MILITARY STANDARD

FASTENING SYSTEMS, MECHANICAL, AIR VEHICLE

NO DELIVERABLE DATA

FSC 5325

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DEPARTMENT OF DEFENSE

WASHINGTON, D.C. 20301

Fastening System, Mechanical, Air Vehicle

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FOREWORD

This document presents the criteria and qualities applicable to air vehicle mechanical fasteners and fastening systems.

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APPENDIX

FIGURES

TABLE

1. SCOPE

1.1 Scope. This standard establishes technical criteria and qualities for air vehicle fastener systems for use in tailoring aerospace system requirements during acquisition.

1.2 Use. This standard cannot be used for direct contractual purposes without supplemental information required for specific application.

1.2.1 Structure. Supplemental information is identified in the appendix/handbook for use in preparation of the tailored document.

1.2.2 Instructional handbook. The handbook which is contained in the appendix herein, provides the rationale for the requirements, guidance for tailoring and applying this standard to a particular program, and a lessons learned repository.

2. REFERENCED DOCUMENTS

2.1 Government documents

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

SPECIFICATIONS

STANDARDS

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

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

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

(Nongovernment publications and standards are generally available for reference from libraries. They are also distributed among nongovernment standard bodies and using Federal agencies.)

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

3. DEFINITIONS

3.1 Anchornut. A non-wrenching or self-wrenching (self holding) multiple piece nut assembly, which is attached by either rivets, adhesives, integral splines or flaring of some portion of the assembly or welded to the structure. Anchornuts, sometimes called plate nuts, can be either floating or non-floating (fixed). If used in strip or circle channels, they are usually called gang channel nuts.

3.2 Approved fastener. A fastener which is established as applicable to a specific program as listed in the Program Parts Selection List (PPSL), as detailed in the applicable Parts Control Program Plan, as specified in this standard and as approved by the procuring activity.

3.3 Blind fastener. Any fastening system which is installed from one side of the structure.

3.4 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 the air vehicle.

b. Preclusion of continued flight and landing within the design limitations of the air vehicle using normal piloting skills and strength.

c. Significant injury to the occupants of the air vehicle or to ground personnel.

d. Failure to complete the mission.

3.5 Design allowables. Tensile and shear strengths of fasteners and yield and ultimate strengths of mechanically fastened joints used in design of air vehicle structures including fatigue and damage tolerance design data where applicable. Design allowables may be stated in terms of loads or stresses as pertains to a particular joint/fastener application.

3.6 Fastener. A mechanical device for holding two or more components in position with respect to each other.

3.7 Fastening system. A fastener, including its component parts, and installation and removal tooling and procedures as well as the geometry of the hole or special hole preparation techniques where they affect the performance of the system.

3.8 **Fatigue life improving fasteners.** Fatigue life improving fasteners include tapered as well as straight shank fasteners and/or any hole process which enhances fatigue life or retards crack growth.

3.9 **Grip length.** The distance from the underhead bearing surface to the commencement of the thread run out or undercut. In flush headed fasteners, the head height is included in the grip length.

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

3.11 **Locking device.** A part or mechanism designed to limit loss of preload or to prevent disengagement of the fastener.

3.12 **Permanent fastener.** A fastener which requires the destruction of the fastener or one of its components during removal.

3.13 **Quick release panel fastener.** This term is a generic name for a category of fasteners and refers to any fastener that has multiple lead threads or operates faster than a single lead, threaded nut and bolt. This category covers structural as well as non-structural fasteners such as 1/4 turn fasteners.

3.14 **Receptacle or anchor.** The undriven mating component which receives a panel or door mounted sleeve bolt/stud nut or stud bolt is referred to as the receptacle or anchor and is usually mounted on the substructure.

3.15 **Reduced head.** Reduced head fasteners refer to any flush fastener which has a head height of less than (usually 1/2) the height of a full head or tension head. Also referred to as a shear head. See shear head.

3.16 **Self-locking.** An attribute of a fastener assembly having an integral locking element to impede relative rotation of mating components.

3.17 **Self-retaining bolt.** Self-retaining bolts are special fasteners (bolts) which incorporate a self-retaining feature at the end of its grip length, just before the threads. They are intended for use in "critical" single joints (such as linkages) and will ensure that the bolt remains in place (linkage remains together) if the nut or cotter pin in the nut is inadvertently omitted or the nut is lost in service. There are two types of self-retaining bolts, one is a positive locking type and the other is an impedance type.

3.18 **Shank length.** That portion of a headed fastener that extends from the plane of the head bearing surface to the opposite end, including threads. The shank length of a headless fastener is the overall length.

3.19 **Shear head.** Shear head refers to any flush fastener which has a head height of less than (usually 1/2) the height of a full head or tension head. Also referred to as a reduced head or reduced shear head. A fastener with a shear head is designed to be loaded normal (at 90 degrees) to the fastener centerline (axis) in shear.

3.20 **Short threaded bolts or screws.** Short threaded bolts or screws are those with threads which are less than the nut height plus two threads.

3.21 **Sleeve bolt/stud nut.** Sleeve bolt/stud nut refers to particular types of panel fasteners. They are hollow and threaded on the inside and are usually captive in the panel or door. These are not to be confused with a fatigue life improvement fastener which incorporates a solid threaded tapered pin in an internally tapered sleeve.

3.22 **Stud bolt.** Stud bolt refers to a particular type of solid, externally threaded bolt and is usually captive in the panel or door.

4. REQUIREMENTS

4.1 **General.** This standard provides technical criteria for air vehicle fastening systems as outlined in the following:

a. Fastening systems (4.2).

b. Fastener attributes criteria, general (4.3).

c. Fastener application criteria, general (4.4).

4.2 **Fastening systems.** The fastening systems used in aerospace applications to which this standard applies shall consist of fasteners listed in the Program Parts Selection List (PPSL), detailed in the Parts Control Program Plan, specified in this standard and approved by the procuring activity.

4.3 **Fastener attributes criteria, general.** The factors delineated in this section identify characteristics of fasteners which require definition and control exclusive of the application environment.

4.3.1 **Flush fasteners.** The nominal head angle of flush fasteners shall be _____ degrees (included angle). Deviations from this nominal head angle for flush head fasteners shall require approval of the procuring activity.

4.3.2 **Threads.** The threads for fasteners shall comply with the requirements of _____.

4.3.3 **Recess/wrenching elements.** The wrenching elements selected for use in aerospace structural fastening systems shall comply with _____.

4.3.4 **Plating and coating.** Fasteners which are plated or coated shall comply with _____.

4.4 **Fastener application criteria, general.** The factors delineated in this section are inclusive of those criteria intended to place specific controls on the overall application of fasteners.

4.4.1 **Design allowables.** The fastener and joint design allowables shall not exceed those design allowable values specified in _____. Where the design allowables are nonexistent, they shall be established in accordance with _____.

4.4.2 **Fasteners in access panels and doors.** Except for captive fasteners, fasteners used to retain access panels and doors shall be of the same diameter, grip length, and shank length within any one panel or door. Where the same grip length and shank length cannot be used, the diameter shall be changed. Sleeve bolt/stud nut panel fasteners shall be at least _____ inch outside diameter. Stud bolt panel fasteners shall be at least _____ inch diameter. Structural panel fasteners shall have an internal hexagonal wrenching recess. Formed-in-place gasket material shall not be used as a spacer or in place of a counterbore for the retaining rings.

4.4.3 **Torque control.** Fastener torque shall be controlled for all installed fasteners as pertains to the specific application.

4.4.4 **Minimum fastener diameter.** The shank diameter of threaded structural fasteners shall not be less than _____.

4.4.5 **Head size.** Reduced head or shear head flush fasteners of _____ inch diameter with a driving recess in the head and a head diameter equal to or less than _____ times the shank diameter shall not be used.

4.4.6 **Screws and bolts.** Screws and bolts, including studs selected for use in aerospace structural joining shall conform to the following:

a. Bolts smaller than _____ inch diameter shall not be used in any single bolted structural connection, including primary flight control systems.

b. Screws and bolts, as installed shall have a remote probability of causing or becoming foreign object damage (FOD) material, particularly fasteners in those areas where they could disengage and become safety of flight FOD material or significantly degrade the mission capability of the air vehicle.

c. Aluminum alloy threaded bolts shall not be used in structural applications.

d. Socket head cap screws shall not be used in air vehicle structures.

e. Titanium alloy bolts shall not be cadmium or silver plated.

f. Cadmium plated screws or bolts shall not be used in temperature probes, electrical components or systems, potable water supplies or food processing equipment. They shall not be used in space vehicle components or systems due to the instability of cadmium in a vacuum environment.

g. Cadmium plated screws and bolts shall not be used where the temperature exceeds _____ °F.

h. Cadmium plated screws and bolts shall not be used in titanium structure where the temperature is above _____ °F.

i. Silver plated screws and bolts shall not be used in contact with titanium and titanium alloy nuts in application where the operating temperature exceeds _____ °F.

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

k. Self-locking bolts shall have a self-locking element in accordance with _____ and are subject to the following limitations.

(1) Self-locking bolts shall be selected and used in a manner that will permit full functional and dimensional interchangeability with parts defined by the applicable standard and drawings.

(2) Self-locking bolts shall be used only in applications that permit full engagement of the locking element with threads of the mating component.

(3) Self-locking bolts with nonmetallic self-locking elements shall not be used where the locking element will encounter keyways, slots, cross holes, or other thread interruptions.

(4) Self-locking bolts that incorporate an insert or part that is nonmetallic shall have the entering end of the threaded holes, used in conjunction with the fastener, countersunk _____ degrees. This countersink shall have a minimum diameter that is _____ inches larger than the major thread diameter of the fastener.

(5) Unthreaded holes or portions of holes through which the locking element of the bolt must pass shall have a diameter sufficient to clear the locking element.

(6) Self-locking bolts shall not be used to attach access panels or doors or to assemble any parts that are routinely disassembled at intervals less than _____ flight hours.

(7) Self-locking bolts shall not be used when the locking device has been reworked or reprocessed.

(8) Self-locking bolts shall not be used with castellated or self-locking nuts.

(9) Self-locking bolts may be used as an axis of rotation for another part provided the fastener is held in position by a positive locking device that requires shearing or rupture of material, e.g. installations involving pulleys, cranks, levers, linkages, hinge pins, and cam followers using cotter pinned or wired castellated nuts.

4.4.7 **Nuts.** Nuts selected for use in aerospace structural applications shall comply with the following requirements.

a. Bolts, screws or studs must extend through the nut for a minimum of two threads.

b. Nuts, as installed shall have a remote probability of causing or becoming foreign object damage (FOD) material, particularly those areas where they could disengage and become safety of flight FOD material or significantly degrade the mission capability of the air vehicle.

c. Silver plated nuts shall not be used with silver plated bolts.

d. Silver plated nuts shall not be used in contact with titanium and titanium alloy screws, bolts or studs in application where the operating temperatures exceeds _____ °F.

e. Cadmium plated nuts shall not be used in contact with titanium structure and bare titanium alloy screws, bolts or studs in application where the operating temperatures exceed _____ °F.

f. Cadmium plated nuts shall not be used in temperature probes, electrical components or systems, potable water supplies or food processing equipment. They shall not be used in space vehicle components or systems due to the instability of cadmium in a vacuum environment.

g. Cadmium plated nuts shall not be used where the temperature exceeds _____ °F.

h. 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.

i. Mating parts (except where flush head bolts or anchor nuts are used) shall have similar external wrenching configurations.

j. 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 degrading the structural integrity of the supporting component and shall permit replacement of the nuts.

k. Self-locking nuts that have been reworked or reprocessed shall not be used.

l. Self-locking nuts may be used on externally threaded parts that serve as an axis of rotation for another component provided the threaded parts are held in position by a positive locking device such as cotter pins, locking wires, et cetera, when used in installations such as those involving pulleys, cranks, levers, linkages, hinge pins, and cam followers.

