

Submitted for recognition as an American National Standard

**SHIP SYSTEMS AND EQUIPMENT—FASTENERS—
SELECTION AND IDENTIFICATION REQUIREMENTS**

Foreword—This Document has not changed other than to put it into the new SAE Technical Standards Board Format.

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1. **Scope**—This SAE Standard provides a comprehensive list of requirements for the selection, identification, and control of metric and inch sized fasteners for use in shipboard applications for both shipbuilder installed joints and for use in shipboard components. The fastener selection requirements include the following:

- a. Materials
- b. Thread selection
- c. Plating, coatings, and surface treatments
- d. Locking devices and elements
- e. Screw thread fastener inserts
- f. Fastener part or identifying numbers
- g. Identification markings

1.1 **Purpose**—The purpose of this document is to assist the designer in selecting a fastener and in determining what fastener options should be specified for a particular application. This document is intended to provide uniform requirements for the shipboard use of threaded fasteners and their associated hardware. It is also intended to promote the use of standardized fasteners and to minimize the variety of fasteners used.

1.2 **DoD Requirements**—Appendix A lists additional requirements that apply to military ships and other ships when specifically invoked.

2. References

2.1 **Applicable Publications**—The following documents form a part of this specification to the extent specified herein. The documents are those issues in effect on the date specified in the invitation for bid or procurement. If an effective date is not specified in the invitation for bid or procurement, the effective date shall be the issue date of the applicable invitation for bid or procurement document.

In the event of a conflict between the text of this document and the references cited herein (excluding equipment specifications and fastener part standards), the text of this document takes precedence in requirements related to fastener selection. The text of this document shall not supersede the requirements of an equipment specification or fastener part standard. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

- SAE J121—Decarburization in Hardened and Tempered Threaded Fasteners, Recommended Practice
- SAE J122—Surface Discontinuities on Nuts, Recommended Practice
- SAE J123—Surface Discontinuities of Bolts, Screws, and Studs in Fatigue Applications
- SAE J429—Mechanical and Material Requirements for Externally Threaded Fasteners, Standard
- SAE J1781—Materials for Fluid Systems of Marine Vehicles
- SAE J2270—Ship Systems—Fasteners—Test, Inspection and Installation Requirements
- SAE J2271—Ship Systems—Part Standard for Studs—Continuous and Double End (Inch Series)
- SAE J2271M—Ship Systems—Part Standard for Studs—Continuous and Double End (Metric Series)
- SAE J2295—Ship Systems and Equipment—Fasteners—Part Numbers
- SAE AMS 5732—Steel Bars, Wire, Forgings, Tubing, and Rings, Corrosion and Heat Resistant
- SAE AS478—Identification Marking Methods
- SAE AS7468—Bolts and Screws, Cobalt-Chromium-Nickel Alloy, Corrosion Resistant Forged Head, Roll Threaded After Aging, Fatigue Rated

2.1.2 AIAA PUBLICATIONS—Available from AIAA, 1250 Eye Street NW, Washington, DC 20005.

- NAS 1283—Fasteners, Male Threaded, Self-Locking
- NAS 1351—Screw, Cap, Socket Head, UNRF-3A Threads
- NAS 1352—Screw, Cap, Socket Head, UNRC-3A Threads

2.1.3 ASME PUBLICATIONS—Available from ASME, 345 East 47th Street, New York, NY 10017.

ASME B1.1—Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B1.2—Gages and Gaging for Unified Inch Screw Threads
ASME B1.3M—Screw Thread Gaging Systems for Dimensional Acceptability, Metric Screw Threads (M and MJ)
ASME B1.12—Class 5 Interference-Fit Thread
ASME B1.13M—Metric Screw Threads—M Profile
ASME B1.15—Unified Inch Screw Thread, UNJ Thread Form
ASME B1.16M—Gages and Gaging for Metric M Screw Threads
ASME B1.21M—Metric Screw Threads—MJ Profile
ASME B18.2.1—Square and Hex Bolts and Screws Inch Series
ASME B18.2.2—Square and Hex Nuts (Inch Series)
ASME B18.2.3.1M—Metric Hex Cap Screws
ASME B18.2.3.2M—Metric Formed Hex Screws
ASME B18.2.3.3M—Metric Heavy Hex Screws
ASME B18.2.3.5M—Metric Hex Bolts
ASME B18.2.3.6M—Metric Heavy Hex Bolts
ASME B18.2.3.7M—Metric Heavy Hex Structural Bolts
ASME B18.2.4.1M—Metric Hex Nuts, Style 1
ASME B18.2.4.2M—Metric Hex Nuts, Style 2
ASME B18.2.4.5M—Metric Hex Jam Nuts
ASME B18.2.4.6M—Metric Heavy Hex Nuts
ASME B18.3—Socket, Cap, Shoulder and Set Screws—Inch
ASME B18.3.1M—Socket Head Cap Screws—Metric
ASME B18.3.5M—Hexagon Socket Flat Countersunk Head Cap Screws—Metric
ASME Y14.34M—Part Lists, Data Lists, and Index Lists

2.1.4 ASTM PUBLICATIONS—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 193/A 193M—Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A 194/A 194M—Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
ASTM A 307—Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 325—Structural Bolts, Steel Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 325M—High-Strength Bolts for Structural Steel Joints [Metric]
ASTM A 354—Quenched and Tempered Alloy Steel Bolts, Studs and Other Externally Threaded Fasteners
ASTM A 449—Quenched and Tempered Steel Bolts and Studs
ASTM A 453/A 453M—Bolting Materials, High-Temperature, 50 to 120 ksi [345 to 827 MPa] Yield Strength, with Expansion Coefficients Comparable to Austenitic Steels
ASTM A 490—Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile
ASTM A 563—Carbon and Alloy Steel Nuts
ASTM A 563M—Carbon and Alloy Steel Nuts [Metric]
ASTM A 574—Alloy Steel Socket Head Cap Screws
ASTM A 574M—Alloy Steel Socket Head Cap Screws [Metric]
ASTM B 446—Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625), Rod and Bar
ASTM B 633—Electrodeposited Coatings of Zinc on Iron and Steel, Standard Specification For
ASTM B 637—Precipitation Hardening Nickel Alloy Bars, Forgings, and Forging Stock for High Temperature Service
ASTM B 695—Coatings of Zinc Mechanically Deposited on Iron and Steel, Standard Specification For
ASTM B 805—Standard Specification for Precipitation Hardening Nickel Alloys (UNS N07716 and N07725), Bar and Wire
ASTM F 467—Nonferrous Nuts for General Use

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ASTM F 467M—Nonferrous Nuts for General Use [Metric]
ASTM F 468—Nonferrous Bolts, Hex Capscrews and Studs for General Use
ASTM F 468M—Nonferrous Bolts, Hex Capscrews and Studs for General Use [Metric]
ASTM F 568—Carbon and Alloy Steel Externally Threaded Metric Fasteners
ASTM F 593—Stainless Steel Bolts, Hex Cap Screws and Studs
ASTM F 594—Stainless Steel Nuts
ASTM F 738M—Stainless Steel Metric Bolts, Screws, and Studs
ASTM F 835—Alloy Steel Socket Button and Flat Countersunk Head Cap Screws
ASTM F 835M—Alloy Steel Socket Button and Flat Countersunk Head Cap Screws [Metric]
ASTM F 836M—Stainless Steel Metric Nuts
ASTM F 837—Stainless Steel Socket Head Cap Screws
ASTM F 837M—Stainless Steel Socket Head Cap Screws [Metric]
ASTM F 879—Stainless Steel Socket Button and Flat Countersunk Head Cap Screws
ASTM F 879M—Stainless Steel Socket Button and Flat Countersunk Head Cap Screws [Metric]
ASTM F 1077—Standard Guide for Selection of Committee F16 Fastener Specifications (contains marking requirements)

2.1.5 U.S. GOVERNMENT PUBLICATIONS—Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094. Industry standards that have been adopted by the Department of Defense (DOD) can be ordered by DOD activities only from this address.

2.1.5.1 *Department of Defense Publications*

DODISS—Index of Specifications and Standards

2.1.5.2 *Federal Specifications*

QQ-N-286—Nickel-Copper-Aluminum Alloy, Wrought (UNS N05500)

2.1.5.3 *Federal Standards*

FED-STD-H28—Screw Thread Standards for Federal Services
FED-STD-H28/2—Screw Thread Standards for Federal Services Section 2 Unified Inch Screw Threads—UN and UNR Thread Forms
FED-STD-H28/6—Screw Thread Standards for Federal Services Section 6 Gages and Gaging for Unified Screw Threads—UN and UNR Thread Forms
FED-STD-H28/22—Screw Thread Standards for Federal Services Section 22 Gages and Gaging for Metric Screw Threads—M and MJ Thread Forms
FED-STD-H28/23—Screw Thread Standards for Federal Services Section 23 Class 5 Interference Fit Screw Threads

2.1.5.4 *Military Handbooks*

MIL-HDBK-57—Listing of Manufacturers' Identification Symbols
MIL-HDBK-131—Identification Markings for Fasteners
H41/H42—Commercial and Government Entities

2.1.5.5 *Military Specifications*

MIL-S-901—Shock Tests, H.I. (High Impact) Shipboard Machinery, Equipment and Systems, Requirements for
MIL-S-1222—Studs, Bolts, Hex Cap Screws, Socket Head Cap Screws and Nuts
MIL-F-8961—Fastener Element, Self-Locking, Externally Threaded, 450°F and 1200°F
MIL-F-18240—Fastener Element, Self-Locking, Threaded Fastener, 250°F Maximum

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DOD-P-24648—Primer Coating, Zinc Dust Pigmented for Exterior Steel Surfaces (Metric)
MIL-N-25027—Nut, Self-Locking, 250°F, 450°F, 800°F, 125 ksi F_{tu} , 60 ksi F_{tu} and 30 ksi F_{tu}
MIL-N-25027/1—Nut, Self-Locking, Heavy Hex (Non-metallic Insert), 250 Degrees F, UNJC-3B, 1/4 through 2-1/2 Inch Nominal Diameters, Nickel-Copper Alloy
MIL-S-46163—Sealing, Lubricating and Wicking Compounds: Thread-Locking, Anaerobic, Single Component
MIL-C-87115—Coating, Immersion Zinc Flake/Chromate Dispersion

2.1.5.6 *Military Standards*

MIL-STD-438—Schedule of Piping, Valves, Fittings and Associated Piping Components for Submarine Service
MIL-STD-777—Schedule of Piping, Valves, Fittings and Associated Piping Components for Naval Surface Ships
MIL-STD-965—Parts Control Program
MIL-STD-1689—Fabrication, Welding, and Inspection of Ships Structure
MS 15981—Fastener, Externally Threaded, Self-Locking Design and Usage Limitations for
MS 17828—Nut, Self-Locking, Hexagon, Regular Height, (Non-Metallic Insert) 250 °F (Nonmetallic Insert), Nickel-Copper Alloy
MS 20995—Wire, Safety or Lock
MS 33540—Safety Wiring and Cotter Pinning, General Practices for
MS 33588—Nut, Self-Locking, Aircraft, Reliability and Maintainability Usage Requirements for
MS 33602—Bolt, Self-Retaining, Aircraft, Reliability and Maintainability Design and Usage Requirements for

2.1.5.7 *Commercial Item Descriptions*

A-A-59004—Anti-galling Compound, Thread Lubricating, Seizing Resistant, and Calcium Hydroxide Containing

2.1.6 NAVSEA PUBLICATIONS—Available from the Naval Sea Systems Command, 2531 Jefferson Davis Highway, Arlington, VA 22242-5160 (Request from appropriate Contracting Officer.)

