



National Aeronautics and
Space Administration

**MEASUREMENT
SYSTEM
INCH-POUND**

MSFC-STD-557

REVISION: B

EFFECTIVE DATE: February 15, 2012

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

EM20

MSFC TECHNICAL STANDARD

**THREADED FASTENERS, TITANIUM
ALLOYS, USAGE CRITERIA FOR
LAUNCH VEHICLES AND
SPACECRAFT APPLICATIONS**

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| MSFC Technical Standard EM20 | | |
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| Title: Threaded Fasteners, Titanium Alloys, Usage Criteria for Launch Vehicles and Spacecraft Applications | Document No.: MSFC-STD-557 | Revision: B |
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DOCUMENT HISTORY LOG

| Status (Baseline/ Revision/ Canceled) | Document Revision | Effective Date | Description |
|--|------------------------------|---------------------------|---|
| Baseline | | | Baseline Release |
| Revision | A | February 1, 2005 | Update doc. Per MSFC rules review. Update applicable documents section. Change paragraph 4.9.1.2.2 to reflect new thread inspection documents. |
| Revision | B | February 15, 2012 | <p>Revision B Release; document is authorized through MPDMS.</p> <p>Title: Changed to reflect intended usage in launch vehicles, delete specific chemical composition of titanium to include all titanium fasteners.</p> <p>Revision: Changed from A to B</p> <p>Effective date: Changed</p> <p>Responsible organization: Changed from EM30 to EM20</p> <p>Forward: Changed to reflect new custodian and division. Launch vehicles added to reflect applicability</p> <p>Scope: Launch vehicles added to reflect applicability</p> <p>Section 1: Delete specific chemical composition of titanium to include all titanium fasteners. This change is reflected in the entirety of the document.</p> <p>Section 2: Applicable specifications, standards, and publications updated.</p> <p>Section 2.2: Replace ASTM E595.07 with NASA-STD-6016.</p> <p>Section 2.2: Added the address for ASME</p> <p>Section 3: Definition of "reuse" added</p> <p>Section 4.1-Delete specific chemical composition of titanium to include all titanium fasteners. Requirements documents update. Applicable sizes of fasteners redefined.</p> <p>Section 4.2-Helical coils and inserts added versus addressing only nuts.</p> <p>Section 4.3-Previous 4.3 bullets deleted, causing all subsequent bullets to be revised. Governing controlling document for corrosion control changed. Previous statement regarding washers deleted. Changed the text in parentheses to: "bolt, washer, helical coils, insert, nut, and coatings"</p> <p>Section 4.4 -Governing requirement for lubricants changed</p> <p>Section 4.5-Governing requirement for fluid compatibility changed. Previous wording of 4.5 deleted.</p> <p>Section 4.6- Requirement revised for clarity</p> <p>Section 4.7.1-Paragraph reworded for clarity.</p> <p>Section 4.8- Delete specific chemical composition of titanium to include all titanium fasteners</p> <p>Section 4.8.1-Delete specific chemical composition of titanium to include all titanium fasteners</p> <p>Section 4.8.1.1-Replace illumination level with magnification level. Bulleted list substituted over previous document hierarchy. .</p> <p>Section 4.8.1.2-Paragraph revised for clarity. Added System 21 and 22.</p> <p>Section 4.9.1.2.2-deleted</p> <p>Section 4.9.1.2.3-deleted</p> <p>Section 4.9-Inserts and helical coils added. Delete specific chemical composition of titanium to include all titanium fasteners</p> <p>Section 4.10-deleted</p> <p>Section 5.2- Add note to clarify use of NAS621 and NAS4004 with titanium alloys other than Ti-6Al-4V.</p> |

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FOREWORD

1. This standard specifies criteria for use of titanium alloy fastener systems for launch vehicles, spacecraft, and associated equipment.
2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to the custodian: Zachary H. Taylor/EM20, Materials and Processes Laboratory, NASA/George C. Marshall Space Flight Center, Huntsville, AL 35812.

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1. SCOPE

This standard establishes criteria for use of titanium alloy threaded fastener systems for launch vehicles, spacecraft, and associated equipment. These criteria are applicable to items designed and fabricated by MSFC and its prime contractors for use on MFSC programs.