4.4.8 **Self-retaining bolts and associated hardware.** All critical bolt linkage joints including those where the bolt serves as an axis of rotation which could cause catastrophic failures (e.g. fuel controls, throttle controls, flight controls, engine air reduction controls, propeller controls, pulleys,

cranks, levers, linkages, hinge pins, cam followers, et cetera) shall employ self-retaining bolts complying with the requirements of _____. Nuts used therewith shall comply with the requirements of _____. Additionally, the following requirements apply.

a. The integrity of the bolt installation shall not be dependent on washers or any other normally removable parts other than the bolt. A maximum of two washers may be used under the head of the bolt to adjust for tolerance variation.

b. Castellated nuts shall be used and secured by cotter pins in accordance with _____.

c. Self-retaining bolts that have had the retaining element or locking device reworked or reprocessed shall not be used.

d. Internally lobed nuts shall not be used.

4.4.9 Blind fasteners. Blind fasteners shall comply with the following requirements.

a. Blind fasteners shall be used primarily for shear applications with secondary tensile loading a consideration.

b. Cadmium plated blind fasteners shall not be used where the temperature is above _____ °F.

c. Cadmium plated blind fasteners shall not be used in titanium structure where the temperature is above _____ °F.

d. Cadmium plated blind fasteners shall not be used in space vehicle components or systems due to the instability of cadmium in a vacuum environment.

e. Blind fasteners that are lubricated with dry film lubricants may be used in space applications, provided the lubricant has been approved as meeting outgassing requirements.

f. Silver plated blind fasteners shall not be used in titanium structure above _____ °F.

g. Flush head styles may be used in conjunction with either countersinking or dimpling of the sheet or part next to the head. Flush head styles shall not be used where the blind side sheet is dimpled.

h. Blind fasteners shall not be used in applications where they are subject to removal during routine servicing and overhaul.

i. Blind fasteners shall not be used in control surface hinges, hinge brackets, flight control actuating system attachments, wing attachment fittings, landing gear fittings, or similar applications.

j. Friction locked blind fasteners (no locking ring or collar) shall not be used in engine air inlet areas. Other blind fasteners used in engine air inlet areas shall have procuring activity approval.

k. Blind fasteners shall not be used in fluid tight areas.

4.4.10 **Fatigue life improving fasteners.** The use of fatigue life improving fasteners, or any hole process which enhances fatigue life or retards crack growth, shall be subject to the approval of the procuring activity. Potentially acceptable fasteners include _____.

4.4.11 **Fasteners used in fuel tanks, environment and pressurized areas.** Fasteners used in and penetrating any fuel tank boundaries, environment and pressurized areas shall comply with _____.

4.4.12 **Latches, hinges, rivets and pins.** Fastener requirements for latches, hinges, rivets and pins (shear pins) are _____.

4.4.13 **Holes, tools and installation procedures.** Fastener system requirements for holes, tools and installation procedures (inserts, lubricants, et cetera) are _____.

5. VERIFICATIONS

5.1 **General.** The verifications specified herein shall be accomplished to show that the requirements of section 4 have been met. All verifications shall be the responsibility of the contractor, however the government reserves the right to witness, conduct or participate in any of the verifications.

5.2 **Fastening systems.** Inspections and hardware sampling shall be performed to verify that the fastening systems used in the design or modification of equipment, systems or subsystems comply with the requirements of section 4.2 and that all fasteners are listed in the approved Program Parts Selection List (PPSL), detailed in the Parts Control Program Plan, and specified in this standard. When a new fastener or fastening system is developed for use on a program to which this standard applies, the physical and mechanical properties shall be verified by test or similarity, as applicable.

5.3 **Fastener attributes criteria, general.** Compliance with the requirements of 4.3 shall be verified as indicated below.

5.3.1 **Flush fasteners.** Verify by inspection of contractor data and hardware sampling that the nominal head angles of flush fasteners meet the requirements of 4.3.1. Particular attention shall be given to assuring that flush fasteners with head angles other than 100 degrees (included angle) are needed and listed in the approved Program Parts Selection List.

5.3.2 **Threads.** Verify by inspection of contractor data and hardware sampling that fastener threads meet the requirements of 4.3.2.

5.3.3 **Recess/wrenching elements.** Verify by inspection of contractor data and hardware sampling that the recess/wrenching elements selected for use in aerospace structural fastening systems meet the requirements of 4.3.3.

5.3.4 Plating and coating. Verify by inspection of contractor data and hardware sampling that the plating and coating requirements of 4.3.4 are being met.

5.4 Fastener application criteria, general. Compliance with the requirements of 4.4 shall be verified as indicated below.

5.4.1 Design allowables. Verify by inspection of contractor data and the performance of analyses, and tests of fasteners and joints as needed, to show that the requirements of 4.4.1 have been met.

5.4.2 Fasteners in access panels and doors. Verify by inspection of contractor data and hardware sampling that fasteners used in access panels and doors meet the requirements of 4.4.2.

5.4.3 Torque control. Verify by inspection of contractor data and hardware sampling that the fastener torque control requirements of 4.4.3 are being applied where necessary. Also after tests of air vehicle structures, for example durability, static, ground vibration test (GVT), et cetera, the torque of critical application fasteners shall be reverified as still meeting the requirements of 4.4.3.

5.4.4 Minimum fastener diameter. Verify by inspection of contractor data and hardware sampling that the shank diameters of threaded structural fasteners meet the requirements of 4.4.4.

5.4.5 Head size. Verify by inspection of contractor data and hardware sampling that the head sizes of fasteners used meet the requirements of 4.4.5.

5.4.6 Screws and bolts. Verify by inspection of contractor data and hardware sampling that the screws and bolts used meet the requirements of 4.4.6.

5.4.7 Nuts. Verify by inspection of contractor data and hardware sampling that the nuts used meet the requirements of 4.4.7.

5.4.8 Self-retaining bolts and associated hardware. Verify by inspection of contractor data, and hardware sampling and demonstrations that the bolts and associated hardware used meet the requirements of 4.4.8.

5.4.9 Blind fasteners. Verify by inspection of contractor data that the blind fasteners used meet the requirements of 4.4.9.

5.4.10 Fatigue life improving fasteners. Verify by inspection of contractor data that the fatigue life improving fasteners used meet the requirements of 4.4.10.

5.4.11 Fasteners used in fuel tanks, environment and pressurized areas. Verify by inspection of contractor data, hardware sampling, demonstration, and tests that the fasteners used in fuel tanks, environment and pressurized areas meet the requirements of 4.4.11.

5.4.12 **Latches, hinges, rivets and pins.** Verify by inspection of contractor data and hardware sampling that the fasteners used meet the requirements of 4.4.12.

5.4.13 **Holes, tools and installation procedures.** Verify by inspection of contractor data and hardware sampling that the fasteners used meet the requirements of 4.4.13.

6. NOTES

6.1 **Data requirements.** When this standard is used in an acquisition which incorporates a DD Form 1423, Contract Data Requirement List (CDRL), the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved CDRL incorporated into the contract. When the provisions of the DoD FAR clause on data requirements (currently DoD FAR Supplement 52.227-7031) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this standard is cited in the following paragraphs.

Paragraph No.	Data Requirement Title	Applicable DID No.	Option

(Data item descriptions related to this standard, and identified in section 6 will be approved and listed as such in DoD 5000.19-L., Vol. II, AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.2 **Responsible engineering office (REO).** The office responsible for development and technical maintenance of this standard is ASD/ENFEM, Wright-Patterson AFB OH 45433-6503; AUTOVON 785-2586, Commercial (513)-255-2586. Any information relating to Government contracts must be obtained through contracting officers.

Custodian:
Air Force - 11

Preparing activity:
Air Force - 11
Project No. 5325-F001

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APPENDIX

FASTENING SYSTEMS, MECHANICAL, AIR VEHICLE

HANDBOOK FOR

10. SCOPE

10.1 Scope. This appendix provides rationale, guidance, lessons learned, and instructions necessary to tailor sections 4 and 5 of the basic standard (MIL-STD-1792) for a specific application.

10.2 Purpose. This appendix provides information to assist the Government procuring activity in the use of MIL-STD-1792.

10.3 Use. This appendix is designed to assist the project engineer in tailoring MIL-STD-1792. The blanks of the basic standard shall be filled in to meet operational needs of the tailored application.

10.4 Format

10.4.1 Requirement/verification identity. Section 30 of this appendix parallels section 4 and section 5 of the basic standard; paragraph titles and numbering are in the same sequence. Section 30 provides each requirement (section 4) and associated verification (section 5) as stated in the basic standard. Both the requirement and verification have sections for rationale, guidance, and lessons learned.

10.4.2 Requirement/verification package. Section 30 of this appendix has been so arranged that the requirement and associated verification is a complete package to permit addition to, or deletion from, the criteria as a single requirement. A requirement is not specified without an associated verification.

10.5 Criteria definitions. The criteria discussed herein is defined as follows:

a. Rationale: The reason for the requirement and associated verification.

b. Guidance: The suggested wording, concept, or design consideration to achieve the stated requirement and associated verification.

c. Lessons learned: Where available, background information and experience from previous programs.

10.6 Verification methods. Verification of the requirements shall be accomplished by inspection, analysis, demonstration, or test, or a combination of these methods as defined below.

a. Inspection. Inspection is defined as visual verification that the fastener/fastening system, including system documentation, comply with the standard requirements. Visual verification shall include inspection of the physical installation and/or inspection of drawings showing physical relationships, and review of documents reflecting qualification status with respect to standard requirements.

b. Analysis. Analysis is defined as verification that standard requirements have been achieved by evaluation of equations, charts, and reduced data, and by comparisons of analytical predictions with available test data, et cetera. Verification analysis, however, does not include the normal analysis of data generated during ground or flight testing.

c. Demonstration. Demonstration is defined as an uninstrumented test where success is determined by observation only, such as fit and function checks and tests that require simple quantitative testing.

d. Test. Test is defined as verification of the standard requirements through the application of established test procedures within specified environmental conditions and subsequent compliance confirmation through analysis of the data generated.

e. Verification by similarity. When verification by similarity is proposed, it shall be accomplished by using verification data from previously developed and qualified items. Considerable effort is expended when similarity claims are made late in a program and rejected by the procuring activity, or additional testing is required. Similarity claims must be established early in a program. The verification data from the earlier verification shall be submitted with design data to substantiate that:

(1) The fastener/fastening system is to perform a similar function in the new application as it did in its earlier verification.

(2) The environment and operating limits for the new fastener/fastening system shall be no more demanding or degrading than in the earlier operation.

(3) The new fastener/fastening system does not incorporate differences that would invalidate the criteria of 10.6.e.(1) or 10.6.e.(2).

(4) The fastener/fastening system meets requirements of its earlier application(s) as indicated by its mean time between failures (MTBF) and other field failure data.