0908-LP-000-3010—Shock Design Criteria for Surface Ships
0941-LP-041-3010—Submarine Material Certification Design Review Procedure Manual (U)—(Document is Confidential, distribution restricted)
0948-LP-045-7010—Material Control Standard (Non-nuclear)
0924-LP-062-0010—Submarine Material Certification Requirements Manual for the Submarine Safety Program (For Official Use Only)

2.1.7 OTHER PUBLICATIONS

Ross, R. W. Jr. and Tuthill, A. H., Practical Guide to Using Marine Fasteners, MATERIALS PERFORMANCE, Vol 29, No. 4 pp 6569 (1990) April

3. Definitions

- 3.1 **Allowance**—The prescribed difference between the maximum material limits of mating parts. The allowance is the difference between limiting dimensions on mating parts which are to be assembled either loosely or tightly, depending on the amount allowed for the fit.
- 3.2 **Alloy Steel**—A type of steel containing significant quantities of alloying elements (other than carbon and the commonly accepted amounts of manganese, silicon, sulfur, and phosphorus) that are added to obtain specific mechanical or physical properties, such as toughness, hardness, strength at elevated temperatures and corrosion resistance.
- 3.3 **Anaerobic Thread-Locking Compound**—A compound that solidifies in the absence of air; used to secure threaded fasteners against loosening in service.
- 3.4 **Anode**—In a metallic couple, the metal that corrodes.
- 3.5 **Bearing Face or Surface**—The surface of the fastener that is at right angles to the fastener centerline and that bears against the part or parts that it fastens; the area under the nut or head of a bolt.
- 3.6 **Body**—The body of a fastener is the unthreaded portion of the shank of an externally threaded fastener.
- 3.7 **Body Bound Bolt**—Another term for fitted bolt. (See "fitted bolt.")
- 3.8 **Bolt**—A bolt is a threaded fastener with an integral, usually hexagonal, head on one end intended to be used with a nut. (Sometimes incorrectly called a cap screw.) (See "cap screw.")
- 3.9 **Bolt-Stud**—See "stud."
- 3.10 **Bottoming**—Bottoming is the process of screwing a fastener into a threaded hole until it contacts the bottom of the hole. The resulting stresses can lead to such things as cracked castings.
- 3.11 **Breakaway Torque**—Breakaway torque is the torque required to start the rotation of a fastener. The magnitude of this torque is significant when checking the bonding of an anaerobic locking compound. The term is also used to describe the torque required to start the rotation of a fastener when loosening it or restarting its rotation when tightening a group of fasteners in successive increments. Breakaway torque will generally be higher than that required to continue the rotation.
- 3.12 **Cap Screw**—A cap screw is a threaded fastener with an integral, usually hexagonal, head on one end that is intended to be used in a tapped hole. It has stringent controls on its dimensions so that it can be more easily screwed into a tapped hole. Because of dimensional differences, cap screws may be used in place of bolts; however, bolts can not necessarily be used in place of cap screws.
- 3.13 **Cathode, Cathodic Protection**—In a metallic couple, the more noble material which is protected against corrosion.
- 3.14 **Clamping Force**—Clamping force is the force created by tightening a threaded fastener.
- 3.15 **Class of Thread**—The class of thread is an alphanumeric designation to indicate the standard grade of tolerance and allowance specified for a thread.
- 3.16 **Cold Heading**—Cold heading is a room temperature metal forging process using high forces to form a head on bolts and screws.

- 3.17 Fastener**—A fastener is a mechanical device that holds two or more main bodies in definite positions with respect to each other.
- 3.18 Fit**—Fit is the general term used to describe the range of looseness or tightness of two mating parts when they are assembled. This is the result of the application of a specific combination of allowances and tolerances.
- 3.19 Fitted Bolt**—A stud or bolt that has been fitted to its mating hole so that the clearances between its unthreaded shank and its mating hole are extremely small. Normally, the hole is drilled and reamed true and square with the bearing surface and the bolt machined to fit the hole. A fitted bolt should not be confused with interference fit.
- 3.20 Free Machining**—A material to which ingredients, such as sulfur or lead, have been deliberately added to improve the machining characteristics. Common examples are 303 stainless (sulfur added) and 836 bronze (lead added).
- 3.21 Functional Diameter**—The diameter of an enveloping thread with perfect pitch, lead and flank angles, and having a specified length of engagement. This diameter includes the cumulative effect of variations in lead (pitch), flank angle, taper, straightness and roundness. Variations at the thread crest and root are excluded.
- 3.22 Galling**—A condition on any of the rubbing surfaces of one or both mating parts where friction between microscopic high spots causes localized welding, resulting in spalling, further roughening of the surface, followed by more severe localized welding.
- 3.23 Grip Length**—Grip length is the distance between the bearing surfaces of a bolt head and nut.
- 3.24 Hardness**—A property of metals which relates strength, elasticity, and toughness to the material's ability to resist abrasion and indentation. Hardness is usually defined quantitatively using the Rockwell, Brinell, and Vickers scales.
- 3.25 Head Type**—The specific geometry or form of a fastener's head. Common head types are:
- 3.25.1 COUNTERSUNK HEAD—A head design usually characterized by a flat top surface and 82 or 100 degree bearing surface (as opposed to a 180 degree or flat-bearing surface found on common hex head fasteners). (Usually with a socket or slotted drive.)
 - 3.25.2 FILLISTER HEAD—A cylindrical head design with rounded or dome top, cylindrical sides and flat-bearing surface.
 - 3.25.3 HEXAGON HEAD—A head design with flat top, six sides used as wrenching surfaces, and a flat-bearing surface.
 - 3.25.4 PAN HEAD—A head design with a flat top radiused into rounded sides and a flat-bearing surface. Usually with a slotted drive.
 - 3.25.5 SOCKET HEAD—A circular head design with a hexagonal or splined recess socket. Commonly used on cylindrical or countersunk head designs.
- 3.26 Hot Heading**—The hot forging of heads on fasteners.
- 3.27 Interference Fit**—An interference fit is the fit between mating assembled parts that provides an interference at their minimum material condition.

- 3.28 Internal Wrenching Bolt**—An internal wrenching bolt is a bolt having a large cylindrical head with a flat top, flat-bearing surface and hexagonal socket. Internal wrenching bolts of a similar design, except that the head is a truncated cone (indicates a large radius between the shank and the head requiring a countersunk washer), are often used in aerospace applications.
- 3.29 ksi**—ksi is the abbreviation for 1000 pounds per square inch, the "k" representing kip, which is 1000 lbf.
- 3.30 Length of Thread Engagement**—Length of thread engagement is the axial distance over which the complete external thread is in contact with the complete internal thread, measured at the pitch diameter.
- 3.31 Machined Threads**—Machined threads are threads that are formed by cutting away material.
- 3.32 Magnetic Permeability**—The relationship, expressed in Oersteds, between magnetic induction and magnetizing force. Absolute permeability is the quotient of a change in magnetic induction divided by the corresponding change in magnetizing force. Relative permeability is the ratio of absolute permeability to the permeability of free space.
- 3.33 Major Diameter**—On a straight thread, the major diameter is the diameter of the crest of the external thread or the root of the internal thread.
- 3.34 Maximum Material Condition**—Maximum material is the condition where a feature of size contains the maximum amount of material within the stated limits of size. For example, the crest and root of an externally threaded fastener are at their maximum diameter, or the crest and root of an internally threaded fastener are at their minimum diameter.
- 3.35 Minimum Material Condition**—Minimum material is the condition where a feature of size contains the least amount of material within the stated limits of size. For example, crest and root of an externally threaded fastener are at their minimum diameter, or the crest and root of an internally threaded fastener are at their maximum diameter.
- 3.36 Minor Diameter**—On a straight thread, the minor diameter is the diameter of the root of the external thread or the crest of the internal thread.
- 3.37 MPa**—The abbreviation for Mega-Pascals or 1 000 000 Pascals, the standard unit of stress for metric fasteners.
- 3.38 Nonstandard Fasteners**—Nonstandard fasteners are fasteners which differ in size, length, material, finish or other controlled characteristic from established and published standards such as military specification sheets or industry standards.
- 3.39 Pitch**—Pitch is the distance, measured parallel to the fastener's axis, between corresponding points on adjacent thread forms in the same axial plane and on the same side of the axis. Usually given in threads per inch (TPI). Metric threads are designated using the actual thread pitch.
- 3.40 Pitch Diameter**—The pitch diameter is the diameter of an imaginary cylinder whose surface passes through the threads at the point where the width of the thread groove is the same as the width of the thread ridge, roughly halfway between the top and bottom of the thread.
- 3.41 Preload**—Preload is the amount of clamping force exerted by a fastener on joined members that is solely attributed to tightening of the fastener.
- 3.42 Prevailing Torque**—Prevailing torque is the torque required to rotate a nut or bolt where the fastener is applying no clamping force to the parts being fastened. The torque required to bring mating parts together is not considered prevailing torque.

- 3.43 Prevailing-Torque Locknut**—A prevailing-torque locknut is a locknut that maintains a prevailing torque or resistance to rotation even with no clamping force present.
- 3.44 Proof Load**—Proof load is a specified test load that a fastener must withstand without any indication of yielding or permanent deformation.
- 3.45 Roll-Formed Threads**—Threads formed by rolling the fastener blank between grooved dies.
- 3.46 Root Diameter**—The root diameter is the diameter of an imaginary cylinder or cone bounding the bottom of the roots of a screw thread. Root diameter is the more common term for the minor diameter of an external thread or the major diameter of an internal thread.
- 3.47 Self-Locking Fastener**—A fastener having a self-contained locking feature, such as a nut with an integral annular nylon ring or a bolt with a nylon pellet, that resists rotation by gripping the mating thread and does not depend upon the applied load for locking.
- 3.48 Socket Head Cap Screw**—A socket head cap screw is a headed, externally threaded fastener with a recessed, hexagonal or spline socket.
- 3.49 Spalling**—Spalling is the breaking or chipping off of material, usually by impact forces.
- 3.50 Standard Fasteners**—Standard fasteners are fasteners which conform in all respects to recognized and published standards such as military specification sheets or industry standards.
- 3.51 Standard PIN**—A standard Part or Identifying Number (PIN) is a part number designation identified in a recognized and published industry or military fastener standard.
- 3.52 Stud**—A stud is a cylindrical rod (headless fastener) threaded on either one or both ends or throughout its entire length. Some of the more common types are defined below:
- 3.52.1 BOLT STUD—See continuous thread stud and double end stud (clamping type).
- 3.52.2 CONTINUOUS THREAD STUD—This stud is threaded its entire length with conventional threads for the assembly of nuts on both ends. (One end may be set in a tapped hole using an anaerobic compound.)
- 3.52.3 DOUBLE END STUD (CLAMPING TYPE)—This stud has conventional threads on both ends of the stud. It serves the function of clamping two bodies together with a nut on either end. (One end may be set in a tapped hole using an anaerobic compound.)
- 3.52.4 DOUBLE END STUD (INTERFERENCE THREAD TYPE)—This stud has conventional threads on the "nut" end and threads on the "stud" or "tap" end that will give an interference fit in the hole in which it is installed.
- 3.52.5 STUD BOLT—See double end stud (clamping type).
- 3.52.6 TAP END STUD—See double end stud (interference thread type).
- 3.53 Tensile Strength**—Tensile strength, also called ultimate strength, is the maximum tensile stress (in pounds per square inch or Mega Pascals) a material can sustain without tearing apart.
- 3.54 Tensile Stress Area**—The tensile stress area is the circular cross-sectional area of a theoretical unthreaded rod whose cross-sectional area is such that it would fail in tension at the same load as a particular threaded fastener.

