120

DRIVE AND WRENCHING ELEMENTS

1. Purpose. This requirement provides for the selection of drive and wrenching elements established as approved for use in aerospace structure fastener systems. Selection may be further limited by other documents.
2. Documents applicable to Requirement 120
 - 2.1 Government documents

Federal Specifications

GGG-W-636	Wrenches, (Box, Open End, and Combination)
GGG-W-660	Socket, Socket Wrench and Attachments (For Power Driven Impact Wrenches)
GGG-W-1437	Wrench, Socket and Box End (Thin Wall-High Strength)

Military Specifications

MIL-W-8982	Wrenches, Splined, Socket and Box, Square Drive, High Strength, Thin Wall
MIL-B-9946	Bits, Screwdriver, General Specification for

Military Standards

MS33787	Wrenching Element, External Spline, Dimensions for
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Other Government Documents

TO 1-1A-8	Engineering Handbook Series for Aircraft Repair; General Manual for Structural Repair
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 - 2.2 Non-Government Documents

ASME B18.3	Socket Cap, Shoulder, and Set Screws, Hex and Spline Keys
NAS7100	Recess, Ribbed Cruciform, Dimensions of Recess and Gages
NAS7101	Bit, Screwdriver, Cruciform, Specification for
NASM9006	Recesses, Cross, Low Torque Drive, Dimensions and Gage Dimensions for
NASM14191	Recess, Ribbed-Offset Cruciform, Dimensions of Recess, Gage and Driver for
NASM21132	Wrenching Element, External Hexagon, for Threaded Fasteners
NASM33750	Recess, Dovetail Slot; Dimensions of Recess, Gage, and Driver for
NASM33781	Recess, Offset Cruciform, Dimensions of Recess, Gage, and Driver for
 - 3. Design and usage limitations
 - 3.1 External wrenching elements (external or internal threaded)
 - 3.1.1 The hexagon drive external wrenching element in accordance with NASM21132 shall be limited to use for fasteners up to 180 ksi maximum ultimate tensile stress only.
 - 3.1.2 All externally threaded fasteners heat treated to 180 ksi minimum ultimate tensile stress and higher and all internally threaded fasteners rated at 180 ksi minimum ultimate tensile stress and higher shall have the MS33787 external wrenching element. Fasteners less than 180 ksi may utilize the MS33787 wrenching element.
 - 3.2 Internal drive elements
 - 3.2.1 The NASM9006 recess shall be limited to use in fasteners heat treated up to 150 ksi maximum ultimate tensile stress.

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REQUIREMENT 120

- 3.2.2 The NAS7100 recess may be used in fasteners heat treated up to 160 ksi maximum ultimate tensile stress. (Note: Fasteners heat treated above 160 ksi maximum ultimate tensile stress with NASM9006 or NAS7100 recess may be used in secondary structure with acquisition activity approval.)
- 3.2.3 Recesses in accordance with NASM33750, NASM33781 and NASM14191 shall be used in fasteners heat treated to 160 ksi minimum ultimate tensile stress and higher. These recesses may be used in fasteners below 160 ksi in order to reduce the recess types used in each system.
- 3.2.4 Internal hexagon recess in accordance with ASME B18.3 shall be limited to the threaded end of pins without head driving recess, set screws, and certain panel fasteners as specified in Requirement 129. Acquisition activity approval is required for use of socket head cap screws in airframe structures.
4. Design selection and approved callout
- Drive and wrench elements identified by this requirement shall conform to the documents listed in Section 2 and shall be selected from Table 120-I.
5. Tooling
- 5.1 Bits for installing internal drive fasteners shall be in accordance with MIL-B-9946, NASM33781, NASM14191, NASM33750, ASME B18.3, and NAS7101, as applicable.
- 5.1.1 Refer to TO 1-1A-8, Section III for driver wear limits.
- 5.2 Wrenches for installing fasteners with spline or hexagon external wrenching elements shall be in accordance with MIL-W-8982, GGG-W-1437, GGG-W-636, as applicable. MIL-W-8982 wrenches are compatible with both the 12-spline and NASM21132 hexagon wrenching elements. Wrenches in accordance with GGG-W-636, GGG-W-660, and GGG-W-1437 are not compatible with the 12-spline wrenching element in accordance with MS33787.
- 5.3 Recesses in accordance with NASM9006 and NAS7100 and their related tools are fully interchangeable. Recesses in accordance with NASM14191 and NASM33781 and their related tooling are fully interchangeable.
- 5.4 Care shall be exercised to ensure that the correct size bit or wrench is used and particularly for internal drives that specified installation torque requirements are not exceeded.
6. Intended use and guidance criteria
- 6.1 Some "off-the-shelf" aerospace systems may contain fasteners with drive and wrenching systems not specified herein. Field replacement with preferred drive and wrenching elements shall be dependent upon availability of equivalent hardware meeting all other required features (configurations, material, performance, etc.) of the original fasteners.

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