10.7 Responsible engineering office. The responsible engineering office (REO) for this appendix is ASD/ENFEM, Wright-Patterson AFB OH 45433-6503. The individual who has been assigned the responsibility for this handbook is Richard P. Stewart, ASD/ENFEM, Wright-Patterson AFB OH 45433-6503, AUTOVON 785-2586, Commercial (513)-255-2586.

20. REFERENCED DOCUMENTS

20.1 References. The documents referenced in this appendix are not intended to be applied contractually. Their primary purpose is to provide background information for the Government engineers responsible for developing the most appropriate performance values (filling in the blanks) for the requirements contained in the standard proper.

20.2 Avoidance of tiering. Should it be determined that the references contained in this appendix are necessary in writing a Request For Proposal (RFP) or a contract, excessive tiering shall be avoided by calling out only those portions of the reference which has direct applicability. It is a goal of the Department of Defense that the practice of referencing documents in their entirety be eliminated in order to reduce the tiering effect.

20.3 Government documents

SPECIFICATIONS

Federal

QQ-P-416	Plating, Cadmium (Electrodeposited)
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

MIL-S-4383	Sealing Compound, Topcoat, Fuel Tank, Buna-N Type
MIL-S-7742	Screw Threads, Standard, Optimum Selected Series: General Specification for
MIL-B-8831/2	Bolt, 100° Reduced Flush Head, Straight Shank, Expandable Aluminum Alloy Sleeve, Alloy Steel Pin, 108 KSI Fsu
MIL-B-8831/3	Bolt, Protruding Head, External Wrenching, Straight Shank, Expandable Aluminum Alloy Sleeve, Alloy Steel Pin, 180 KSI Ftu

MIL-B-8831/4	Bolt, 100° Reduced Flush Head, Low Interference, Straight Shank, Expandable Aluminum Alloy Sleeve, Alloy Steel Pin, 108 KSI Fsu
MIL-B-8831/5	Bolt, Protruding Head, External Wrenching, Straight Sleeve, Low Interference Expandable Aluminum Alloy Sleeve, Alloy Steel Pin, 180 KSI Ftu
MIL-S-8879	Screw Threads, Controlled Radius Root with Increased Minor Diameter: General Specification for
MIL-L-8937	Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting NATO Code Number S-1738
MIL-F-8961	Fastener, Externally Threaded, 450°F and 1200°F, Self Locking Element for
MIL-W-8982	Wrenches, Splined, Socket and Box, Square Drive, High Strength, Thin Wall)
MIL-B-9946	Bit, Screwdriver, General Specification for
MIL-F-18240	Fastener, Externally Threaded, 250°F Self-Locking Element for
MIL-B-23964	Bolt, Self Retaining, Positive Locking
MIL-C-27725	Coatings, Corrosion - Preventive, for Aircraft Integral Fuel Tanks
MIL-C-83019	Coatings, Polyurethane, for Protection of Integral Fuel Tank Sealing Compound
MIL-B-83050	Bolt, Self Retaining, Impedance Type
MIL-C-83488	Coating, Aluminum, High Purity
MIL-S-85069	Sleeves, Fastener, General Specification for
MIL-C-85614	Coating, Fastener, Aluminum Pigmented, Organically Bonded
MIL-A-87221	Aircraft Structures, General Specification for

STANDARDS

Military

MIL-STD-965	Parts Control Program
MIL-STD-1312	Fastener Test Methods

MIL-STD-1515	Fastener Systems for Aerospace Applications
MS 9006	Recesses-cross, Low Torque Drive, Dimensions of Recess, Gage and Driver for
MS 14191	Recess, Ribbed Torq set, Dimensions of Recess, Gage and Driver for
MS 21132	Wrenching Element, External Hexagon, for Threaded Fasteners
MS 21224	Nut, Self-Locking, Castellated, Hexagon, Counterbored, Assembled Washer, 250°F, Non-Metallic Insert (For Self-Retaining Bolts)
MS 21244	Nut, Castellated, Hexagon, Counterbored, Assembled Washer, 450°F (for Self-Retaining Bolts)
MS 33522	Rivets, Blind, Structural, Mechanically Locked and Friction Retainer Spindle, (Reliability and Maintainability) Design and Construction Requirements for
MS 33540	Safety Wiring and Cotter Pinning, General Practices for
MS 33588	Nuts, Self-Locking, Aircraft, Reliability and Maintainability, Usage Requirements for
MS 33602	Bolts, Self-Retaining, Aircraft Reliability and Maintainability, Design and Usage Requirements for
MS 33750	Recess, Hi-torque, Dimensions of Recess, Gage, and Driver for
MS 33781	Recess, Torq set, Dimensions of Recess, Gage, and Driver for
MS 33787	Wrenching Element, External Spline, Dimensions for

HANDBOOKS

Military

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

20.4 Other documents

Test Reports

AFFDL-TR-79-3047	Aircraft Integral Fuel Tank Design Handbook

Air Standardization Coordinating Committee

AS 17/2	Hexagon Bolt Head and Nut Sizes

American National Standards Institute

ANSI B18.3	Socket Cap, Shoulder and Set Screws, Inch Series (including Dimensions of Hexagon and Spline Sockets and Keys to Match)

National Aerospace Standards Association, Inc.

NAS 1724	Bolt, Taper Shank, Shear Type, 100° Head
NAS 1725	Bolt, Taper Shank, Shear Type, 100° Head - Oversize
NAS 1728	Bolt, Taper Shank, Shear Type, Protruding Head
NAS 1729	Bolt, Taper Shank, Shear Type, Protruding Head - Oversize
NAS 7100	Recess, Phillips, Dimensions of Recess and Gages
NAS 7101	Bit, Screwdriver, Phillips, Specification for

30. REQUIREMENTS AND VERIFICATIONS

4.1 **General.** This standard provides technical criteria for air vehicle fastening systems as outlined in the following:

a. Fastening systems (4.2).

b. Fastener attributes criteria, general (4.3).

c. Fastener application criteria, general (4.4).

REQUIREMENT RATIONALE (4.1)

This paragraph provides an outline of the content of this standard.

REQUIREMENT GUIDANCE

This requirement is advisory and need not be included in the tailored standard.

REQUIREMENT LESSONS LEARNED

5.1 **General.** The verifications specified herein shall be accomplished to show that the requirements of section 4 have been met. All verifications shall be the responsibility of the contractor, however the government reserves the right to witness, conduct or participate in any of the verifications.

VERIFICATION RATIONALE (5.1)

This is an introductory paragraph for the verification section. Every requirement in the tailored standard must be verified.

VERIFICATION GUIDANCE

Include this paragraph in the tailored standard to establish the general requirement for verification.

VERIFICATION LESSONS LEARNED

4.2 **Fastening systems.** The fastening systems used in aerospace applications to which this standard applies shall consist of fasteners listed in the Program Parts Selection List (PPSL), detailed in the Parts Control Program Plan, specified in this standard and approved by the procuring activity.

REQUIREMENT RATIONALE (4.2)

In the interest of standardization of parts in aerospace vehicle and equipment design and manufacture, parts control programs per MIL-STD-965 are being applied. This standard applies to all parts categories included in the covered federal supply classifications which are inclusive of fasteners. Consequently, standardization is emphasized through the selection, approval, and submittal procedures specified in the parts control portion of the acquisition documents.

The purpose of referencing PPSLs and Parts Control Program Plans in lieu of identifying specific fastener systems is to prevent conflicting requirements which may result from the myriad of variations of application of MIL-STD-965 through tailoring.

This is not to be construed as a lessening of the importance of standardization of fastener systems selections. In all cases where there are fastener selections or selection criteria specified herein, standardization must be a prime consideration. Further, in the interest of standardization, identifying specific fastener systems herein shall be avoided or minimized insofar as practical.

REQUIREMENT GUIDANCE

The enforcement of standardization of fasteners and the reduction or inhibiting of parts proliferation in Government inventory is critical to the DoD and is accomplished through the MIL-STD-965 parts control programs. Though the actual fastener standardization is controlled through the Parts Control Program, awareness of the overall importance and impact of fastener selections is vital in completing the criteria herein.

In the interest of optimization of fasteners to the performance requirements, if the contractor determines that advantages may be available through the use of non-standard fasteners, justification for this situation shall be submitted prior to consideration.

Specific factors, which may require further controls beyond the PPSL coverage or direction when parts control programs do not apply, may be specified by extracting the applicable paragraphs herein and completing the appropriate blanks.

The use of non-standard fasteners may be of an advantage to the Government on some occasions. Where the contractor concludes to the satisfaction of the procuring activity that non-standard fasteners are of an advantage to the program, the PPSL must be modified to reflect these procuring activity approved changes.

The use of approved parts from a PPSL is cost effective and shall be given selection priority in new aerospace systems design.

When new fastener designs are proposed and the performance characteristics are without precedence, establishment of those performance characteristics by test is appropriate.

Fastener testing, if accomplished for purposes of gaining approval through non-standard parts submittal for the Parts Control Program, should be reported in accordance with DI-E-7030. In such cases, DI-E-7030 must be specified as a portion of the MIL-STD-965 parts control program. If, however, fastener related data is expected to be gathered during systems testing, the results should be reported in accordance with DI-S-3581. The acquisition document preparer for the fastener section must make this assessment and ensure that DI-S-3581 is included in the CDRL list as applicable. Other data item descriptions used are included in MIL-STD-965, that is DI-E-7026, DI-E-7027, and DI-E-7028. The responsible engineer must ensure that these DIDs are covered in the acquisition documentation as required.

The initial report, per DI-E-7030 or DI-S-3581, is to be submitted prior to the Preliminary Design Review (PDR) and kept current until completion of the contract.

The subject of trade studies is frequently applicable to fasteners in the sense that overall economy or performance enhancement may be achievable through the selective use of non-standard fasteners. Validation of the desirability, acceptance and approval of the non-standard fastener shall include review of data submitted by DI-S-3606 and must include an assessment of initial cost, installation tooling, fabrication factors, weight, fastener performance, effects on Government inventory, and availability. Other factors such as substitutions for repair, minimizing maintenance, and maximizing supportability must also be assessed.

5.2 ***Verifying fastening systems.*** Inspections and hardware sampling shall be performed to verify that the fastening systems used in the design or modification of equipment, systems or subsystems comply with the requirements of 4.2 and that all fasteners are listed in the approved Program Parts Selection List (PPSL), detailed in the Parts Control Program Plan, and specified in this standard. When a new fastener or fastening system is developed for use on a program to which this standard applies, the physical and mechanical properties shall be verified by test or similarity, as applicable.

VERIFICATION RATIONALE (5.2)

Standard fasteners and fastening systems are expected to be used on most applications. In these instances verification by inspection and hardware sampling is adequate to demonstrate compliance with the requirements.

VERIFICATION GUIDANCE

Consequently, this requirement can be verified through inspection of installations, reviews of Parts Control Program documentation, and hardware sampling. Hardware sampling is to be performed using sound statistical techniques and tailored as necessary to meet the minimum verification requirements of each applicable paragraph of 4.2. New fasteners used in the design may be verified by test data from testing of the new product, by analysis of similarities to previously used or tested fasteners, or by other arrangements with the contractor. The latter may entail a complete analysis of a system test in which the new fastener was included, a technical analysis of the principles involved, or a waiver of the verification on the basis that the application is not critical and the verification formality is not cost effective. Where testing of the fastener system is a requirement for verification, the use of MIL-STD-1312 test methods is encouraged because of the commonality of resulting data from similar tests.