- 3.55 Through Bolt**—A through bolt is a bolt that passes completely through both members to be fastened and has a head on one end and a nut on the other. (See "bolt.")
- 3.56 Tolerance(s)**—Tolerances are specified amounts by which dimensions are permitted to vary. The tolerance is the difference between the maximum and the minimum limits permitted.
- 3.57 Torque**—Torque is a turning or twisting moment exerted on a fastener.
- 3.58 Torque, Breakaway**—See "breakaway torque."
- 3.59 Torque, Prevailing**—See "prevailing torque."
- 3.60 Ultimate Strength**—See "tensile strength."
- 3.61 Washer-Faced**—A bolt or nut configuration where the fastener has a raised bearing surface. The bearing surface is smooth and has a round outer diameter, and acts as an integral washer.
- 3.62 Yield Strength**—Yield strength is a mechanical property that represents the maximum tensile stress that a material can sustain without causing more than a specified amount of permanent deformation.
- 4. Fastener Selection**—Unless otherwise specified, fasteners shall be selected based on the requirements specified herein. The materials and other fastener options selected shall be suited to the application.
- 4.1 Fastener Part Standard Selection** —After determining the required materials and other fastener options, a fastener part standard that defines those requirements shall be selected. Fasteners that have Part or Identifying Numbers (PINs) associated with an industry or government standard or specification, are preferred for use over fasteners identified by company standards and drawings. The applications and limitations associated with fastener Part or Identifying Numbers are outlined in Section 10.
- 4.1.1 ORDER OF PREFERENCE FOR PART STANDARD SELECTION**—Fastener part standards should be selected according to the following list. The order of precedence is in descending order.
- a. Fasteners with a Part or Identifying Numbering system developed by a nongovernment standards body (NGSB).
 - b. Government issued Commercial Item Descriptions with part or identifying numbers.
 - c. Fasteners with a Part or Identifying Number based on a federal or military standard.
 - d. Fasteners to drawings complying with ASME Y14.34M part identification requirements and based on nongovernment standards.
- NOTE—Part identification numbers for many fasteners to industry and military standards are identified in SAE J2295. Many additional part identifying numbers are identified in individual ASME, NAS and SAE fastener part standards.
- 4.2 Bolting for Shock Resistance**—Requirements for selecting fasteners used in shock-qualified equipment are provided in Appendix A.
- 4.3 Panel Fasteners and Welding Studs**—Fasteners that do not normally require replacement or logistic support, such as captive or panel fasteners, may have nonstandard or proprietary configurations. The fastener materials shall be selected in accordance with Section 5. There are no part standards for captive fasteners. Some military part standards have been developed for welding studs. The length of welding studs after installation can vary with the size of the weld stud and the welding process. If length is critical in an application, drawings should specify after weld length requirements.

- 4.4 Washers**—Washers are normally used under the fastener being tightened. Washers may be used to provide load distribution, a hardened bearing surface, locking assistance, or some combination of these functions. Washer material should be compatible with the threaded fastener materials. If the washer material does not have the strength level of the threaded fasteners, the fastener may relax or loosen in service. Washers are recommended under bolt heads and/or nuts in the weather or in wet areas. Washer faced fasteners may be installed without washers.
- 5. Performance Requirements for Fastener Material Selection**—The basic criteria for selecting a fastener material are the required strength of the fastener; the material of the component, equipment or structure in which the fastener is to be located; and the application. Table 1 shall be used as a guide in determining an appropriate fastener material for a particular application. Appendix A provides requirements for military applications for better corrosion control which may result in higher initial material costs but lower maintenance costs. For fastener compatibility with nonmetallic materials, consult the paper by Ross and Tuthill listed in 2.1.7. This paper also indicates that bolt holes in aluminum structure both below and above the waterline should be packed with a graphite-free, water repellent lubricant. This helps prevent the loss of aluminum and enlargement of bolt holes to the point where the joint may be jeopardized.

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TABLE 1—MATERIAL SELECTION GUIDE FOR FASTENERS

Application	Metals to be Joined Steel to Steel	Metals to be Joined CRES to CRES	Metals to be Joined Steel to Aluminum Alloys	Metals to be Joined Aluminum and Aluminum Alloys	Metals to be Joined Copper and Copper Alloys	Metals to be Joined Nickel Alloy to Nickel Alloys	Metals to be Joined Titanium to Titanium
1. Submerged and intermittently submerged	MP35N Titanium NiCu Alloy 400/405 NiCuAl QQ-N-286 CRES 660 or Alloy A286 Carbon & Alloy Steel (with coating)	CRES 660 or Alloy A286 Titanium MP35N NiCu Alloy 400/405 NiCuAl QQ-N-286	CRES 660 or Alloy A286 Titanium	Titanium CRES 660 or Alloy A286 Aluminum	NiCu Alloy 400/405 NiCuAl QQ-N-286 MP35N	NiCu Alloy 400/405 NiCuAl QQ-N-286 Alloy 265+ Alloy 725 Titanium	Titanium Alloy 625 Alloy 625+ Alloy 725
2. Wet spaces, bilges or where exposed to the weather or salt spray	Materials listed above Weathering steel (with coating) CRES 304 CRES 316	Materials listed above CRES 304 CRES 316 Alloy 718	Materials listed above CRES 304 CRES 316 Alloy 718 Carbon & Alloy steel (with coating)	Materials listed above CRES 304 CRES 316	Materials listed above Naval Brass Alloy 625+ Alloy 718 Alloy 725	Materials listed above CRES 660 or Alloy A286 Alloy 625 Alloy 718	Materials listed above Alloy 718
3. General Purpose (not involving submerged, bilges, wet spaces, or weather conditions)	Materials listed above Carbon & Alloy Steel CRES (300 Series) Alloy 718	Materials listed above CRES (300 series)	Materials listed above Carbon & Alloy steel CRES 300 series	Materials listed above Alloy 718 Aluminum 6061T6	Materials listed above Copper Alloy (Naval Brass) Alloy 462 Alloy 464 Copper Silico Alloy 651 CRES 660 or Alloy A286	Materials listed above	Materials listed above Alloy A286

NOTE—Standard installation preload tables are normally based on bolt yield strength. Verify that preload requirements of nut and bolt/stud combinations or stud and set end material combinations will not exceed nut stripping strength. If necessary, specify acceptable torque or preload information on drawing.

5.1 Nonmagnetic Applications—Fasteners required for nonmagnetic applications, such as minesweepers, shall be of nonmagnetic materials. Unless special requirements exist for sensitive instrumentation or equipment, a value of 2.0 Oersteds maximum is normally adequate.

5.1.1 **NICKEL ALLOYS**—Not all nickel alloys are magnetically acceptable (relative magnetic permeability of 2.0 or less after fabrication). Ni-Cu-Al, but not Ni-Cu, is magnetically acceptable. The magnetic permeability of nickel-copper can change when the material is cooled since the transition temperature is often within the temperature operating range of the equipment.

5.1.2 **TITANIUM ALLOYS**—Titanium and titanium alloys are considered totally nonmagnetic regardless of temperature or amount of hot or cold work. Titanium alloys have a relative magnetic permeability of 1.0001.

5.1.3 **CRES**—Not all corrosion-resistant steels (CRES) are acceptable for use in nonmagnetic applications. All 400 series CRES is magnetic. Some 300 series CRES is acceptable, while other 300 series are not. The relative magnetic acceptability of commonly used 300 series CRES materials is shown in Table 2.

TABLE 2—MAGNETIC ACCEPTABILITY OF CORROSION RESISTANT STEEL (300 SERIES)

Good	Poor	Bad
305	302 ⁽¹⁾	301
310	304 ⁽¹⁾	309
3161	347	
321		

1. Magnetic after heavy (extreme) cold work.

5.1.4 **MAGNETIC PERMEABILITY TESTS**—Fasteners used in nonmagnetic applications may require magnetic permeability testing. See SAE J2270 for information on specifying test requirements, if required.

5.2 Corrosion Resistance—Selecting a fastener material that is the same or similar to the interfacing parts of the system ensures that galvanic corrosion will be kept to a minimum. When a fastener material must be selected that is different than the respective components or structures to be joined, choosing the specific fastener material that is the least susceptible to degradation is critical. In general, it is best to select a fastener material which is lightly cathodic (more noble and protected from corrosion), or at least not anodic, to the materials being fastened. Consider both the materials compatibility with the environment (inherent corrosion resistance) and with the materials to be joined (galvanic corrosion resistance). For further guidance on determining what materials are cathodic to the materials to be fastened, as well as general corrosion control guidance, consult SAE J1781.

- 5.2.1 **INHERENT CORROSION RESISTANCE**—Inherent corrosion resistance refers to the materials compatibility with the environment and includes the following: uniform corrosion, localized corrosion (pitting and crevice corrosion), and stress corrosion. Localized corrosion is of special concern since fasteners have inherent crevices and partially enclosed voids which can trap moisture. General corrosion attack is most prevalent for carbon and alloy steel fasteners in the form of rust. The corrosion resistance of carbon and alloy steels can be improved by coating, such as zinc plating or galvanizing. Aluminum and other materials can experience significant attack in certain environments. The corrosion resistance of aluminum can be improved by anodizing.
- 5.2.2 **GALVANIC CORROSION**—Galvanic corrosion occurs between dissimilar metals in mutual contact with a liquid, either under immersion conditions or in crevices where moisture has collected. Corrosion is accelerated at the less noble material (the anode), and is decreased at the more noble material (the cathode). In general, the surface area of fasteners is small compared to the other materials in the system. Since galvanic corrosion is accelerated for large cathode to anode surface area ratios and since fasteners are generally the most prone to failure if corrosion occurs, fastener materials should be cathodic (more noble) to the surrounding materials. Surface treatments such as anodizing and passivating may help to reduce galvanic corrosion of certain fastener materials.
- 5.3 High-Strength Fasteners**—Some high-strength fasteners such as Ni-Cu-Al (K-Monel) and steel with a tensile strength greater than 1034 MPa (150 ksi) are susceptible to hydrogen embrittlement, including hydrogen evolved by cathodic processes. Not all high-strength materials are susceptible but, as a general rule, do not use coatings containing sacrificial material on high-strength fasteners, and do not use high-strength material to fasten components whose surfaces are very anodic to the fastener material. For submerged systems, avoid the use of high-strength fasteners in the vicinity of cathodic protection anodes (sacrificial or impressed current type).
- 5.3.1 **STRESS-CORROSION CRACKING**—The combination of stress and corrosion can result in stress-corrosion cracking, which is a problem generally associated with high-strength materials. To avoid stress-corrosion cracking, it is good practice to use lower strength materials whenever possible.
- 5.4 Minimizing Galling**—Galling can damage thread surfaces and may be caused by a lack of lubrication, high contact pressure between the mating threads, and heat. Galling can occur, especially with stainless steel and NiCu, if the mating fasteners are fabricated from the same alloy. For example, Heavy Hex NiCu nuts should be used with NiCuAl bolts, screws, and studs to minimize galling. An appropriate thread lubricant may be used to minimize galling. (See SAE J2270 for information on the selection of fastener lubricants.) The class of fit may also affect the tendency to gall when mating materials are the same (see Section 6).
- NOTE—Standard installation preload tables are normally based on bolt yield strength. Verify preload requirements of nut and bolt/stud combinations or stud and set end material combinations will not exceed nut stripping strength. If necessary, specify acceptable torque or preload on drawing.
- 5.5 Temperature Limits**—Temperature shall be considered when determining the required strength of a fastener for a given application. Material tensile strength reduces as operating temperature increases. Maximum temperature limits for some fastener materials are provided in Table 3.