2. APPLICABLE DOCUMENTS

2.1 Government publications.

The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal **shall** apply.

| | |
|---------------|--|
| MIL-PRF-46010 | Performance Specification, Lubricant, Solid Film, Heat Cured, Corrosion Inhibiting |
| MIL-I-45914 | Military Specification, Insert, Screw Thread - Locked In, Key Locked , General Specification For |
| MIL-I-45931 | Military specification: Insert, Screw Thread, Thin Wall, Locked In |
| MIL-I-45932 | Military Specification, Insert, Screw Thread, Thin Wall, Locked In, General Specification For |
| NASA-STD-6016 | Standard Materials and Processes Requirements for Space Craft |

(Copies of Specifications and Standards required by contractors in connection with specified procurement functions should be obtained from the procuring 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 indicated, the issue in effect on date of invitation for bids or request for proposal, **shall** apply.

| | |
|----------------|---|
| ANSI/ASME-B1.2 | Gages and Gaging for Unified Inch Screw Threads |
|----------------|---|

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ANSI/ASME-B1.3M Screw Thread Gaging System for Acceptability -Inch and Metric Screw Threads (UN, UNR, UNJ, M, and MJ)

(Applications for copies should be addressed to ASME International, Three Park Avenue, New York, N.Y. 10016-5990)

2.2.1 NATIONAL AEROSPACE STANDARDS

| | |
|-----------|---|
| NAS621 | Fasteners, Titanium Alloy, Procurement Specification |
| NAS4004 | Fasteners, 6Al-4V Titanium Alloy, Externally Threaded |
| NASM8846 | Inserts, Screw-Thread, Helical Coil |
| NASM25027 | Nut, Self-Locking , 250 F, 450° F, and 800° F |

(Applications for copies should be addressed to the Aerospace Industries Association of America, Inc., 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3901)

2.2.2 SOCIETY OF AUTOMOTIVE ENGINEERING

| | |
|------------|---|
| SAE-AS8879 | Screw Threads -UNJ Profile, Inch Controlled Radius Root with Increased Minor Diameter |
|------------|---|

2.2.3 SAE AEROSPACE MATERIAL SPECIFICATION

| | |
|-------------|--|
| SAE-AMS5525 | Steel, Corrosion and Heat Resistant, Sheet, Strip, and Plate 15Cr-25.5Ni-1.2Mo-2.1Ti-0.006B-0.30V, 1800 Degrees F (982 Degrees C) Solution Heat Treated |
| SAE-AMS5732 | Steel, Corrosion and Heat Resistant, Bars, Wire, Forgings, Tubing and Rings 15Cr-25.5Ni-1.2Mo-0.006B-0.30V Consumable Electrode Remelted 1800 Degrees F (982 Degrees C) Solution and Precipitation Heat Treated |
| SAE-AMS5737 | Steel, Corrosion and Heat Resistant Bars, Wire, Forgings, and Tubing 15Cr-25.5Ni-1.2Mo-2.1Ti-0.006B-0.30V Consumable Electrode Melted 1650 Degrees F(899 Degrees C) Solution and Precipitation Heat Treated |
| SAE-AMS5758 | Alloy Bars, Corrosion Resistant, 20Cr-35Ni-35Co-10Mo, Vacuum Induction Plus consumable Electrode Vacuum Melted, Solution Heat Treated For Work Strengthening |

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(Applications for copies should be addressed to the SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001)

3. DEFINITION

Reuse. When pertaining to fastening system elements, fasteners and helical coils, inserts, or nuts that are reinstalled with any amount of preload applied.

4. GENERAL REQUIREMENTS

4.1 Titanium alloy bolts **shall** comply with the requirements of the applicable sections of either NAS621 or NAS4004. Tailoring or exceptions (e.g, alloy, material strength, etc) shall be noted on the bolt standard part drawing. Titanium bolt size **shall** be limited to less than 0.750 inch diameter. Any bolt size greater than 0.750 inch diameter **shall** be submitted to MSFC for review.