VERIFICATION LESSONS LEARNED

4.3 ***Fastener attributes criteria, general.*** The factors delineated in this section identify characteristics of fasteners which require definition and control exclusive of the application environment.

REQUIREMENT RATIONALE (4.3)

The various subsections to this requirement present the rationale to place controls on specific attributes of fasteners which apply in general to the end product or item.

REQUIREMENT GUIDANCE

The applicable factors shall be completed (blanks filled) and the requirements inserted in whole or in part into the acquisition document.

Screening of the performance requirements of the end item is necessary prior to selection of these factors, and the use of the factors limited to those which are necessary and appropriate.

REQUIREMENT LESSONS LEARNED

5.3 **Verification of fastener attributes criteria, general.** Compliance with the requirements of 4.3 shall be verified as indicated below.

VERIFICATION RATIONALE (5.3)

The rationale is presented with each subsequent verification subparagraph.

VERIFICATION GUIDANCE

The guidance is presented with each subsequent verification subparagraph.

VERIFICATION LESSONS LEARNED

4.3.1 **Flush fasteners.** The nominal head angle of flush fasteners shall be _____ degrees (included angle). Deviations from this nominal head angle for flush head fasteners shall require approval of the procuring activity.

REQUIREMENT RATIONALE (4.3.1)

Flush or countersunk head fasteners shall have 100 degrees included angle. Special head configurations utilizing other head angles may be approved as part of a fastener system whose purpose is to improve joint properties and characteristics. For non-metallic structure, there is currently no existing industry standard. The value of the countersink angle directly affects the cross servicing of aircraft world-wide and is covered by ASCC Air Standard 17/2.

REQUIREMENT GUIDANCE

Fill in the blank with 100. The nominal head countersink included angle of 100 degrees has been accepted as the standard angle for use in air vehicle applications and is the subject of an international standards agreement. Accordingly the data base for fasteners using that configuration is significant and well established. Other included angles of 60, 82, 120, 130, and 159 degrees have been used in the past for special applications.

REQUIREMENT LESSONS LEARNED

The commercial fastener industry adopted the 82 degrees included angle for flush head fasteners. With the development of thin skin construction, it was found that the deep countersinks associated with this angle tended to produce knife edges in the fastener holes at the faying surface of the joint, making the joint prone to early fatigue failure. Standardization on the 100 degree angle for all applications requiring a flush head eliminated the confusion of having many different head angle fasteners and the potential of installing a fastener with a different angle than the sheet countersink and thereby causing hole deformation of fatigue problems. The intermixing of fastener head angles with differing sheet countersink angles have been noted and should be avoided.

5.3.1 Flush fasteners verification. Verify by inspection of contractor data and hardware sampling that the nominal head angles of flush fasteners meet the requirements of 4.3.1. Particular attention shall be given to assuring that flush fasteners with head angles other than 100 degrees (included angle) are needed and listed in the approved Program Parts Selection List.

VERIFICATION RATIONALE (5.3.1)

Verification of the proper countersink angle is accomplished by inspection and hardware sampling prior to installation. There are no quick, economical tests which will discern between 100 degrees and 82 degrees countersinks with the fastener installed. Inspection of the physical parts and components as well as inspection of drawings can accomplish this most readily.

VERIFICATION GUIDANCE

Since various countersink included angles exist, not only on the fasteners but also in the sheet or plate in which the countersunk fasteners are installed, many inadvertent combinations may exist. Mismatching of flush fasteners and countersunk holes is possible. These misapplications can be detected by inspection of contractor data and hardware sampling prior to use. Inspection of drawings, tooling and fastener standards will aid in determining that fasteners with the proper head countersink included angles are being used.

VERIFICATION LESSONS LEARNED

There have been numerous cases where various installation errors have occurred relative to countersink angles, usually with some detrimental effect. Except for inspection and hardware sampling, no other method of verification of countersunk angles has proven to be effective.

4.3.2 **Threads.** The threads for fasteners shall comply with the requirements of _____.

REQUIREMENT RATIONALE (4.3.2)

Selection of screw threads for fasteners is critical. The need to standardize on thread dimensions is readily apparent, which is the purpose of this requirement.

REQUIREMENT GUIDANCE

There are two general specifications for screw threads, MIL-S-8879 and MIL-S-7742. The thread form of MIL-S-8879 provides for improved fatigue resistance. Usage limitations for self-locking nuts of MS 33588 may be useful in controlling short thread installation problems. Fill in the blank with the appropriate specifications, standards and other applicable thread requirements.

REQUIREMENT LESSONS LEARNED

Past experience has proven that thread mismatch can cause numerous problems.

5.3.2 **Verifying threads.** Verify by inspection of contractor data and hardware sampling that fastener threads meet the requirements of 4.3.2.

VERIFICATION RATIONALE (5.3.2)

This verification is needed to verify that the screw threads of applicable fasteners meet acceptable dimension standards for use in aerospace applications.

VERIFICATION GUIDANCE

Verification that the correct threads have been selected should be accomplished through inspection and sampling of contractor data and parts.

VERIFICATION LESSONS LEARNED

4.3.3 **Recess/wrenching elements.** The wrenching elements selected for use in aerospace structural fastening systems shall comply with _____.

REQUIREMENT RATIONALE (4.3.3)

Recess/wrenching elements must be of sufficient strength to support installation and removal torques in excess of the anticipated application level. In addition, to minimize tooling proliferation, standardization of recess/wrenching elements configurations is required.

REQUIREMENT GUIDANCE

Drive and wrench elements shall be selected from table I.

REQUIREMENT LESSONS LEARNED

Ever since flush recess fasteners have been used in aircraft structure, field problems have arisen as a result of overtorque and cam-out of fasteners which then requires the fasteners to be drilled out. Another design factor which caused many recess problems in the past was the use of the reduced head fasteners.

During the design of one fighter aircraft, the number of types of fastener heads was reduced by twenty percent, resulting in a corresponding reduction in the inventory of driver tools.

5.3.3 Recess/wrenching elements verification. Verify by inspection of contractor data, hardware sampling, and demonstration that the recess/wrenching elements selected for use in aerospace structural fastening systems meet the requirements of 4.3.3.

VERIFICATION RATIONALE (5.3.3)

This verification is needed to confirm the selection of drive elements and compatibility thereof with the wrenching elements in meeting the requirements of 4.3.3.

VERIFICATION GUIDANCE

Verification can best be accomplished by reviewing installation, assembly, and fabrication drawings. The compatibility of the wrenching elements can best be verified by demonstration and hardware sampling.

VERIFICATION LESSONS LEARNED

4.3.4 Plating and coating. Fasteners which are plated or coated shall comply with _____.

REQUIREMENT RATIONALE (4.3.4)

This requirement defines the corrosion protection for fasteners.

TABLE I. Drive or wrench element selection.

Drive or Wrench Element	Design Standard	Tooling 1/	Design Strength and Usage Limitations
Hexagon (External) 	MS 21132	GGG-W-1437 GGG-W-636	Less Than 200,000 psi tensile stress.
		GGG-W-660	.190 inch nominal diameter and larger.
12 Spline (External) 	MS 33787	MIL-W-8982 2/	200,000 psi minimum tensile stress. (Optional below this level)
Phillips (Internal) 	MS 9006	MIL-B-9946	150,000 psi maximum tensile stress.
	NAS 7100 (Ribbed)	NAS 7101	150,000 psi maximum tensile stress.
Torq-Set (Internal) 	MS 14191 3/ (Ribbed) MS 33781	MIL-B-9946	160,000 psi minimum tensile stress. (Optional below this level)
Hi-Torque (Internal) 	MS 33750	MIL-B-9946	160,000 psi minimum tensile stress. (Optional below this level)
Hexagon (Internal) 	ANSI B18.3	ANSI B18.3	4/

1/ Care should be exercised to ensure that the correct size bit or wrench is used, particularly for internal drives, so that specific installation requirements are not exceeded.

2/ MIL-W-8982 wrenches are compatible with both the 12-spline and MS 21132 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 MS 33787.

3/ Recesses in accordance with MS 14191 and MS 33781 and their related tooling are fully interchangeable.

4/ Limited to threaded end of pins without head driving recess, set screws, and panel fasteners.

REQUIREMENT GUIDANCE

Fill in the blank with appropriate requirements, including those selected from the following.

Cadmium plating of fasteners shall conform with QQ-P-416, Type II, Class 2. Note - Use of cadmium plated steel fasteners in areas where temperatures may exceed 450°F may cause embrittlement.

Aluminum coating of fasteners shall conform to MIL-C-83488. Note - Aluminum coated fasteners are not to be used in areas where the temperatures may exceed 500°F. AFWAL/MLSA has recommended acceptance of aluminum coating such as Ion Vapor Deposition (IVD) to stainless steel fasteners as an alternate choice to cadmium plated stainless steel fasteners.

Several characteristics of the IVD aluminum coatings and other coatings must be recognized. For instance, the torque versus tension relationship is different than that for other harder coatings and the beneficial effective interference fit of the soft aluminum may not be maintained.

Alternative coatings to cadmium and IVD aluminum are being developed and tested by the Air Force, Navy, and the fastener industry. MIL-C-85614, Aluminum Pigmented Phenolic Base Coatings (bonded film) is one such alternative.

Prior to the use of any alternatives to cadmium, tests of mechanical behavior, structural integrity, and corrosion resistance must be conducted for the particular and environment. Particularly, in those applications where Ion Vapor Deposition (IVD) coatings or Aluminum Pigmented Phenolic Base coatings are contemplated, testing must be done to verify the validity and applicability of the coating in the particular use or application.

Note - Aluminum or cadmium plated fasteners are not to be used in contact with graphite/epoxy structures. Titanium or stainless steel fasteners are preferred for this application and are to be installed with a wet sealant.

REQUIREMENT LESSONS LEARNED

Ion Vapor Deposition (IVD) coated PH 13-8 stainless steel fasteners are undergoing in-service test on Air Force aircraft. At the present time the test results are inconclusive, detailed evaluation for applications are comtemplated.

The exposure of IVD aluminum coated fasteners in a severe shipboard environment is being studied by the Navy. IVD aluminum coated PH 17-4 stainless steel fasteners corroded extensively and failed to protect the adjacent countersinks in 7075-T6 aluminum panels.

Past experiences with cadmium plated parts used in a large cargo and other aircraft have failed upon installation or shortly thereafter due to hydrogen embrittlement. This was determined to be due to one or more of the following: poor plating procedures, contaminants in the plating baths, or insufficient or no post baking after plating. In many cases no stress durability tests were run on a sample basis as required.

The use of fastener materials, which are at the opposite end of the dissimilar metals scale from graphite, on graphite/epoxy structures will increase the probability of galvanic corrosion to the fastener. For example, when aluminum of cadmium plated fasteners are used with a graphite/epoxy material, a galvanic corrosion problem usually occurs due to dissimilar metals contact.

The original equipment fasteners used in the production of graphite/epoxy structures are usually titanium or stainless steel since these fasteners are more corrosion resistant than typical aluminum of cadmium plated fasteners. When coupled with graphite/epoxy, the fasteners are installed with a wet sealant that further protects them from corrosion. The use of aluminum or cadmium plated fasteners in the manufacture or repair or graphite/epoxy structures are normally prohibited because accelerated corrosion can occur to the fastener due to the dissimilar metals in contact. Aluminum and cadmium plated fasteners have a greater potential for galvanic corrosion than titanium and stainless steel when in contact with graphite.