TABLE 3—MAXIMUM TEMPERATURE LIMITS FOR FASTENER MATERIALS

Material Standard	Material Grade (Alloy)	Temperature °C	Temperature °F
ASTM A 193	Grade B16 (Alloy steel)	540	1000
	Grade B7 (Alloy steel)	480	900
ASTM A 194	Grades 4 and 7 (Alloy steel)	540	1000
ASTM A 354	Grade BD (SAE Grade 8) (uncoated or black oxide)	345	650
ASTM A 449	Type 1 (SAE Grade 5) (uncoated or black oxide) (zinc coated)	345	650
		150	300
Various	CRES (300 Series passivated finish) (if submerged in sea water)	315	600
		50	120
ASTM A 453	Alloy 660 (May be higher for A286 materials to SAE AMS specifications)	540	1000
ASTM F 467 &	Alloy 400, 405 (Nickel-Copper) Alloy 500 (Nickel-Copper-Aluminum)	230	450
		150	300
ASTM F 468	Alloy 19 (Titanium)	220	425

5.6 Material Standards—Fastener materials shall be in accordance with the applicable military part standard (MS sheet or specification sheet) or industry standard for the fastener, as applicable.

5.6.1 **NI-CU-AL (K-MONEL)**—The processing of Ni-Cu-Al alloy (K-monel) material for fasteners in accordance with QQ-N-286 provides better controls on the material than do ASTM F 467 and F 468 Alloy 500 requirements.

5.6.2 **POWDER-METALLURGY**—Fasteners fabricated by powder-metallurgy processes shall not be used.

5.6.3 **INDUSTRY FASTENER MATERIAL AND DIMENSION STANDARDS**—Table 4 provides a list of selected fastener materials and dimensional standards which may be suitable to identify fasteners for ship systems. The majority of the dimensional standards have been developed by the ASME and have been adopted as ANSI standards. For materials, these national standards usually refer to ASTM standards. The ASTM material standards usually reference the ASME standards for fastener configurations. For many fastener part standards, the full material requirements are identified in the fastener procurement specification. For other configuration fasteners, such as set screws, refer to a more complete listing of ASME and ASTM standards.

5.6.3.1 **Use of Table 4**—Table 4 is a listing of some of the more common material and dimensional standards. When the fasteners types or materials needed are not covered by the preferred parts identified in Section 10 or other industry and government standards, Table 4 can be used to identify applicable standards to refer in order to develop fastener drawings.

5.6.3.2 **Coating for Fasteners to Industry Standards**—Table 4 also contains recommendations as to coatings for the material types listed.

TABLE 4—SELECTED INDUSTRY AND FASTENER MATERIAL STANDARDS

Material Standard (ASTM)	Material Type	Recommended Coating	Type Fastener	Typical Dimensional Standards (ASME)
A 193/ A 193M	Gr B7 (Alloy steel) Gr B16 (Alloy steel)	None None	Screws/Bolts	B18.2.1 B18.2.3.1M B18.2.3.2M B18.2.3.3M B18.2.3.5M B18.2.3.6M SAE J2271 SAE J2271M
	For standardization B16 is preferred to B7			
A 194/ A 194M	Gr 7 (Alloy Steel) (Can be used in place of ASTM A 563 Grades C, D and DH unplated nuts)	None	Nuts	B18.2.2 B18.2.4.1M B18.2.4.2M B18.2.4.5M B18.2.4.6M
A 307	Grade B (carbon steel)	None or Zinc	Bolts	B18.2.1
A 325 & A 325M	Type 1 (medium carbon steel) Type 3 (weathering steel)	None or Zinc	Heavy Hex Structural Bolts	B18.2.1 B18.2.3.7M
A 354	Gr BD (Alloy Steel) or SAE J 429 Grade 8	None	Screws/Bolts Studs	B18.2.1 SAE J2271
A 449	Type 1 or SAE J 429 Gr 5	None or Zinc	Screws/Bolts Studs	B18.2.1 SAE J2271
A 453/ A 453M	Gr 660 (Heat & Corrosion Resisting Steel) Heat and Corrosion Resisting socket head cap screws of higher strength than Grade 660 covered under NAS 1351 and NAS 1352 Other configurations (particularly UNF threads) of higher strength are covered by MS and SAE part standards. (Typical material - SAE AMS 5732 for chemistry with higher strength)	Passivate	Screws/Bolts Nuts Socket Head Screws Studs	B18.2.1 B18.2.3.1M B18.2.3.2M B18.2.3.3M B18.2.3.5M B18.2.3.6M B18.2.2 B18.2.4.1M B18.2.4.2M B18.2.4.5M B18.2.4.6M NAS 1351 NAS 1352 SAE J2271 SAE J2271M
A 490	Type 1 Alloy Steel (1/2 to 1-1/2 D) Type 3 Weathering steel (1/2 to 1-1/2 D)	None None	Heavy Hex Structural Bolts	B18.2.1
A 563 & A 563M (See ASTM A 194 for alternatives)	Gr A (See ASTM A 563 for nut and bolt Gr C bolt suitability guide.) Gr DH Gr C3 Gr DH3	Zinc None or Zinc Zinc or None None None	Hex & Heavy Hex Nuts	B18.2.22 B18.2.4.1M B18.2.4.2M B18.2.4.5M B18.2.4.6M
A 574 & A 574M	Alloy steel (No alloy designation)	Cadmium or Black oxide (See 6.2.3.1.d)	Socket Head Cap Screws	NAS 1351 NAS 1352

TABLE 4—SELECTED INDUSTRY AND FASTENER MATERIAL STANDARDS (CONTINUED)

Material Standard (ASTM)	Material Type	Recommended Coating	Type Fastener	Typical Dimensional Standards (ASME)
B 446	Alloy 625 (Nickel base)		Barstock	As required
B 637	N07718 (Formerly 718) (Nickel base)		Barstock	As required
B 805	Alloy 625+ (UNS 7716), Alloy 725 (UNS 7725) (Nickel base)		Barstock	As required
F 467 & F 467M	Same as F 468	Same as F 468	Nuts	B18.2.2 B18.2.4.1M
F 468 & F 468M	6061T6 Aluminum Alloy 400/405 Nickel-Copper Alloy 500 Nickel-Copper-Aluminum Titanium, Alloy 19	Anodize None None Anodize, Dry Film Lubricant	Screw/Bolts Studs	B18.2.1 B18.2.3.1M B18.2.3.2M B18.2.3.5M SAE J2271 SAE J2271M
F 568	Carbon, Alloy, and Weathering Steel	None or Zinc	Regular & Heavy Hex Cap Screws/Bolts Studs	B18.2.3.1M B18.2.3.2M B18.2.3.3M B18.2.3.5M B18.2.3.6M SAE J2271M
F 593	Alloy 304, 316 (Cond CW recommended)	Passivate	Hex Cap Screws, Bolts, Studs	B18.2.1 SAE J2271
F 594	Alloy 304, 316 (Cond CW)	Passivate	Nuts	B18.2.2
F 738M	Alloy 304*, 316 (Cond CW) *Note: In alloy group 1, 304, 305, 384, & XM7 are interchangeable and marked the same	Passivate	Metric Screws, Bolts & Studs	B18.2.3.1M B18.2.3.2M B18.2.3.3M B18.2.3.5M B18.2.3.6M SAE J2271M
F 835 & F 835M	High strength alloy steel	Black oxide	Flat Countersunk Head Cap Screws	B18.3 B18.3.5M
F 836M	Alloy 304 Cond CW (See ASTM F 738M Note) Alloy 316 Cond CW	Passivate	Metric Nuts	B1.13M B18.2.4.1M
F 837 & F 837M	Alloy 304 (See ASTM F 738M Note) Condition CW recommended	Passivate	Socket Head Cap Screws	B18.3 B18.3.1M
F 879 & F 879M	Alloy 304 (Cond CW for F 879) (See ASTM F 738M Note)	Passivate	Flat Countersunk Head Cap Screws	B18.3 B18.3.5M
AS 7468 (SAE)	Cobalt-Chromium-Nickel Alloy (Alloy MP35N)	None	Bolts & Screws	As required

- 6. Fastener Thread Selection Criteria**—When selecting a fastener thread, the requirements of the application such as strength, fatigue, temperature, and use of coatings, platings, or anaerobic locking compounds shall be considered.
- 6.1 Fastening**—Through bolting for fastening applications is preferred where this is an option.
- 6.2 Thread Form**—Unless otherwise specified in the equipment specification or fastener part standard, threads for fasteners shall be of the Unified Series in accordance with FED-STD-H28/2 or ASME B1.1. Metric threads shall be in accordance with ASME B1.13M or ASME B1.21M. When the thread form is not specified by a reference to a thread standard in the fastener acquisition document, the designer shall specify threads in accordance with one of the standards listed previously.
- 6.2.1 CONTROLLED ROOT RADIUS SCREW THREADS**—When controlled root radius screw threads are needed, MJ or UNJ threads may be selected. MJ threads shall conform to ASME B1.21M. UNJ threads shall conform to the requirements of ASME B1.15. Screw threads for fasteners whose application involves very precise tolerances for extremely critical applications shall have a controlled root radius.
- 6.3 Thread Series**—The Unified Coarse Thread Series (UNC) or the Unified Fine Thread Series (UNF) shall be used unless there are unique component or equipment design features that require other thread types. Other thread types that may be used to meet unique design requirements include the Unified Constant Pitch Thread Series (8UN), UNR, and UNJ thread series. Table 5 highlights the differences among these thread series. (Note—See Table 5 for assembly limitations between different series.)
- 6.3.1 UNIFIED COARSE THREADS**—The coarse thread series extends from 1-64 UNC (0.0730 in diameter) to 44 UNC (4 in diameter). UNC threads are recommended for general applications and for threading into materials of a lower tensile strength. Coarse threads are recommended particularly for fasteners up to and including 1 in diameter. Coarse threads are used more often than fine threads in shipboard applications for the following reasons:
- a. Easier to assemble
 - b. Less likely to cross thread
- 6.3.2 UNIFIED FINE THREADS**—The fine thread series extends from 0-80 UNF (0.0600 in diameter) to 1.512 UNF (1.5 in diameter). Fine threads provide a larger tensile-stress area than coarse threads of the same nominal size fastener. Fine threads may be used in shipboard applications for the following reasons:
- a. Length of thread engagement is short
 - b. A small lead angle is needed for adjustment applications
 - c. Wall thickness demands a fine pitch
- 6.3.2.1** UNF threads are commonly used in preference to UNC threads in applications involving socket head cap screws, where the fastener strength is to exceed 160 ksi. The use of the UNF thread series helps to prevent the inadvertent substitution of lower-strength fasteners in these applications.