4.2 All nuts, helical coils, and inserts **shall** be self-locking, lubricated, and **shall** be made from material conforming to SAE-AMS5525, SAE-AMS5732, SAE-AMS5737, SAE-AMS5758, or a MSFC approved corrosion resistant alloy and **shall** comply with the applicable sections of NASM25027, MIL-I-45914, MIL-I-45931, MIL-I-45932, or NASM8846. Tailoring or exceptions (e.g, alloy, material strength, etc) shall be noted on the bolt standard part drawing.

4.3 The fastener system (bolt, washer, helical coil, inserts, nut and coating) **shall** be designed to prevent corrosion in accordance with the guidelines given in NASA-STD-6016. The use of cadmium or silver on any fastener system component is specifically prohibited.

4.4 Lubricants for nuts, helical coils and inserts **shall** be selected in accordance with the requirements of MIL-PRF-46010, NASM25027, MIL-I-49514, MIL-I-45931, MIL-I-49532, or NAS8846 and **shall** pass the requirements of NASA-STD-6016 for use in launch vehicles and space craft applications. Lubricants not meeting the requirements contained in these documents **shall** be submitted to MSFC for review.

4.5 All titanium alloy fasteners shall meet the requirements for fluid compatibility and for titanium in NASA-STD-6016.

4.6 Titanium alloy fasteners shall be prohibited from use in any application or design where failure of a single bolt or nut will cause the structure to become unstable and unable to carry design loads or will result in the design no longer meeting its intended function (i.e., a single point failure).

4.7 Allowable Bolt Loads.

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4.7.1 The maximum ultimate tensile load for titanium bolts **shall** be no greater than sixty percent (60%) of the allowable ultimate tensile strength for the bolt material as published in the fastener design specification or procurement specification. The ultimate shear load may be up to 100% of the allowable shear strength values as published in the fastener design specification or procurement specification.

4.7.1.1 The total applied tensile load **shall** include the additive influences of installation preloading and service loading.

4.8 Reuse of Titanium Alloy Threaded Fastener Systems.

4.8.1 Reuse of titanium alloy bolts **shall** be limited to fifteen (15) cycles, subject to the following requirements for inspection.

4.8.1.1 After removal of the components from the structure, the fastener components **shall** be visually inspected under a magnification level of at least 5X for damage at the fastener surface. The following conditions **shall** be cause for rejection:

- a. Visible corrosion or corrosion products.
- b. Galling, stripping, scoring or scratching of threads or plating.
- c. Deformation of any part of the bolt.
- d. Foreign material in threads (not easily removed with a nonmetallic bristle brush and using an approved solvent).
- e. Cracks and discontinuities

4.8.1.2 After visual inspection, the fastener system components **shall** be inspected in accordance with the methods of measuring the characteristics of thread forms presented in ANSI/ASME B1.3M. At a minimum, System 22 shall be used to inspect external thread characteristics and System 21 shall be used to inspect internal thread characteristics. Gages shall meet the requirements of ANSI/ASME B1.2.

4.8.2 Bolt threads **shall** be protected from damage during any handling operation.

4.9 Reuse of Nuts, Inserts, and Helical Coils Installed with Titanium Alloy Bolts.

4.9.1 Nuts, helical coils and inserts can be reused up to five (5) cycles, provided that the hardware pass the corrosion, galling, stripping, scoring, scratching, and foreign material in threads inspection requirements of 4.8.1.1, 4.8.1.2, and the prevailing and breakaway torque limits of NASM25027, MIL-I-45931, MIL-I-45931, MIL-I-45932, or NAS8846 as applicable.

5. NOTES

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5.1 When Government specifications, drawings or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished or in any way supplied the said specifications, drawings or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person, corporation or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

5.2 In general, titanium alloy fasteners can be procured to the requirements of NAS621 or NAS4004 with some exceptions. NAS621 and NAS4004 specify the Ti-6Al-4V alloy at a strength level of 160ksi Ft_u, and NAS4004 calls out a specific microstructure for the Ti-6Al-4V alloy. Other titanium alloys may have different strength levels and microstructures than specified in these two specifications. Bolts can be manufactured from other titanium alloys, and strength levels as specified by part standards and still be procured to the requirements within NAS621 and NAS4004 (exceptions being the differences in alloy, strength level, and microstructure).