5.3.4 **Verification of plating and coating.** Verify by inspection of contractor data and hardware sampling that the plating and coating requirements of 4.3.4 are being met.

VERIFICATION RATIONALE (5.3.4)

This verification is needed to confirm compliance of the plating and coating of fasteners with the requirements of 4.3.4.

VERIFICATION GUIDANCE

Verification of this requirement can best be accomplished by review of process specifications, drawings and fastener standard sheets for application and use of accepted military process specifications. In applications where IVD or other coatings are contemplated, torque/tension relationships, disassembly capability, fatigue degradation, corrosion characteristics must be explicitly evaluated for each application.

VERIFICATION LESSONS LEARNED

4.4 **Fastener application criteria, general.** The factors delineated in this section are inclusive of those criteria intended to place specific controls on the overall application of fasteners.

REQUIREMENT RATIONALE (4.4)

This general requirement is needed as lead-in to the specific controls to be applied on the overall application of fasteners to a particular system acquisition or modification.

REQUIREMENT GUIDANCE

The applicable requirements shall be included, in whole or in part, in the acquisition or modification documentation with variations as needed to tailor the requirements to the program.

Screening of the performance requirements of the end item is necessary prior to selecting the requirements from herein and limiting them to those which are necessary and appropriate.

REQUIREMENT LESSONS LEARNED

5.4 **Verification of fastener application criteria, general.** Compliance with the requirements of 4.4 shall be verified as indicated below.

VERIFICATION RATIONALE (5.4)

This is a general verification, needed to provide for the overall verification of the fastener application criteria requirements contained herein.

VERIFICATION GUIDANCE

Check each section 4.4 requirement to assure that a verification paragraph is associated with it.

VERIFICATION LESSONS LEARNED

4.4.1 **Design allowables.** The fastener and joint design allowables shall not exceed those design allowable values specified in _____. Where the design allowables are nonexistent, they shall be established in accordance with _____.

REQUIREMENT RATIONALE (4.4.1)

This requirement is needed to determine the strength and durability of mechanical joints, it is necessary to know the strength of the individual fasteners by themselves and to know their strength and durability when installed in various thicknesses of various materials.

REQUIREMENT GUIDANCE

Fill in the first blank with MIL-HDBK-5, and the second with MIL-HDBK-5, Chapter 9. MIL-HDBK-5 establishes the joint design allowables for a wide variety of fasteners, mechanically fastened and metallurgical joints and describes the factors to be considered in determining the strength of fasteners and joints. Various tables present the joint allowables and information for selecting the proper joint allowable is described.

Valid sources or methods for establishing fatigue and damage tolerance design data may also be included in the blanks as applicable.

REQUIREMENT LESSONS LEARNED

5.4.1 **Verifying design allowables.** Verify by inspection of contractor data and the performance of analyses and tests of fasteners and joints as needed to show that the requirements of 4.4.1 have been met.

VERIFICATION RATIONALE (5.4.1)

This verification is needed to ensure that the design allowables used in design of aerospace structures are valid values.

VERIFICATION GUIDANCE

MIL-HDBK-5 is the most authoritative documentation of the actual properties of the products covered. Most of the design allowables can be confirmed by inspection using the data in MIL-HDBK-5, Chapter 8. Where the data is not available in MIL-HDBK-5, it can be determined by following the guidelines of Chapter 9, since this chapter provides the detailed information on the generation and analysis of fastener and joint data that results in the determination of design allowables. The minimum data requirements and analytical procedures are defined in Chapter 9 for the establishment of MIL-HDBK-5 design allowables. MIL-STD-1312 is the recommended source for the test procedures in developing required design allowable information.

VERIFICATION LESSONS LEARNED

4.4.2 **Fasteners in access panels and doors.** Except for captive fasteners, fasteners used to retain access panels and doors shall be of the same diameter, grip length, and shank length within any one panel. Where the same grip length and shank length cannot be used, the diameter shall be changed. Sleeve bolt/stud nut panel fasteners shall be at least _____ inch outside diameter. Stud bolt panel fasteners shall be at least _____ inch diameter. Structural panel fasteners shall have an internal hexagonal wrenching recess. Formed-in-place gasket material shall not be used as a spacer or in place of a counterbore for the retaining rings.

REQUIREMENT RATIONALE (4.4.2)

This requirement establishes the limitations on the use of different size and length of fasteners in individual aircraft access panels. The design of individual aircraft access panels using different size/length fasteners makes installation/removal difficult and time consuming. When an access panel is attached by various grip and shank length fasteners of the same diameter, maintenance technicians often do not know which fastener fits into which hole.

REQUIREMENT GUIDANCE

Fill in the first blank with 3/8 and the second with 1/4. Except for captive fasteners, removable fasteners of the same diameter must have the same grip and shank length in any one access panel.

REQUIREMENT LESSONS LEARNED

A problem was identified on an aircraft where threaded fasteners that had identical diameters but different grip lengths were used on the same panel. As a result, maintenance technicians often did not know which fastener fit into which hole and frequently installed the wrong length fastener in any given hole. This mistake caused one of two problems, either the attaching hardware (that is, nut plate or dome nut) was damaged because the fastener was too long or the panel attachment was inadequate because the fastener was too short. Furthermore, unsecured panels and improperly installed fasteners become foreign object damage (FOD) material.

Experience has shown that 1/4 inch stud nut sleeve type panel fasteners have demonstrated a lack of durability. An aircraft using both 1/4 inch and 3/8 inch outside diameter sleeve type fasteners was subject to severe maintenance problems with the smaller size and almost no problems with the larger.

5.4.2 **Verification of fasteners in access panels and doors.** Verify by inspection of contractor data and hardware sampling that fasteners used in access panels and doors meet the requirements of 4.4.2.

VERIFICATION RATIONALE (5.4.2)

This verification is needed to ensure that the fasteners used in access panels and doors are fully functional for their intended use.

VERIFICATION GUIDANCE

Verification of this requirement can best be accomplished by review of installation and assembly drawings and data. The first access panel and door made of every assembly is to be examined to assure that on a random basis no fastener for that panel or door can be installed so as to damage the fastener, panel or door or appear to be properly installed when it should not be used in that hole. All production changes to access panels and doors involving fasteners are to be reverified to ensure that the requirements of 4.4.2 are still being met.

VERIFICATION LESSONS LEARNED

4.4.3 **Torque control.** Fastener torque shall be controlled for all installed fasteners as pertains to the specific application.

REQUIREMENT RATIONALE (4.4.3)

This requirement is needed to invoke controls on the torque of fasteners used in specific applications. In particular, torque control for small diameter and shear head fasteners is necessary to preclude damage. Small diameter and shear head fasteners may be easily over torqued. In other applications, the torque must be precisely controlled to enable the fastened assembly to function properly or in some cases, to function at all.

REQUIREMENT GUIDANCE

It is to be emphasized that this requirement is only for threaded structural fasteners which are installed by a driving recess in the head of the fastener or are otherwise torqued. This requirement does not apply to rivets, either solid or blind, or to pin and collar type fasteners where the driving recess is in the thread end when utilized with the intended or designed mating torque off collar. When torque limiting methods are used, the above requirement is inherently being applied.

REQUIREMENT LESSONS LEARNED

Small diameter threaded fasteners are easily overtorqued. Many field cases have been discovered where small diameter threaded fasteners were overtorqued causing damage, in particular causing recesses to fail and heads to "dish."

5.4.3 **Torque control verification.** Verify by inspection of contractor data and hardware sampling that the fastener torque control requirements of 4.4.3 are being applied where necessary. Also after tests of air vehicle structures, for example durability, static, ground vibration test (GVT), et cetera, the torque of critical application fasteners shall be reverified as still meeting the requirements of 4.4.3.

VERIFICATION RATIONALE (5.4.3)

This verification is needed to assure that torque controls are applied where needed as well as to guard against over controlling torque on all fastener installations, particularly those that are self controlling, for example calling out torque requirements for nuts that are to be loosely installed and lock wired.

VERIFICATION GUIDANCE

Verification is to be accomplished by review of available data generated under the contract, this includes drawings, installation procedures, test results, et cetera.

Inspection is the best way to determine that torque control is being used to install small diameter and shear head fasteners. Verification by demonstration, analysis, and test for these fasteners has been attempted without significant success.

VERIFICATION LESSONS LEARNED

4.4.4 **Minimum fastener diameter.** The shank diameter of threaded structural fasteners shall not be less than _____.

REQUIREMENT RATIONALE (4.4.4)

The rationale for having a fixed minimum fastener diameter for threaded structural applications is to provide structural integrity in the bearing and shear load paths. Establishing 0.190 inch diameter as a minimum structural fastener diameter aids in maintainability.

REQUIREMENT GUIDANCE

Fill in the blank with 0.190 inch (#10 size). It is to be emphasized here that this requirement is only for threaded structural fasteners. This requirement does not apply to rivets, either solid or blind. When small diameter fasteners are utilized in long grip lengths, bolt bending also becomes a problem and joint stiffness is lost.

REQUIREMENT LESSONS LEARNED

Throughout the service life of many aircraft where threaded fasteners smaller than 0.190 inch diameter were used in structural applications, there have been many cases of sheet tear-out in thin skins and fastener shear failures in thicker skin materials. Joint stiffness relaxation due to bolt bending has been found to occur when small diameter threaded fasteners were used with long grip length fasteners, usually where the grip length exceeds the diameter by a factor of 4.

5.4.4 **Verifying minimum fastener diameter.** Verify by inspection of contractor data and hardware sampling that the shank diameters of threaded structural fasteners meet the requirements of 4.4.4.

VERIFICATION RATIONALE (5.4.4)

This verification is needed to ensure that fasteners with too small a diameter are not used in aerospace applications.

VERIFICATION GUIDANCE

Since some military, industry, prime contractor and vendor drawings on threaded fasteners allow or call out diameters smaller than 0.190 inch diameter, it is easy for a designer to inadvertently select a fastener smaller than 0.190 inch diameter. Merely checking a PPSL list, which usually does not go into detail as to diameter or limitations, will not find this problem. Also PPSL's usually do not give the mating parts, that is, nut or collar with the pin or bolt. Inspection is the preferred way to determine what parts are mated together. Various shop practices, rework/repair procedures and deviations from design drawings also may change what diameters are actually used from what is called out. Also there are grey areas where a designer may believe that his application is not structural or critical and select a smaller than 0.190 inch diameter fastener.

VERIFICATION LESSONS LEARNED

As indicated in the Guidance Lessons Learned, there have been numerous problems with the use of smaller than 0.190 inch diameter threaded fasteners in air vehicle structures. Attempts have been made to verify by demonstration, analysis and tests that small diameter fasteners are adequate or have not been used, without significant success.

4.4.5 **Head size.** Reduced head or shear head flush fasteners of _____ diameter with a driving recess in the head and a head diameter equal to or less than _____ times the shank diameter shall not be used.