TABLE 5—THREAD TYPE COMPARISON

Thread Form	Thread Series	Thread Standard	Gage and Gaging Standards	Characteristics
Unified inch	UNC	ASME B1.1	ASME B1.2	Used for general purpose applications and provides more thread clearance for plating than UNF
	UNF	ASME B1.1	ASME B1.2	Used where wall thickness is inadequate for UNC, thread engagement length is short, and for adjusting screws.
	UNJC UNJF	ASME B1.15	ASME B1.2	Covers internal and external threads. Provides a mandatory root radius which increases fatigue resistance. UNJ internal threads should be assembled only with UNJ external threads.
	UNRC UNRF	ASME B1.1	ASME B1.2 FED-STD-H28/6	No UNR internal threads. Root radius increases fatigue resistance.
	8UN	ASME B1.1	FED-STD-H28/6	Used as a substitute for UNC threads for fastener diameters 1 in and larger. Provides 8 threads per inch regardless of diameter.
National	Class 5	FED-STD-H28/23	ASME B1.12 FED-STD-H28/6	Provides an interference fit. Used where high temperatures prevent the use of an anaerobic thread locking compound.
Metric	M	ASME B1.13M	ASME B1.3M ASME B1.16M FED-STD-H28/22	Used for general purpose applications.
	MJ	ASME B1.21M	ASME B1.3M ASME B1.16M FED-STD-H28/22	Used for fatigue resistance.

- 6.3.3 CONSTANT PITCH THREADS—The 8UN Pitch Thread Series are recommended for use in applications with fasteners greater than 1 in in diameter, particularly those involving pumps, valves, and piping components. The thread pitch is constant at 8 threads per inch. Fasteners with 8UN threads shall have a nominal diameter of at least 1 in. The scarcity of 8 UN self-locking nuts may require the selection of a different thread form in some applications.
- 6.3.4 MJ, UNR, AND UNJ THREADS—MJ, UNR, and UNJ external threads have mandatory rounded root radii and experience much lower stress concentrations than other thread types. These thread types provide an increase in the fatigue life of the threaded fastener.
- 6.3.4.1 MJ (metric) or UNJ (inch) threads are recommended for use in fatigue or strength sensitive applications or where physical size and weight are critical. Thread rolling after heat treatment provides the maximum increase in fatigue strength.
- 6.3.5 NONSTANDARD THREADS—When an application requires the use of a thread type not listed herein, the fastener shall be submitted to the customer for approval by the customer.

- 6.4 Thread Class**—Thread class is used to specify fit which controls the looseness or tightness between mating threads. With the exception of Class 5, which is an inch standard interference fit, all thread classes covered by this standard are clearance fits. For inch standard, the higher the number, the tighter the fit; i.e., Class 3 is tighter than Class 2. For metric threads, the converse is true. To identify external threads, the designator "A" is used in inch standard and lower case letters, such as "g" or "h," in metric standard. Internal threads are identified by the designator "B" (inch standard) and upper case letters in metric standard. Coated fasteners are produced to one of the "looser" fits (such as 2A for an inch standard) and then coated so as not to exceed the limits of the tightest fit which enables them to assemble with dimensionally correct mating parts. Unless otherwise specified in the equipment specification or fastener part standard, fastener threads for general applications shall be Class 2A/2B, 3A/3B, or a combination thereof. Class 5 threads may be used in accordance with the requirements specified herein.
- 6.4.1 **METRIC THREADS**—The M profile threads with a tolerance class of 6H/6g may be used in applications where a Class 2A/2B would be appropriate. A 4H5H/4h6h may be used in metric applications where a Class 3A/3B fit would be appropriate. (For metric threads, the fit is indicated by the internal thread tolerance class followed by the external tolerance class separated by a slash.
- 6.4.2 **SELECTION CRITERIA**—Class 2A/2B fits may be used for general applications. Class 2A threads are designed to provide a plating allowance. Class 3A/3B fits may be used in applications where closeness of fit and high accuracy of lead angle are important, such as for adjusting devices and long thread engagements or where Class 2A or 2B threads have been plated. Class 5 threads are for use in applications where an interference fit is required.
- 6.4.2.1 Class 2A, 2B, 3A, and 3B fits on external and internal components may be mixed to achieve a particular fit or to utilize standard fasteners. Similarly, the tolerance classes for metric threads may be mixed to obtain a particular fit or to use standard fasteners.
- 6.4.2.2 The use of mating fasteners of similar material for Class 3A/3B and Class 5 fits should be avoided to prevent galling. If necessary for use, ensure that proper thread lubricants are used.
- 6.4.3 **CLASS 5**—Class 5 threads are used for the setting of studs. The set-in portion of the studs are locked in place using Class 5 interference fits. ASME B1.12 and FED-STD-H28/23 define Class 5 threads and their uses. The problem is that there are many variations of class 5 threads and their fits. The thread selection depends upon the stud material and the material into which the stud is to be driven and the length of engagement. Also the use of rolled versus cut threads may be a factor. Experience and guidance for thread selection are often lacking.
- 6.4.3.1 *Class 5 Fits Length of Engagement*—The NC5 CSF and NC5 ONF threads are identical except for their length of engagement, the CSF having a recommended length of engagement of 1.25 diameters and the ONF having a recommended length of engagement of 2.5 diameters. At 2.5 diameters engagement the torque to drive the fastener may exceed the fastener capability. In most applications the 1.25 diameters engagement will be satisfactory. Only in cases where high strength studs are driven into low strength materials may a longer engagement be necessary to develop the full strength of the stud. Studs per SAE J2271 and SAE J2271M have a minimum set end thread length of 1.5 diameters.
- 6.4.3.2 *Recommendation for Class 5 External Threads*—External threads shall meet the requirements in ASME B1.12. In order to promote standardization of studs and to facilitate installation, NC-5 HFS in accordance with Appendix C of ASME B1.12 external threads are recommended for all initial installations in all materials. This thread form meets all the basic ASME B1.12 requirements but the tighter tolerances will facilitate installation. In addition, it should permit the use of the same thread rolling dies and gages for all materials.

6.4.3.3 *Recommendations for Class 5 Internal (Tap Hole) Threads*—Internal threads shall meet the requirements of ASME B1.12. For stud standardization purposes and to facilitate installation, the following thread selection recommendations should be followed.

- a. *Installation in Harder Materials*—When installing interference fit studs in materials with a Brinell hardness of 160 or higher, the use of NC-IFS threads in accordance with ASME B1.1 Appendix C is recommended. Materials with a Brinell hardness of 160 or higher include, Nickel-Copper-Aluminum, Titanium, and steel metric grades 8.8 and higher, and steel inch type fasteners with a tensile strength of 85 000 psi or higher. The NC5-IFS threads minimize the maximum interference and minimize installation problems.
- b. *Installation in Softer Materials*—Use NC5-INF internal threads per ASME B1.12 for installation of interference fit studs in materials (both ferrous and nonferrous) with a Brinell hardness less than 160.

6.4.3.4 *Alternatives to Interference Fits*—Before selecting an interference fit, the designer should be familiar with ASME B1.12 and be aware that problems may be encountered in obtaining the required fit. In applications where temperatures do not exceed 230 °C (450 °F), the setting of studs with anaerobic compound should be considered as it can generally be accomplished at lower cost. Temperatures above 230 °C (450 °F) exceed the limits where an anaerobic thread locking compound or self-locking element can normally be used although there are compounds which have been satisfactorily used at higher temperatures. For additional information, see Section 8 on locking devices.

6.5 Thread Length

6.5.1 TAPPED-HOLE INSTALLATION

6.5.1.1 *Thread Engagement*—When threading into a tapped hole, specifying the proper length of the thread engagement is critical to ensure that the minimum specified tensile strength of the fastener is developed. The thread engagement length is customarily stipulated as a function of fastener diameter. For ferrous materials, this value is typically given as a minimum of 0.8 times the fastener diameter. FED-STD-H28/2 provides detailed guidance in determining the thread engagement length. The designer should also refer to the applicable fastener and fastener material standards. The proper fastener length shall be specified to avoid bottoming out of the fastener and to prevent damage to bottom-tapped holes.

6.5.1.2 *Shouldering*—The length of thread engagement shall be adequate to preclude material distortion which can result from shouldering.

6.5.2 THROUGH-HOLE INSTALLATION

6.5.2.1 *Design Thread Protrusion*—In selecting the length of fasteners for designs, the length shall provide for the protrusion of at least one full thread and preferably no more than five threads beyond the top of the nut or plastic insert as applicable. (Since the first thread is often incomplete this will help ensure that the engaged threads are full threads and thus the full strength of the nut is developed). The preference to limit protrusion to five threads shall not override the use of standard length fasteners. Particularly, for small diameter fasteners with fine threads, the use of standard lengths may require the selection of fasteners which result in protrusions greater than five threads. Washers shall not be added to reduce protrusion except as specifically required by design drawings or technical manuals.

6.5.2.2 *Thread Protrusion at Installation*—Thread protrusion at installation may be different than the thread protrusion determined during the design of the joint. When specifying installation and tightening requirements for fasteners, the assembly instructions should include the following requirements:

When installing and tightening fasteners, the protrusion of the male threads shall have, as a minimum, a protrusion equivalent to one thread pitch above the top of the nut or plastic locking element, as applicable. In any application where the thread protrusion exceeds ten threads, verification shall be made that the proper length fastener was installed.

- 6.5.2.3 *Stud Standout*—The stud standoff, the distance the stud is to protrude when installed, or the depth to which the stud is to be driven, shall be identified on assembly and installation drawings. These dimensions must be selected so that bottoming or shouldering are avoided. Shouldering, which is the practice of driving the stud until the thread run-out engages with the top threads of the hole, may create excessive radial compressive stresses and bulging of the material.

6.6 Fasteners for Safety Critical Applications

- 6.6.1 DEFINITION OF "SAFETY CRITICAL" THREADS—A safety critical thread is one that meets both of the following criteria:

- a. Based upon Failure Modes & Effects Analysis, Engineering Analysis or experience it is determined that a single fastener thread failure will result in one or more of the following:
 - (1) Loss of ship propulsion or a ship control surface (steering, diving planes, but not fin stabilizers).
 - (2) A failure which jeopardizes ship or personnel safety. (Example: Cargo or weapon handling where the load would be dropped as a result of failure.)
 - (3) Loss of hull integrity.

NOTE—A single fastener thread failure includes cases in a multiple thread design where failure of one thread will cause an overload and failure of additional threads.

- b. The primary joint failure mode is tension in a cyclic application.

- 6.6.2 REQUIREMENTS FOR SAFETY CRITICAL APPLICATIONS—Safety critical threads shall be avoided whenever feasible.

- 6.6.2.1 *Thread Form*—Thread shall be of an UNJ or MJ configuration unless otherwise approved by the cognizant contracting activity.

- 6.6.2.2 *Approval Requirements*—If a thread falls within the criteria of "safety critical" its use shall be approved by the cognizant contracting engineering activity. The following information should be provided in requesting approval:

- a. Complete identification of the application.
- b. Justification as to why it is necessary for the design to be dependent upon a single thread.
- c. Whether or not the threads forms in 6.6.2.1 are to be used. If not used provide engineering justification for not using them.
- d. Complete thread inspection requirements.

7. **Platings, Coatings, and Surface Treatments**—The following requirements are intended to be general guidelines for the selection of proper fastener platings and coatings, and to prevent problems associated with plating and coating interactions. For some applications, fastener platings and coatings should not be used. The use of corrosion resistant fastener materials rather than reliance on a protective coating usually results in the lowest life cycle costs.

- 7.1 **General Guidance**—Use of coated fasteners to obtain corrosion resistance is often attempted but often leads to unsatisfactory results. While it may minimize initial costs, life cycle maintenance and repair costs may be high. With care, coated and plated fasteners are satisfactory for some installations.

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- 7.1.1 DRY APPLICATIONS—Coated fasteners generally perform satisfactorily in dry spaces inside the ship. In these applications zinc coatings (and cadmium where permitted) will perform satisfactorily.
- 7.1.2 WET APPLICATIONS—In wet spaces, bilges, and the weather, most coated fasteners do not perform satisfactorily without some sort of supplemental treatment. Supplemental treatments for steel fasteners are covered in SAE J2270.
- 7.1.3 SUBMERGED APPLICATIONS—In general, coated fasteners do not perform satisfactorily in submerged applications.
- 7.2 Selection Criteria**—An appropriate plating or coating shall be selected from those identified herein. Selection shall be based on the fastener materials and the application requirements.
- 7.2.1 THREAD FIT—The type of thread fit shall be considered when selecting a plating or coating since plating or coating thickness affects the fit of the threads and can be scraped from the fastener during installation. Refer to the fastener part standard to determine the thread fit of a particular fastener before and after plating.
- 7.2.2 APPLICATION—The process of applying a plating or coating to a particular fastener type shall be in accordance with the part standard for the fastener.
- 7.2.3 HIGH-STRENGTH STEEL FASTENERS—High-strength steel fasteners with a tensile strength greater than 150 ksi with sacrificial coatings may be subject to hydrogen embrittlement and stress-corrosion cracking. Sacrificial coatings include, but are not limited to, zinc plating, cadmium plating, and metallic-ceramic coating. Susceptibility to stress-corrosion cracking is dependent upon the following factors.
- a. Plating Material—Zinc plated fasteners are often susceptible to stress-corrosion cracking at less than one-half the stress levels at which cadmium plated fasteners are susceptible.
 - b. The Strength of the Steel Fastener—Fasteners with a tensile strength less than 150 ksi are rarely subject to stress-corrosion cracking.
 - c. Diameter—The larger the diameter the more susceptible to stress-corrosion cracking. For example the stress level which will initiate cracking in a 25.4 mm (1 in) diameter screw is only about 50% of the stress level required to initiate cracking in a 6.35 mm (1/4 in) diameter screw.
 - d. The Stress Level of the Application—If the stress applied due to load, torquing and possible bending is low, stress-corrosion cracking will not occur.
 - e. The Presence of Moisture—This need not be salt water; condensation on a plated fastener with a damaged coating may be sufficient.
- 7.2.3.1 *Limitations on Plated High-Strength Alloy Steel Fasteners*—The following limitations apply to the use of steel fasteners with a tensile strength of 1034 MPa (150 ksi) or greater with the exception of heat and corrosion resistant steel (ASTM A 453 Gr. 660 or Alloy A286) fasteners.
- a. The fasteners shall not be used in submerged, intermittently submerged (including bilge) applications, wet spaces, or where exposed to the weather or salt spray.
 - b. Zinc-plated internal threaded fasteners should not be mated with the ASTM A 354 Grade BD (or SAE J429 Grade 8) uncoated fasteners in applications prohibited in 7.2.3.1.a. The plated nuts can result in stress-corrosion cracking of the higher strength externally threaded fasteners.
 - c. Although not recommended, ASTM A 354 Grade BD (SAE J429 Grade 8) fasteners may be used to replace lower-strength steel zinc-plated fasteners for general purpose applications (see Table 1). These fasteners shall not be used in the applications prohibited in 7.2.3.1.a. The torque of the Grade BD fastener shall not produce a stress in the Grade BD fastener that exceeds the stress of the properly installed lower grade fastener being replaced.

- d. Socket head cap screws of alloy steel (ASTM A 574 or equivalent) shall not be zinc plated because of susceptibility to stress-corrosion cracking in nearly every size. Cadmium plated socket head cap screws may be used, when not prohibited for environmental reasons for diameters through 38 mm (1-1/2 in). Black oxide coated socket head cap screws are not subject to stress-corrosion cracking but are subject to corrosion unless protected by paint or other supplemental coating.

7.3 Zinc and Cadmium Plating—Zinc plating may be used, and is preferred for use over cadmium plated fasteners since the processes associated with cadmium plating create environmental concerns. For new designs, cadmium plating shall only be used when an applicable part standard for a fastener with zinc plating is not available or permitted.

7.3.1 USAGE RESTRICTIONS

7.3.1.1 Temperature Limits—Cadmium plating shall not be used in applications where temperatures may exceed 200 °C (400 °F). Cadmium can create toxic fumes at these temperatures. Zinc plating (typically per ASTM B 695 or ASTM B 633) shall not be used in applications where the temperature may exceed 150 °C (300 °F). Immersion zinc flake (typically in accordance with MIL-C-87115) shall not be used in applications where the temperature may exceed 340 °C (650 °F).

7.3.1.2 Application Restrictions—Cadmium plating and zinc plating shall not be used in applications where the fastener may be submerged or wetted, such as in the bilge, on the weather deck, or where it may be exposed to salt spray. These platings have little corrosion resistance for use in direct exposure to moisture.

7.3.1.3 Mating Materials—Cadmium-plated steel fasteners shall not be mated with zinc-plated steel fasteners (such as in bolt, nut, and washer combinations) at temperatures exceeding 150 °C (300 °F). The cadmium and zinc platings interact and increase the susceptibility of the steel fastener to hydrogen embrittlement, which is a cause of fastener failure.

7.3.1.4 Fluid System Restrictions—Cadmium or zinc plating shall not be used in applications where there may be contact with petroleum-based products. The cadmium and zinc produce a catalytic type reaction with petroleum-based products that can have detrimental results on system operations. Petroleum-based products include fuel oil, lubricating oil, and grease or hydrocarbon based hydraulic fluid. This restriction does not prohibit the use of cadmium or zinc plated fasteners in locations that are external to these systems, if there is no danger of internal or working fluid contamination.

7.4 Metallic-Ceramic Coating—Metallic-ceramic coatings are not recommended for use as fastener coatings. Several concerns are:

- a. The required coating thickness cannot be applied within the conventional coating thickness allowance and therefore threads have to be manufactured undersize. This increases cost and material lead time.
- b. The coating is subject to chipping and accelerated corrosion can occur at the point where chipped.
- c. The coating should not be used on fasteners with a tensile strength of 1034 MPa (150 ksi) or greater due to concerns for hydrogen embrittlement and stress-corrosion cracking.
- d. In-service problems in disassembling the fasteners have been reported.

7.5 Inorganic Zinc Primer—DOD-P-24648, type I, class 1, composition B covers an inorganic zinc primer which is similar to metallic-ceramic coatings in performance but is less expensive. A coating thickness of 3 to 5 mils is recommended. However, it is limited to outside applications where the temperature does not exceed 50 °C (122 °F).

- 7.6 Black Oxide and Black Chemicals**—Black-oxide coatings on steel fasteners provide very limited short-term protection against rusting. Generally, an additional oil preservative or wax coating is used to provide increased protection. Even with this increased protection, rusting may occur within a year. The coatings are also used on various nonferrous fastener materials to cover the shiny metal surface to prevent detection of military vehicles and equipment. If the fastener is to be subsequently painted, an oil or wax coating is not recommended since it will prevent good paint adherence.
- 7.6.1 **USAGE RESTRICTIONS**—Black oxide and black chemical coatings shall not be used to provide a corrosion barrier after installation. These coatings are generally provided to prevent corrosion during storage and handling only. (See SAE J2270 for guidance on providing corrosion protection for these fasteners.)
- 7.7 Silver Plating**—Silver plating is primarily used as a thread lubricant to prevent galling. Silver plating should only be specified for fasteners that are more noble than silver such as NiCu (Alloy 400/405), and nickel-based Alloys 625, 625+, and 725. Silver plating shall not be applied to titanium fasteners and shall not be used in contact with titanium structures.
- 7.8 Solid Film Lubricants**—Solid film lubricants may be used as a fastener coating in some applications. (See SAE J2270 for more information on the selection and use of solid film lubricants.)
- 7.9 Surface Treatments**—Passivating is required for corrosion resistant steel fasteners. Anodizing is required for aluminum and titanium fasteners.
- 8. Locking Devices and Elements**—Unless otherwise specified in the equipment or system specifications, the use of self-locking fasteners shall comply with industry or military standards. MS 15981 and MS 33588 provide general design and usage recommendations and limitations for self-locking fasteners.
- 8.1 Usage Criteria**—When a suitable self-locking fastener is not available, an anaerobic locking compound may be used. Mechanical thread-locking devices and methods, such as lock washers, safety wiring, and tab washers, may be used when a self-locking fastener is not suitable for the application or when the use of two separate types of locking devices is specified.
- 8.1.1 **SPECIAL APPLICATIONS**—Threaded fasteners used in foundation bolting and hull integrity piping for military applications are often required to be self-locking. (See Appendix A.)
- 8.1.2 **FASTENERS SUBJECT TO TAMPERING**—Hand-adjustable threaded parts that may be subject to tampering shall be securely locked by safety (lock) wiring or safety cable, self-locking nuts or other methods, as specified in the component specification.
- 8.1.3 **THREAD FIT CONSIDERATIONS**—For temperatures below 150 °C (300 °F), where fasteners are to be locked in place or where disassembly is unlikely, Class 2A/2B (Inch), 3A/3B (Inch), 6g/6H (Metric), and 4H5H/4h6h (Metric), or combinations thereof, may be used with the appropriate anaerobic thread-locking compound.
- 8.1.4 **HELICAL INSERTS**—Anaerobic locking compounds may be used with helical inserts. A self-locking insert is preferred to the use of a male fastener with a self-locking element.
- 8.1.5 **INACCESSIBLE FASTENERS**—Fasteners that are accessible only by disassembling a component should be self-locking or installed with safety wire or safety cable.
- 8.1.6 **FASTENERS USED IN REASSEMBLY**—Each bolt, nut, screw or other type of fastener whose application requires removal and reassembly shall incorporate two separate and different types of locking devices or elements, if its loss could endanger the ship's mission or crew safety. This requirement does not apply to applications where loss of multiple fasteners are required for safety to be endangered.