REQUIREMENT RATIONALE (4.4.5)

In order to obtain optimum joint efficiency and structural integrity, while providing a reasonable degree of maintainability, a restriction has been placed upon the use of 1/4 inch and 3/16 inch diameter fasteners with reduced or shear heads. The reduced shear head configuration utilizes a recess size

one size smaller than the tension head configuration. The resultant loss in recess durability is reflected in significant maintenance problems which increase life cycle costs and decrease the operational capability of the air vehicle. Because of the multitude of head sizes available for the designer to select from and the physical capability of overtorqueing the small diameter reduced or shear head fastener, this restriction outweighs any weight advantage the small heads would gain.

REQUIREMENT GUIDANCE

This requirement is to have the blanks completed as follows. In the first blank insert, 1/4 inch or less. In the second blank insert, 1.5.

REQUIREMENT LESSONS LEARNED

There have many field maintenance problems with the use of the 1/4 and 3/16 inch diameter reduced or shear head fastener with a driving recess in the head in access panels. It has been shown that the average percentile airman or maintenance person using a speed wrench can easily overtorque or cam-out a recess. When this happens, a machinist is required to drill the fastener out, a sheet metal specialist is required to install a new nut plate, and the crew chief is then required to reassemble the joint, adding up to three different maintenance personnel and a lot of man hours needed to replace a damaged fastener.

5.4.5 **Verification of head size.** Verify by inspection of contractor data and hardware sampling that the head sizes of fasteners used meet the requirements of 4.4.5.

VERIFICATION RATIONALE (5.4.5)

This verification is needed to ensure that the head sizes of fasteners used meet the intent of 4.4.5 because of the actual field problems encountered with the reduced head size fasteners used in air vehicles.

VERIFICATION GUIDANCE

Verification of fastener head sizes meeting 4.4.5 requirements can best be accomplished by inspection. This can be either physical inspection of the actual parts or drawings provided the drawings are explicit and detailed enough to determine head sizes. Verification by analysis, demonstration, simple tests or similarity have not been successful at discerning such subtle differences.

VERIFICATION LESSONS LEARNED

4.4.6 **Screws and bolts.** Screws and bolts, including studs selected for use in aerospace structural joining shall conform to the following:

a. Bolts smaller than _____ inch diameter shall not be used in any single bolted structural connection, including primary flight control systems.

b. Screws and bolts, as installed shall have a remote probability of causing or becoming foreign object damage (FOD) material, particularly fasteners in those areas where they could disengage and become safety of flight FOD material or significantly degrade the mission capability of the air vehicle.

c. Aluminum alloy threaded bolts shall not be used in structural applications.

d. Socket head cap screws shall not be used in air vehicle structures.

e. Titanium alloy bolts shall not be cadmium or silver plated.

f. Cadmium plated screws or bolts shall not be used in temperature probes, electrical or life support space vehicle components or systems, potable water supplies, or food processing equipment.

g. Cadmium plated screws and bolts shall not be used where the temperature exceeds _____ °F.

h. Cadmium plated screws and bolts shall not be used in titanium structure where the temperature is above _____ °F.

i. Silver plated screws and bolts shall not be used in contact with titanium and titanium alloy nuts in application where the operating temperatures exceeds _____ °F.

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

k. Self-locking bolts shall have a self-locking element in accordance with _____ and are subject to the following limitations.

(1) Self-locking bolts shall be selected and used in a manner that will permit full functional and dimensional interchangeability with parts defined by the applicable standard and drawings.

(2) Self-locking bolts shall be used only in applications that permit full engagement of the locking element with threads of the mating component.

(3) Self-locking bolts with nonmetallic self-locking elements shall not be used where the locking element will encounter keyways, slots, cross holes, or other thread interruptions.

(4) Self-locking bolts that incorporate an insert or part that is nonmetallic shall have the entering end of the threaded holes, used in conjunction with the fastener, countersunk _____ degrees. This countersink shall have a minimum diameter that is _____ inches larger than the major thread diameter of the fastener.

(5) Unthreaded holes or portions of holes through which the locking element of the bolt must pass shall have a diameter sufficient to clear the locking element.

(6) Self-locking bolts shall not be used to attach access panels or doors or to assemble any parts that are routinely disassembled at intervals less than _____ flight hours.

(7) Self-locking bolts shall not be used when the locking device has been reworked or reprocessed.

(8) Self-locking bolts shall not be used with castellated or self-locking nuts.

(9) Self-locking bolts may be used as an axis of rotation for another part provided the fastener is held in position by a positive locking device that requires shearing or rupture of material, e.g. installations involving pulleys, cranks, levers, linkages, hinge pins, and cam followers using cotter pinned or wired castellated nuts.

REQUIREMENT RATIONALE (4.4.6)

Application requirements relative to screws and bolts are necessary to maintain design continuity relative to size, material, and finish limitations and application scope for male threaded components.

REQUIREMENT GUIDANCE

Size and material limitations are based on accepted design convention. Material and finish limitations, if applicable relate to corrosion/material compatibility considerations as established by the air vehicle specification. The application scope of self-locking male threads is defined by currently active design limitation specifications.

Fill in the blanks as indicated below.

a. Insert 1/4 in the blank in 4.4.6.a.

b. Insert 450 in the blank in 4.4.6.g.

c. Insert 200 in the blank in 4.4.6.h.

d. Insert 600 in the blank in 4.4.6.i.

e. Insert MIL-F-8961/MIL-F-18240 in the blank in 4.4.6.k.

f. Insert 90 to 120 in the first blank in 4.4.6.k.(4) and 0.015 in the second blank in 4.4.6.k.(4).

g. Insert 400 in the blank in 4.4.6.k.(6).

REQUIREMENT LESSONS LEARNED

5.4.6 **Verifying screws and bolts.** Verify by inspection of contractor data and hardware sampling that the screws and bolts used meet the requirements of 4.4.6.

VERIFICATION RATIONALE (5.4.6)

This verification is needed to ensure that the screws and bolts used in the air vehicle structure meet the requirements of 4.4.6.

VERIFICATION GUIDANCE

Inspection of assembly drawings and the actual parts/equipment will be adequate in most cases to determine compliance with this requirement.

VERIFICATION LESSONS LEARNED

4.4.7 **Nuts.** Nuts selected for use in aerospace structural applications shall comply with the following requirements.

a. Bolts, screws or studs must extend through the nut for a minimum of two threads.

b. Nuts, as installed shall have a remote probability of causing or becoming foreign object damage (FOD) material, particularly those areas where they could disengage and become safety of flight FOD material or significantly degrade the mission capability of the air vehicle.

c. Silver plated nuts shall not be used with silver plated bolts.

d. Silver plated nuts shall not be used in contact with titanium and titanium alloy screws, bolts or studs in applications where the operating temperatures exceeds _____ °F.

e. Cadmium plated nuts shall not be used in contact with titanium structure and bare titanium alloy screws, bolts or studs in applications where the operating temperatures exceed _____ °F.

f. Cadmium plated nuts shall not be used in space vehicle components or systems due to the instability of cadmium in a vacuum environment.

g. Cadmium plated nuts shall not be used where the temperature exceeds _____ °F.

h. 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.

i. Mating parts (except where flush head bolts or anchor nuts are used) shall have similar external wrenching configurations.

j. 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 degrading the structural integrity of the supporting component and shall permit replacement of the nuts.

k. Self-locking nuts that have been reworked or reprocessed shall not be used.

l. Self-locking nuts may be used on externally threaded parts that serve as an axis of rotation for another component provided the threaded parts are held in position by a positive locking device such as cotter pins, locking wires, et cetera, when used in installations involving pulleys, cranks, levers, linkages, hinge pins, cam followers, et cetera.

REQUIREMENT RATIONALE (4.4.7)

This requirement is needed to ensure that the nuts used in air vehicle structural applications will function as intended and not cause loss of the air vehicle or create excessive maintenance actions.

REQUIREMENT GUIDANCE

Nuts are an integral part of a fastening system and require careful selection to mate with and match the associated bolt in strength, thread selection, and drive configuration and material compatibility. Nut material/finish limitations are based on corrosion control/material compatibility considerations as established in the vehicle application scope of currently active design limitation specifications.

Fill in the blanks as indicated below.

a. Insert 600 in the blank in 4.4.7.d.

b. Insert 200 in the blank in 4.4.7.e.

c. Insert 450 in the blank in 4.4.7.g.

REQUIREMENT LESSONS LEARNED

5.4.7 **Verification of nuts.** Verify by inspection of contractor data and hardware sampling that the nuts used meet the requirements of 4.4.7.

VERIFICATION RATIONALE (5.4.7)

This verification is needed to ensure that the nuts used in aerospace applications meet their intended requirements and application limitations as called out in 4.4.7.

VERIFICATION GUIDANCE

Inspection of assembly drawings and the actual parts/equipment will determine compliance with this requirement.

VERIFICATION LESSONS LEARNED

4.4.8 **Self-retaining bolts and associated hardware.** All critical bolt linkage joints including those where the bolt serves as an axis of rotation which could cause catastrophic failures (e.g. fuel controls, throttle controls, flight controls, engine air reduction controls, propeller controls, pulleys, cranks, levers, linkages, hinge pins, cam followers, et cetera.) shall employ self-retaining bolts complying with the requirements of _____. Nuts used therewith shall comply with the requirements of _____. Additionally, the following requirements apply:

a. The integrity of the bolt installation shall not be dependent on washers or any other normally removable parts other than the bolt. A maximum of two washers may be used under the head of the bolt to adjust for tolerance variation.

b. Castellated nuts shall be used and secured by cotter pins in accordance with _____.

c. Self-retaining bolts that have had the retaining element or locking device reworked or reprocessed shall not be used.

d. Internally lobed nuts shall not be used.

REQUIREMENT RATIONALE (4.4.8)

This requirement is needed because critical bolt linkage joints are used throughout an aircraft. In many cases, loss of a single bolt could cause catastrophic failure and loss of the air vehicle.

Many means of ensuring linkage integrity or connections exist. There are double and triple redundant systems, that is, permanent fasteners whereby a piece or part has to be destroyed to be removed, cotter pinning or safety wiring, and directives mandating rigorous compliance with safety inspections. However, none of these methods are practical or reasonable from the life cycle maintenance viewpoint. These joints need to be periodically removed. Ground functional checks and inspections will only determine that a bolt is in the linkage joint and that a nut and cotter pin are installed.

REQUIREMENT GUIDANCE

Two types of self self-retaining bolts (SRB) have been developed for critical flight safety applications and are considered of similar performance. These are described below with guidance for their selection. Both are equal in overall performance. Select either MIL-B-23964 or MIL-B-83050. Only one type shall be selected for a weapon system. Cotter pins shall be used in accordance with MS 33540.

Fill in the first blank of 4.4.8 with one of the following choices.

a. MS 33602 and MIL-B-23964.

b. MS 33602 and MIL-B-83050.

Fill in the second blank of 4.4.8 with one of the following choices.

a. MS 21224, MS 21244 and MIL-B-23964.

b. MS 21224, MS 21244 and MIL-B-83050.

Fill in the blank in 4.4.8.b with MS 33540.

Type I - Positive locking bolts. Type I bolts (figure 1) are designed to be installed and removed after the retaining element release button is actuated to allow the locking elements to retract into the bolt body. This bolt is more resistant to inadvertent loss due to vibration than the Type II impedance type bolt.