8.2 Selection Criteria—Locking devices and elements shall be selected according to the following criteria.

- 8.2.1 **SELF-LOCKING FASTENERS**—Externally and internally threaded self-locking fasteners may be in accordance with applicable industry or military standards. Externally threaded self-locking fasteners may be in accordance with MS 15981 or MS 33602 or industry standards such as NAS 1283. A fastener with either MIL-F-8961 or MIL-F-18240 locking element may also be used. Internally threaded fasteners, as applicable, may be in accordance with MS sheet standards such as MS 17828 for which MIL-N-25027 is the procurement specification.
- 8.2.1.1 *Temperature Limits*—Polyamide plastic ring self-locking nuts in accordance with MIL-N-25027 or equivalent shall not be used in temperatures exceeding 120 °C (250 °F). Polyamide plastic ring self-locking nuts in accordance with MIL-N-25027 or equivalent shall not be used in temperatures exceeding 230 °C (450 °F). The polyamide inserts may be subject to deterioration from ultraviolet exposure. All metal self-locking nuts of the distorted collar or spring beam type in accordance with MIL-N-25027 shall not be used at temperatures exceeding 425 °C (800 °F).
- 8.2.1.2 *Self-Locking Fastener Test and Inspection*—Self-locking fasteners shall be tested and inspected in accordance with their applicable specification. Self-locking fasteners that are not procured to a self-locking fastener standard or specification, such as those manufactured by shipyards, shall be tested and inspected in accordance with SAE J2270.
- 8.2.2 **ANAEROBIC LOCKING COMPOUNDS**—When a thread-sealing or thread-locking compound is specified, the material and its application shall be in accordance with MIL-S-46163 or equivalent. Fasteners with anaerobic-locking compounds shall be selected and inspected in accordance with SAE J2270.
- 8.2.3 **MECHANICAL THREAD-LOCKING DEVICES**
- 8.2.3.1 *Safety Wire*—When the use of safety (lock) wiring is required, safety wiring shall be applied in general accordance with MS 33540 and shall be selected and identified, when possible, in accordance with MS 20995. MS 20995 provides part identification numbers for various sizes of several wire materials.
- 8.2.3.2 *Tab Washers*—Tab washers may be used if a locking problem cannot be solved by more conventional means. When tab washers are used, provision shall be made for locking to a keyway or adjacent structure. Tab washers shall not be used where breakage of the tabs would endanger the system.
- 8.2.3.3 *Lock Washers*—Lock washers are dependent upon proper torquing to be effective. In applications where lock washers are used, the following guidance and requirements are applicable.
- Lock washers shall be of a material similar to the threaded fasteners used in the application to minimize corrosion.
 - Helical-split lock washers have greater compression than toothed washers and are generally preferred in nonelectrical applications. If the same torque is applied to a helical-split lock washer as to a flat washer, the helical-split lock washer will produce a greater stress level in the bolt because the surface area in contact with the bolt is smaller for a helical-split lock washer than for a flat washer.
 - Tin-brass or phosphor-bronze tooth type lock washers are preferred for use in electrical applications since the teeth maintain a larger area of contact.
 - External tooth lock washers provide greater locking efficiency and should be used in preference to internal tooth lock washers in most applications. Internal tooth style lock washers may be used where the teeth must be hidden under the screw head or nut or where finished appearance is a factor.
 - External-internal type lock washers are for use where a larger bearing surface is desired or as an insert between two adjustable pieces where the adjustment must be maintained after the original setting. Because of extra biting teeth, these washers are ideal for electrical connections.
 - Countersunk type lock washers with 82 degree or 100 degree countersunk angles are for use with fasteners having 82 degree or 100 degree head angles, respectively.

- 9. Screw Thread Fastener Inserts**—These requirements establish selection criteria for screw thread fastener inserts. Screw thread fastener inserts are required only where their use is necessitated by design concerns. The documents listed herein identify specific preparation and installation requirements, as well as other instructional limitations, for each specific insert style.
- 9.1 General Requirements**—When threading into a low-shear material such as aluminum or composites or when the restoration of damaged threads is necessary, the use of helical coil, solid wall bushing or thin wall bushing type inserts shall be used to improve the holding strength of the joint. For high-shear materials, above 345 MPa (50 ksi), inserts are not normally required when adequacy of design is verified by calculations.
- 9.2 Insert Selection**—Inserts of helical coil, bushing type, or thin wall type shall be selected based on the requirements of the following paragraphs.
- 9.3 Insert Materials**—The material selection guidelines in Section 5 shall be considered when selecting a screw thread insert material.
- 9.3.1 The use of CRES inserts with CRES fasteners may increase the susceptibility of the fasteners to galling.
- 9.4 Insert Length**—The insert length selected for the joint shall allow the minimum specified strength of the fastener to be developed. When a helical coil insert is used with a fastener, thread engagement length may be reduced if space constraints limit the insert length and the full tensile strength of the fastener (and its associated assembly torque) is not required.
- 9.5 Temperature Limits**—The temperature limits of screw thread fastener inserts are determined by the insert material, plating, and lubricant. Recommended temperature limits are available from the insert manufacturer. Where no other installation guidance is provided, the temperature limits listed in Table 6 may be used.

TABLE 6—RECOMMENDED TEMPERATURE LIMITS FOR SCREW THREAD INSERTS

Insert Type	Material	Plating or Lubricant	Recommended Temperature Limits
Thin wall insert	CRES 660 (Alloy A286)	Passivated, silver plated or dry film lubricant	650 °C (1200 °F)
		With solid film lubricant	340 °C(650 °F)
	CRES	Passivated	480 °C (900 °F)
		With solid film lubricant	315 °C (600 °F)
	Alloy steel	Cadmium plate with solid film lubricant	230 °C (450 °F)
Helical coil inserts	CRES	Passivated	425 °C (800 °F)

10. Fastener Part or Identifying Numbers

- 10.1 Scope and Purpose**—These requirements establish guidelines for the use of Part or Identifying Numbers (PINs) to identify fasteners. The use of fastener Part or Identifying Numbers aids in the development of equipment acquisition specifications, enhances availability and documentation procedures, and streamlines logistic and supply system cost.

10.2 General Requirements—Fasteners shall be identified using standard industry or government PINs where available. When not available, Part Identification Numbers (PINs) shall be developed using the guidance provided herein.

10.2.1 When a fastener is needed that does not have a standard industry or government PIN, a PIN shall be assigned to the fastener based on the Commercial and Government Entity (CAGE) code and drawing dash number. The fastener shall be approved by the contracting activity.

10.3 Detailed Requirements

10.3.1 PART NUMBERING SYSTEMS—Military part standards and specification sheet part standards for fasteners have a part or identifying number to comply with DoD requirements. Many industry specifications also have part or identifying numbers identified in the standard. However, most of the fastener standards developed by ASTM which cover fasteners needed for ship systems and equipment do not have part identification numbers. In order to provide part or identifying numbers for these fasteners, SAE J2295 has been developed. In addition the Appendices to SAE J2295 list recommended industry and military part standards for a large number of fastener types that may be used in ship systems and equipment.

10.3.1.1 *Part or Identifying Numbers*—Part numbering systems for fasteners are usually composed of a document number that identifies the controlling military or industry standard, and alphanumeric characters that identify the engineering parameters of the fastener. These characters or dash numbers specify the characteristics of the fastener. Some dash numbers only indicate diameter and length, while others indicate size, material, platings, coatings, and locking features. Size options are generally specified numerically. Material, plating, coating, locking features, and other options are usually specified alphanumerically.

10.3.1.2 *Types of Part Numbers*—Part numbers covered by industry and military standards fall into two basic types. In the first type, a dash number is used to identify the fastener and it is necessary to always refer to the standard to determine the characteristics. In some standards, the part number consists of a number of significant fields. By knowing the order of the fields and the codes for each field it is often possible to determine the characteristics of the fastener without frequent reference to the standard. Fasteners without an industry or military part number must be identified by a drawing part as discussed in c. as follows:

- a. Most MS sheets use a nonsignificant dash number. For example, MS17828-16C is a nickel-copper alloy self-locking regular hex nut with 1-8UNC-3B threads. To determine these characteristics one must refer to the MS sheet.
- b. Many industry standards utilize significant characters to identify the various features of the fastener. For example, SAE J2295 has fields that identify the fastener standard, type of thread, thread class, type of fastener, nominal diameter, special features such as coating and locking elements, length, and the material property. This is usually accomplished with a part number of 15-17 characters or less.
- c. An example of a drawing based part number: 53711-6673969—This is a nonstandard nickel-copper shoulder bolt detailed on the drawing. The CAGE code assigned to the drawing and the PIN assigned to the specific item provide a unique identification. In this case 53711 is the CAGE for the Naval Sea Systems Command and 6673969 is the drawing number. If multiple items are detailed on a drawing, a dash number suffix can be used to identify the specific item. The preference is for fasteners to be detailed on separate drawings rather than on drawings detailing other nonfastener parts.

11. Identification Markings

11.1 **Scope and Purpose**—These requirements establish guidelines for specifying the identification marking of fasteners. These guidelines are intended for use when a fastener part standard requires marking in accordance with the fastener acquisition document or when specifying marking requirements on the drawing of a nonapproved fastener.

11.2 Fastener Marking—Fasteners shall be identification marked in accordance with the applicable specification, standard or part drawing. When the fastener part standard requires marking in accordance with the fastener acquisition document or when specifying marking requirements on the drawing of a nonapproved fastener (see Appendix A for Government use), the fastener marking guidance identified herein shall be used.

11.3 Fastener Marking Guidance—Fasteners shall be identification marked with the material/condition symbol or PIN as identified on acquisition specification or drawing, manufacturer's symbol, and lot number (when required). When there is not enough space available on the fastener for the identification marking, the marking shall be applied using the following order of precedence: material/condition symbol or PIN, manufacturer's symbol, lot number. The material/condition symbol or PIN is mandatory for all fasteners except those so small that marking is impractical.

11.3.1 MILITARY—Extensive information on fastener marking can be found in MIL-HDBK-131. This document contains information regarding the marking requirements, the material, and the mechanical properties of fasteners conforming to specific military and industry specifications and standards. Appendix A contains additional marking requirements for Level I fasteners.

11.3.2 COMMERCIAL—Information concerning the marking and material properties of commercial fasteners conforming to industry standards can be found in ASTM F 1077 and SAE J429. Additional marking and material property information for fasteners can be found in the applicable ASTM fastener specifications.

11.3.3 MARKING METHODS—Fastener marking shall be permanent and may be raised or depressed. Information concerning fastener marking methods can be found in SAE AS478. Stamping shall be made with a low-stress stamp.

11.3.4 SELF-LOCKING IDENTIFICATION—If the part standard does not require marking, marking requirements for externally threaded self-locking fasteners shall include a minimum of six dots, raised, or depressed, on the fastener head.

11.4 Manufacturer's Identification—An extensive list of manufacturers' marks can be found in MIL-HDBK-57. Those manufacturers not listed and who desire to be listed in MIL-HDBK-57 should submit their identification symbol, Commercial and Government Entities (CAGE) code information found in CAGE document H41/H42, and a company address and telephone number to the preparing activity (listed as follows) for inclusion.

MIL-HDBK-57 (Preparing Activity)
Defense Industrial Supply Center
Attn: DISC-ESA
700 Robbins Avenue
Philadelphia, PA 19111-5096

Application requests for a CAGE code, for the purpose of symbol listing in MIL-HDBK-57, should be submitted to:

Commander
Defense Logistics Services Center
Attn: DLSCWXA
Federal Center
Battle Creek, MI 49017-3084

12. Notes

12.1 Marginal Indicia—The change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

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

12.3 Military and Government Applications—Requirements specific to military fastener applications are provided in Appendix A. This appendix also provides guidance for contracting officers in determining what data should be submitted. For other users the requirements of Appendix A are for information and guidance only unless contractually invoked.

12.4 Keywords—Nuts, bolts, screws, threads, studs

PREPARED BY THE SAE SHIP SYSTEMS AND EQUIPMENT COMMITTEE

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APPENDIX A

SUPPLEMENTAL MILITARY REQUIREMENTS

A.1 Scope—This appendix provides requirements which supplement those in the standard for the proper selection of fasteners used in components and systems in military and other applications when specifically invoked. In addition, fastener requirements for Material Identification Control Level I systems, hull integrity, and shock applications are addressed.

A.2 General Requirements

A.2.1 Fastener Selection—Fasteners shall be selected by utilizing the criteria of the basic document as modified herein.

A.2.2 Threads—Class 5 threads shall be in accordance with the recommendations of the basic document. Fasteners of thread classes 2 and 3 installed with an anaerobic locking compound may be used as a replacement for Class 5 interference fit threads in applications where the locking compound is suitable for the thread clearance and temperature of the application. Similarly, the use of an anaerobic locking compound is preferred to interference fits for metric threads as metric thread standards often do not provide for interference fits.

A.2.3 Fastener Materials and Coatings

A.2.3.1 FASTENER MATERIALS—Fastener materials for applications unless specifically authorized in component, equipment, or ship specifications shall be selected from Table 1 of the basic document with the following additional restrictions:

- a. Carbon and alloy steel shall not be used in submerged or intermittently submerged applications.
- b. Aluminum fasteners shall not be used in application categories 1 or 2 without specific approval of the contracting activity.
- c. For applications in wet spaces, bilges, or where exposed to the weather, CRES 304 shall not be used.
- d. Silicon bronze fasteners are not to be used for new design. (See Table A.2 for alternatives.)
- e. A minimum elongation of 10% shall be required for ASTM A 574 and ASTM A 574M socket head cap screws. (Additional testing of finished screws is not required for verification but the 10% requirement shall apply to any machined specimens.)
- f. Whenever Ni-Cu-Al material is required it shall be in accordance with QQ-N-286 rather than Alloy 500 per the applicable ASTM standard. When the manufacturing process consists of thread rolling, heading, or other forming operations, the starting material shall be in the annealed condition. After all forming procedures are completed, the fasteners shall be reannealed and age hardened per QQ-N-286. When the fastener manufacturing process consists solely of machining operations, the starting material may be in the final annealed and age hardened condition with no supplementary heat treatment required.

A.2.3.2 FASTENER COATINGS

A.2.3.2.1 Fastener Coatings Requiring Approval—The coatings described as follows shall not be used for new designs without approval of the contracting activity.

- a. Cadmium coatings
- b. Metallic-ceramic coating
- c. Any coating on brass fasteners or nickel-copper nuts 6 mm (1/4 in) diameter or larger which have 8UN, UNC, or metric threads

- A.2.4 Fluid System Fasteners**—Materials for fasteners used in fluid systems shall be in accordance with the fastener material requirements of the shipbuilding specification or MIL-STD-777 (surface ships) and MIL-STD-438 (submarines), as applicable. Fastener configurations selected shall be in accordance with fastener standards and requirements identified in the basic document and herein.
- A.2.5 Structural Fasteners**—Structural fasteners shall be in accordance with the material and strength requirements for mechanical fasteners in MIL-STD-1689.
- A.2.6 Fitted Bolts**—For new designs, fitted bolts should be selected in accordance with this document. Fitted bolts are not interchangeable after installation.
- A.2.7 Thread Lubricants**—Thread lubricants in accordance with CID A-A-59004 are approved for use and especially recommended as a replacement for red lead and graphite in mineral oil.
- A.2.7.1 IDENTIFICATION OF LUBRICANTS—Lubricants shall be identified for maintenance personnel on drawings, in technical manuals and/or in information books. Where controlled pre-stress of a threaded fastener is a design consideration and specific preloads are identified on technical documentation, the applicable lubricant shall also be identified.
- A.2.8 Use of Later and Earlier Revisions of Fastener Documents**—This requirement applies to those fastener specifications and standards permitted for use and where a specific revision is not invoked by date.
- A.2.8.1 USE OF LATER DOCUMENT REVISIONS—Later revisions of DoD adopted documents may be used without detailed justification.
- A.2.8.2 USE OF FASTENERS TO EARLIER REVISIONS—Fasteners already in stock to earlier revisions of documents may be used subject to the following restrictions:
- For fasteners with military or industry part numbers, the part number is the same as for the latest revision.
 - For fasteners without military or industry part numbers, an engineering analysis has been conducted and technical justification provided that the fasteners to the earlier requirements are suitable for use and approval of the contracting activity is obtained. (For Navy ships, concurrence from the applicable Supervisor of Shipbuilding is acceptable.)
- A.3 Requirements for SUBSAFE, Level I, and Hull Integrity Applications**—For these applications, fasteners in accordance with MIL-S-1222 may be selected in preference to similar fasteners to industry or other government specifications. However, if a standard PIN does not exist, approval is required in accordance with A.6.2. Nickel-copper self-locking nuts in accordance with MIL-N-25027/1 are particularly applicable for Level 1 applications.
- A.3.1 Material Control**—Level I system fasteners shall be controlled in accordance with Material Control Standard 0948-LP-045-7010. The Material Control Standard establishes a Material Identification and Control (MIC) program to ensure that the correct material is installed in Level I piping systems and component installations aboard ship. Criteria for determining MIC/Level I system boundaries, testing, marking, and certification requirements are provided in the Material Control Standard.
- A.3.2 Fastener Insert Usage Restrictions**—Screw thread fastener inserts shall not be used in MIC/Level I applications unless specifically approved by the contracting activity.

A.3.3 Uniform Strength Fasteners

A.3.3.1 **USAGE CRITERIA**—Threaded fasteners exhibiting essentially uniform strain (uniform or constant strength) over their entire length will be subject to slightly lower stresses in shock and therefore improve shock resistance.

A.3.3.2 **SELECTION CRITERIA**—Essentially uniform strength in fasteners may be achieved by selecting fasteners that have the following attributes (listed in order of preference):

- a. Using studs (bolt-studs) that are continuously threaded with roll-formed or cut threads (roll-formed threads preferred).
- b. Using studs (bolt-studs) with roll-formed threads whose unthreaded shank diameter is approximately equal to the pitch diameter.
- c. Using studs (bolt-studs) with cut threads whose unthreaded shank diameter is approximately equal to the root diameter.
- d. Screws and bolts are less desirable than studs for obtaining essentially uniform strength. However, significant changes in cross-section between the threaded and unthreaded portion of the shank are to be avoided.

A.3.4 Hull Integrity Piping Joints—Hull integrity bolted joints shall also meet the following additional requirements:

- a. For Surface Ships—Hull integrity bolting materials for surface ship piping shall be in accordance with MIL-STD-777 or the shipbuilding specification, as applicable, and the requirements herein.
- b. For Submarines—Hull integrity bolting for submarine piping shall be in accordance with MIL-STD-438 or the shipbuilding specifications, as applicable, and the requirements herein, and shall apply to bolted sea water connections up to and including the inboard flange of the backup valve.
- c. For services involving integrity of the hull against the sea, essentially uniform strength fasteners shall be specified. Fasteners such as headed bolts and screws are acceptable provided the design is in accordance with A.3.3.2.d and use of a stud or bolt-stud is not practical.

A.3.5 Fasteners for Shock Applications

A.3.5.1 **MATERIALS**—Where corrosion resistance or nonmagnetic criteria govern the selection of hold-down fasteners, CRES 660 (Alloy A286) or Ni-Cu-Al fasteners are recommended where relatively high strength is required. The strength and ductility of the fasteners shall be considered during the design of the joint. (See A.3.5.3.3 for requirements when the material used is not the material subjected to shock tests.)

A.3.5.2 **MOUNTING BOLT HOLE DIAMETER**—Unless otherwise specified, hole diameters for mounting bolts shall not exceed those diameters produced using standard size drills as identified in Table A1. The requirements in Table A1 do not apply for applications where mounting holes of greater clearance have successfully passed shock tests.

TABLE A1—MOUNTING BOLT HOLE DIAMETER

Bolt Diameter	Maximum Standard Size Drill
20 mm and smaller	Nominal bolt diameter +1 mm
Larger than 20 mm	Nominal bolt diameter +1.5 mm
3/4 in and smaller	Nominal bolt diameter +1/32 in
Larger than 3/4 in	Nominal bolt diameter +1/16 in

- A.3.5.2.1 Improved resistance to shear forces can be achieved by beveling the mating surfaces of the bolt holes. For bolts 20 mm (3/4 in) diameter size and smaller, the recommended bevel is 1.6 mm (1/16 in) by 45 degrees. For bolts larger than 20 mm (3/4 in) diameter size, the recommended bevel is 3 mm (1/8 in) by 45 degrees.
- A.3.5.3 SHOCK TESTING—Hold-down fasteners used for shock testing of equipment shall suit the equipment hold-down fastener mounting holes. MIL-S-901 defines shock test requirements.
- A.3.5.3.1 NAVSEA 0908-LP-000-3010 shall be used for analysis of surface ship equipment and foundation fasteners under shock loads.
- A.3.5.3.2 Fasteners shall not be torqued to a value where the fastener stress is greater than 2/3 of the fastener material yield strength unless a specific torque value is provided on the drawing.
- A.3.5.3.3 Fasteners used for shock tests should be identical to those that will be used aboard ship. If the type or strength of the fastener used during shock testing cannot be determined or if the shipbuilder wants to utilize a different fastener, the following requirements apply:
- a. The mounting or hold-down fasteners selected shall possess strength characteristics at least equal to those of the fasteners used during the shock test.
 - or
 - b. NAVSEA 0908-LP-000-3010 or other approved criteria shall be used to verify by analysis that the fasteners to be used are satisfactory. The analysis shall be approved by the contracting activity if the fasteners selected have lower strength than those used in the shock test.
- A.3.5.3.4 Threaded fasteners used to hold down equipment during shock tests are not recommended for reuse in the shipboard installation. However, the fasteners may be reused when measurements and inspections indicate no permanent deformation of the fasteners.

A.3.6 Submarine Safety (SubSafe) Fastener Requirements—Fasteners used in specific submarine applications shall be subject to the requirements of NAVSEA 0924-LP-062-0010 and 0941-LP-041-3010 as applicable.

A.4 Fastener Test Requirements

A.4.1 Fastener Testing—Fasteners shall be tested in accordance with the applicable fastener part standard (or drawing) and procurement specifications. When testing is not specified in procurement specifications, standards and documentation, the requirements of SAE J2270 shall be followed. This document requires that fastener tests be specified on the fastener drawings that are submitted for approval.

A.4.2 Fastener Inspection—To ensure fastener quality, the following tests and inspections shall be invoked unless the applicable procurement specification invokes an essentially equivalent inspection:

- a. Nondestructive inspection for surface discontinuities in bolts, screws, and studs shall be in accordance with SAE J123.
- b. Nondestructive inspection for surface discontinuities in nuts shall be in accordance with SAE J122.
- c. For externally threaded and heat-treated carbon or alloy steels, decarburization inspection shall be in accordance with SAE J121 Class B method.

NOTE—This test does not apply to ASTM A 574 and ASTM A 574M socket head cap screws which contain adequate decarburization tests. Decarburization examination is not required for fully machined fasteners where the depth of total decarburization is removed during machining and no heat treatment is performed after machining.