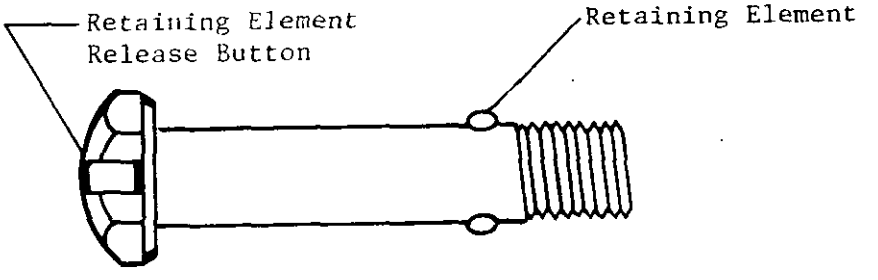

FIGURE 1. Positive locking bolts per MIL-B-23964.

Type II - Impedance type bolts. Type II bolts (figure 2) are designed to be installed and removed by overcoming the retaining elements. These bolts are stronger and less complex than the type I bolt.

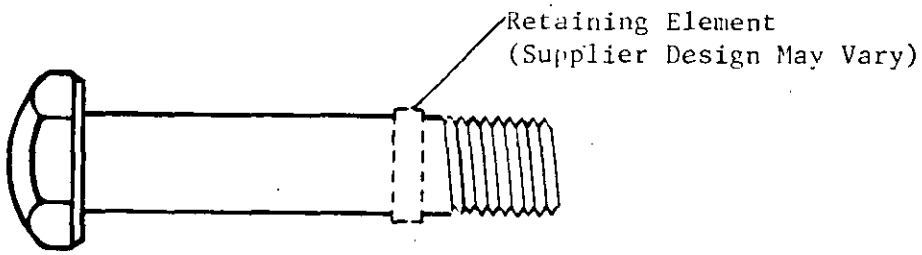

FIGURE 2. Impedance type bolts per MIL-B-83050.

REQUIREMENT LESSONS LEARNED

The services have had many aircraft accidents due to critical single joint linkage separation. These were primarily due to rigging or adjustments in blind or inaccessible areas, under adverse weather of battle conditions, where the cotter pins and even the nuts in some applications were inadvertently omitted.

In the late 60's and early 70's when it was determined that missing bolts caused the loss of many aircraft, many wing commanders professed that, through increased maintenance supervision and inspections, they would no longer have safety incidents and accidents due to linkage joint separations. After a period of time it was borne out that this had not occurred, because the safety record did not change or reflect any difference in accident rate. At this time Air Force Flight Safety directed the Aeronautical Systems Division to test, develop, and enforce the use of self-retaining bolts in all future system procurements.

5.4.8 **Verifying self-retaining bolts and associated hardware.** Verify by inspection of contractor data, hardware sampling and demonstrations that the bolts and associated hardware used meet the requirements of 4.4.8.

VERIFICATION RATIONALE (5.4.8)

This verification is needed to ensure that self-retaining bolts are used in the air vehicle as required by 4.4.8.

VERIFICATION GUIDANCE

Inspection of data, hardware sampling and demonstrations are essential to making sure that critical linkage joints meet requirements of 4.4.8 and 5.4.8 must be included in the tailored standard.

VERIFICATION LESSONS LEARNED

Service experience and accident records have proven that it must be verified that critical linkage joints contain self-retaining bolts.

4.4.9 Blind fasteners. Blind fasteners shall comply with the following requirements:

a. Blind fasteners shall be used primarily for shear applications with secondary tensile loading a consideration.

b. Cadmium plated blind fasteners shall not be used where the temperature is above _____ °F.

c. Cadmium plated blind fasteners shall not be used in titanium structure where the temperature is above _____ °F.

d. Cadmium plated blind fasteners shall not be used in space vehicle components or systems due to the instability of cadmium in a vacuum environment.

e. Blind fasteners that are lubricated with dry film lubricants may be used in space applications, provided the lubricant has been approved as meeting outgassing requirements.

f. Silver plated blind fasteners shall not be used in titanium structure above _____ °F.

g. Flush head styles may be used in conjunction with either countersinking or dimpling of the sheet or part next to the head. Flush head styles shall not be used where the blind side sheet is dimpled.

h. Blind fasteners shall not be used in applications where they are subject to removal during routine servicing and overhaul.

i. Blind fasteners shall not be used in control surface hinges, hinge brackets, flight control actuating system attachments, wing attachment fittings, landing gear fittings, or similar applications.

j. Friction locked blind fasteners (no locking ring or collar) shall not be used in engine air inlet areas. Other blind fasteners used in engine air inlet areas shall have procuring activity approval.

k. Blind fasteners shall not be used in fluid tight areas.

REQUIREMENT RATIONALE (4.4.9)

Application requirements for blind fasteners are necessary to maintain design continuity relative to material/finish limitations.

REQUIREMENT GUIDANCE

Fill in the blanks as indicated below.

a. Insert 450 in the blank in 4.4.9.b.

b. Insert 200 in the blank in 4.4.9.c.

c. Insert 600 in the blank in 4.4.9.f.

The application scope for blind fasteners reflects currently active design limitation specifications. Material/finish limitations, if applicable, relate to corrosion control/materials compatibility considerations as established by the vehicle specifications.

REQUIREMENT LESSONS LEARNED

The nature of blind fastener systems relative to conventional fastener systems lends itself to malfunctions due to uninspectability of the back side and grip or hole diameter sensitivity.

5.4.9 **Verifying blind fasteners.** Verify by inspection of contractor data that the blind fasteners used meet the requirements of 4.4.9.

VERIFICATION RATIONALE (5.4.9)

This verification is needed to ensure that blind fasteners used in the air vehicle meet the requirements of 4.4.9.

VERIFICATION GUIDANCE

Verification can best be accomplished by review of assembly, installation, fabrication, et cetera, drawings and processing specifications.

VERIFICATION LESSONS LEARNED

4.4.10 **Fatigue life improving fasteners.** The use of fatigue life improving fasteners, or any hole process which enhances fatigue life or retards crack growth, shall be subject to the approval of the procuring activity. Potentially acceptable fasteners include _____.

REQUIREMENT RATIONALE (4.4.10)

This requirement provides the means whereby the durability and damage tolerance characteristics of joints, as applicable from a fastener viewpoint, are established.

REQUIREMENT GUIDANCE

The use of fatigue life improving fasteners and hole cold working is a very complex subject. Use of these fasteners or any hole process which enhances fatigue life or retards crack growth shall be subject to the approval of the procuring activity. This is because their use is in fatigue and fracture critical areas. Significant structural design weights, loads analysis and presumed initial flaw sizes are involved. Compatibility with MIL-A-87221, is necessary to prevent conflicts of requirements from arising in this very critical area of joints.

Fill in the blank with a choice or choices selected from the following fatigue improving fasteners: NAS 1724, NAS 1725, NAS 1728, NAS 1729, and MIL-B-8831/2 through MIL-B-8831/5. The application and usage of fatigue enhancement fasteners, cold working, and interference fits shall be accomplished in consultation with the structures engineering specialist.

REQUIREMENT LESSONS LEARNED

Specific lessons learned are covered in detail in MIL-A-87221, the general specification for aircraft structures. A summary is presented here.

All aircraft have experienced fatigue to some degree. One of the most common origin of fatigue is at the fastener holes. Generally, the most critical holes are the lower wing skins and some other mounting points of the horizontal stabilizer. These are categorized as fatigue and fracture critical locations. It was learned that stop drilling a crack would delay or stop crack growth. Then it was determined that interference fit fasteners would increase the fatigue life of the structure. Taperlok fasteners became the industry standard fatigue resistant or life enhancement fastener since the B-52G. Later other alternative interference fit fasteners and hole processes such as cold working with solid or split sleeves have been used successfully in fatigue and fracture critical areas. In all cases the initial hole tolerance and quality is of the utmost importance. Many components and full scale fatigue tests as well as extensive research programs have verified this.

5.4.10 Fatigue life improving fasteners verification. Verify by inspection of contractor data that the fatigue life improving fasteners used meet the requirements of 4.4.10.

VERIFICATION RATIONALE (5.4.10)

This verification is needed to ensure that any fatigue life improving fastener used in the air vehicle meets the requirements of 4.4.10.

VERIFICATION GUIDANCE

This is a very critical and complex area which must be coordinated with the structures technical specialist. Experience has shown that detailed analyses, fatigue, fracture, coupon, component and large scale tests are required to

determine the performance characteristics of fatigue improving fasteners. Therefore it is crucial that procuring activity approval be established prior to use of these fasteners.

VERIFICATION LESSONS LEARNED

Many service problems have been encountered due to the misuse or misapplication of fatigue enhancement fasteners and hole processes attributable to the lack of adequate data to justify their use or approval.

4.4.11 Fasteners used in fuel tanks, environment and pressurized areas. Fasteners used in and penetrating any fuel tank boundaries, environment and pressurized areas shall comply with _____.

REQUIREMENT RATIONALE (4.4.11)

The use of fasteners in fuel tanks, including those penetrating fuel tank boundaries, and those used in environment and pressurized areas are considered critical from a sealing integrity viewpoint, which is the reason for this requirement. Sealing factors and design practices which influence or are influenced by mechanical fasteners installed in structural joints are covered by this section. General or specific fuel tank design practice, door seal design, continuous non-metalic material strip seals, fillet sealing, and similar fuel tank design factors not directly related to mechanical fastener installation are excluded.

REQUIREMENT GUIDANCE

Because of the critical nature of fastener selection, sealing and overcoating methods, as well as methods of hole preparation and fastener installations, the design practices, criteria and guidelines of MIL-STD-1515 (or the handbook which replaces it) and AFFDL-TR-79-3047 should be consulted. The following general guidance is provided for use in filling in the blank.

Fastener consideration and selection. The type of fastener and method of joint sealing must be considered as a unit and selections made by factor trade offs. The fastener system factors which interface for total joint sealing integrity may be considered separately and combined. The five basic methods used in aerospace vehicles for fuel tank sealing (structural joint sealing) are as follows.

Interference fit fasteners. Smooth shank straight or tapered fasteners, when installed into a hole with aluminum of 0.003 inch interference fit, are generally considered capable of providing a joint seal relative to fluids and air pressure. However, operational stress level and fastener diameter must be considered. The hole must be of a high quality surface finish, 125 RHR or better, free of rifling or scratches, and less than 0.005 out of roundness.

Interference levels should be such that applied stresses do not deform the hole and allow a leak path. Interference fit fasteners should be used for sealing only in joint thicknesses of four times the nominal fastener diameter or less.

Hole filling fasteners. Fastener types which expand to fill the hole upon installation, such as aluminum rivets, slug rivets, et cetera, may be considered for environmental sealing or pressure sealing but should not be considered as the sole mode of fastener sealing in fuel tanks. Faying surfaces sealing grooves which pass through the fastener holes should not be used with hole filling type fasteners.

Fasteners sealed with preformed packing. Fasteners which seal by the use of preformed packing can be classified into three categories as follows.

a. Preformed packing integral with or placed under the head of the screw, bolt or pin.

b. Washers containing preformed packing.

c. Nuts, collars, or captive nuts with integral preformed packing or used with separate preformed packing.

Several factors must be considered in the selection of fasteners sealed with preformed packing which include the following.

a. The surface of the counterbore of laminate surface is critical to assure a good seal and prevent damage to the preformed packing. A 125 RHR or better surface finish is recommended. This condition is applicable to seals under the head or nut/collar and washer.

b. The sealing washer may be used with protruding head fasteners or nuts/collars

c. The grip length of threaded fasteners shall be such that preformed packings are not squeezed into contact with either the internal or external threads or between the threads. This is not applicable to nuts with integral seals.

d. This type of sealing is generally considered acceptable for fuel tank, environmental, and pressure sealing joints.

e. The preformed packing must be squeezed to block potential leak paths, not just between the bolt and the nut.

f. If the preformed packing is adjacent to the rotated part, lubrication is required to preclude preformed packing damage.

Fasteners installed with a sealing fluid. Fasteners may be installed with an accompanying sealant which cures after installation. This is commonly called "wet installation" of fasteners. This method may be used with both interference fit and clearance fit fasteners. The preferred method is to apply sufficient sealant to the fastener or hole to provide a sealant bead at the head

and nut/collar. However, for specific applications, sealants may be used only at one or the other end of the fastener. Wet installed fasteners may be used in fuel tank, environmental, or pressure sealing applications.

Overcoating the installed fastener with a sealing material. Overcoating is defined as enclosing the fastener head or nut/collar with a sealing material which cures and forms a seal against the passage of fluids or gases. Overcoating may be used separately or in conjunction with any of the other modes of fastener sealing. Overcoating shall be applied in a manner which completely covers all possible leak paths relative to the fastener/hole interface or between components of a multiple piece fastener system at the laminate surface overcoat.

Sealing of multi-piece fasteners are addressed in the following paragraphs.

a. Fastener and sleeves. MIL-S-85069 sleeves used with straight shank fastener systems for repair or modification of structural joints with fluid sealing requirements require consideration and evaluation of the factor that there are two leak paths which must be sealed in lieu of the usual one. With appropriate attention to this factor, sleeved fasteners may be used in fuel tank, environmental, or pressure applications by installing them wet or by overcoating them. When installed wet, both sleeves and fastener must be installed with sealant. Overcoating must cover the sleeve/bolt interface.

b. Blind fasteners. Multi-piece blind fasteners are not approved for sealing repairs and never used for fuel tanks. When joint sealing is required and blind fasteners must be used, they must be installed wet. Sealant shall be applied to each element of the fastener prior to installation and to the hole or exterior of the fastener such that all leak paths are sealed. Sealants may have an adverse effect on the lubricant of the blind fastener components that will affect the performance characteristics of the fastener. Blind fasteners intended for use in sealing application must be specifically procured for this purpose or, as a minimum, the lubricant must be removed prior to application of the sealant.

Structural joint configuration and loading relative to fasteners. Initial considerations relative to joint configurations and loading shall include the following.

a. Fasteners used in joints required to be sealed should be loaded in shear. Avoid tension loading, particularly for fuel tank joints.

b. Where interference fit fasteners are used as a sealant, mode joint deflection must be considered. Holes will tend to elongate under high loads and may result in open leak paths. Install fastener with a resilient sealant and/or overcoat.

c. Where joints will tend to flex under load, use a high preload type of fastener system and adjust fastener spacing for less distance between fasteners. Adhesive sealants, for example, are extremely sensitive to joint deflections. Therefore, close fastener spacing, such as 3 to 3.5 times the fastener nominal diameter should be considered.

d. When adhesive sealants are used in faying surfaces, design the joint to be structurally independent of fastener preload or require retorqueing of all fasteners prior to sealant curing.

e. Accessibility shall be provided to allow appropriate fastener sealing and overcoating, as applicable.

f. Ensure that the number and types of fasteners and their diameters, grip lengths, and shank lengths are kept to a minimum.

Leak detection and evaluation relative to fasteners. Repair must be considered in design. Factors to be considered include access to fasteners, application and reapplication of sealants, joint disassembly, effects of oversize or substitute fasteners, fillet sealing and overcoating for a repair, inspectability of sealing mode, and addition to splices. One specific requirement is that groove sealed integral fuel tanks shall be designed to allow fastener repair from the exterior of the tank.

Fastener repair. Repair fasteners, whether oversize, sleeved, or change of fastener system, shall be sealed in the same manner as the originally specified fasteners or that required for the repair system selected, whichever is the more extensive.

Compatibility of sealants with fastener lubrication. Sealants must be compatible with lubricants applied to fastener elements. Refer to Section 103, of MIL-STD-1515 (or the handbook which replaces it).

Corrosion prevention considerations. The prevention of corrosion exists in fastener sealing by its inherent nature of moisture exclusion. However, an awareness of all of the factors influencing corrosion aspects of fastener installation must permeate the design, parts, materials, and processes selection process. Some of these consideration and cautionary factors are listed below.

a. Sealants are not considered sufficient for the sole mode of prevention of galvanic corrosion between two dissimilar metals. Parts materials selections and platings must be used for this purpose as if the sealant were not present.

b. Fastener materials, platings, coatings, and lubricants must be chemically compatible with sealants and overcoatings. Platings and coatings on fasteners must be such that sealants will adhere.

c. Fastener type selection and joint design must preclude "pockets" whereby fluids may be trapped.

d. Fastener types and installations which possess characteristics which aid sealant in moisture exclusion should be given prime consideration. Examples are interference fits, installation with formed heads, and/or nuts or collars which force the sealant to fill voids.

e. If cadmium plated parts are to be used in integral fuel tanks, the cadmium coating must be overcoated with one of the following listed barrier coatings or other such coatings as approved by the procuring activity.

(1) MIL-C-27725 Corrosion preventive coating.

(2) MIL-A-4383 Buna-N type sealing compound.

(3) MIL-C-83019 Polyurethane coating.

(4) MIL-L-8937 Solid film lubricant.

REQUIREMENT LESSONS LEARNED

Almost without exception, every aircraft which uses integral fuel tanks has had varying degrees of fuel leakage over the life of its structure. There are many reasons or causes for this, including sealant misuse and misapplication, fatigue and sealant cracking, peeling, and the use of sealant beyond its useful life. A recently built multi-national fighter aircraft has fuel leaks appearing from the use of blind fasteners after as little as 17 hours of life.

Fuel leakage is very expensive and time consuming to repair if it cannot be fixed from the exterior, which is usually the case, and if the leak or leaks are extensive, the tanks have to be emptied, and purged prior to any interior work on the fastener and joints.

Use of blind fasteners in integral fuel tanks.

a. Experience has confirmed that blind fasteners provide an additional leak path and are not usually hole filling. They usually cannot be retorqued to provide faying surface clamp-up.

b. A fighter-bomber aircraft deseal/reseal program permitted the use of blind fasteners in one of the fuel tank areas because they were convenient and easy to install. Blind fasteners were used extensively on another fighter aircraft fuselage and wing tanks because of convenience and lack of adequate access. Both aircraft suffered from extensive fuel leakage which is costly to repair, in time and dollars. MS 33522 guidance was used to correct the problems. Blind fasteners were prohibited from use in the fighter/bomber deseal/reseal work. Over ninety percent of the blind fasteners in the integral fuel tank areas of the fighter aircraft were eliminated in follow-on production aircraft.

Inadequate access to integral fuel tanks prevents the incorporation of accepted fuel tank sealing procedures and has resulted in unacceptable leakage. A fighter aircraft has experienced an excessive number of fuel leaks in its integral fuselage fuel tanks. Some of the leaks resulted from inadequate access to the upper portion of the fuselage tanks. As a result, the tank interior could not be fillet sealed nor could the fasteners be overcoated. Sixteen additional fuselage fuel tank access doors are being added to allow for conventional interior tank sealing.

5.4.11 **Verifying fasteners used in fuel tanks, environment and pressurized areas.** Verify by inspection of contractor data, hardware sampling, demonstration, and tests that the fasteners used in fuel tanks, environment and pressurized areas meet the requirements of 4.4.11.

VERIFICATION RATIONALE (5.4.11)

This verification is needed to ensure that the fasteners used in fuel tanks, environment and pressurized areas meet the requirements of 4.4.11.

Because of the large number of sealing type fasteners, some of which have no proven fuel sealing experience or data, and the acute possibility of misusing the proper sealing fastener and method, it is extremely hard to detect these subtle problems without a combination of inspection, hardware sampling, demonstration and testing.

VERIFICATION GUIDANCE

Inspections of data and the physical hardware will aid in verifying that the proper fasteners are used. Demonstration that the fastener selection and sealing methods will not leak after a specified period of usage is essential in showing that the requirements of 4.4.11 have been met. The applicability of the fasteners and fastening systems may be accomplished by testing of components and full scale articles, as applicable.

VERIFICATION LESSONS LEARNED

From experience it has been learned that even if a proper sealing fastener or method is called out, if it is not used properly and checked, leakage will occur. Hence, all of the verification techniques are needed and are to be used where applicable.

4.4.12 **Latches, hinges, rivets and pins.** Fastener requirements for latches, hinges, rivets and pins (shear pins) are _____.

REQUIREMENT RATIONALE (4.4.12)

This requirement is needed to define the requirements for latches, hinges, rivets and pins.

REQUIREMENT GUIDANCE

Include in the blank those requirements and references directly applicable to latches, hinges, rivets and pins. Refer to MIL-STD-1515 (or the handbook which replaces it) for additional guidance in selection of requirements for 4.4.12.

REQUIREMENT LESSONS LEARNED

5.4.12 Latches, hinges, rivets and pins verification. Verify by inspection of contractor data and hardware sampling that the fasteners used meet the requirements of 4.4.12.

VERIFICATION RATIONALE (5.4.12)

This verification is needed to ensure that the requirements of 4.4.12 are met.

VERIFICATION GUIDANCE

The method of verification is to be applicable to the latches, hinges, rivets and pins application under consideration.

VERIFICATION LESSONS LEARNED

4.4.13 Holes, tools and installation procedures. Fastener system requirements for holes, tools and installation procedures (inserts, lubricants, et cetera) are _____.

REQUIREMENT RATIONALE (4.4.13)

This requirement is needed to define the requirements for holes, tools and installation procedures.

REQUIREMENT GUIDANCE

Include in the blank those requirements and references directly applicable to holes, tools and installation procedures. Refer to MIL-STD-1515 (or the handbook which replaces it) for additional guidance in selection of requirements for 4.4.13.

REQUIREMENT LESSONS LEARNED

5.4.13 Verification of holes, tools and installation procedures. Verify by inspection of contractor data and hardware sampling that the fasteners used meet the requirements of 4.4.13.

VERIFICATION RATIONALE (5.4.13)

This verification is needed to ensure that the requirements of 4.4.13 are met.

VERIFICATION GUIDANCE

The method of verification is to be applicable to the holes, tools and installation application under consideration.

VERIFICATION LESSONS LEARNED

40. DATA REQUIREMENTS

When this standard is used in an acquisition requiring the delivery of data in accordance with the contract requirements, the following Data Item Descriptions are to be considered.

Paragraph No.	Data Requirement Title	Applicable DID No.	Option
5.2	Subsystem Design Analysis Report	DI-S-3581	
5.2	System/Design Trade Study Reports	DI-S-3606	
5.2	Part Control Program Plan	DI-E-7026	
5.2	Program Parts Selection List	DI-E-7027	
5.2	Nonstandard Part Approval Requests	DI-E-7028	
5.2	Test Data for Nonstandard Parts	DI-E-7030	

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-STD-1792(USAF)	Fastening Systems, Mechanical, Air Vehicle

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR
	☐ USER
b. ADDRESS *(Street, City, State, ZIP Code)*	☐ MANUFACTURER
	☐ OTHER *(Specify)*:

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

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