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**NASA FASTENER PROCUREMENT, RECEIVING
INSPECTION, AND STORAGE PRACTICES FOR
SPACEFLIGHT HARDWARE**

**MEASUREMENT SYSTEM IDENTIFICATION:
METRIC/SI (ENGLISH)**

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FOREWORD

This standard is published by the National Aeronautics and Space Administration (NASA) to provide uniform engineering and technical requirements for processes, procedures, practices, and methods that have been endorsed as standard for NASA programs and projects, including requirements for selection, application, and design criteria of an item.

This standard is approved for use by NASA Headquarters and NASA Centers, including Component Facilities.

This standard defines fastener control requirements for all fasteners used in spaceflight hardware. Fastener control consists of practices related to the procurement, receiving inspection, and storage of fasteners, such as threaded bolts, inserts, washers, rivets, set screws, shear pins, and retention devices.

Requests for information, corrections, or additions to this standard should be submitted via “Feedback” in the NASA Technical Standards System at <http://standards.nasa.gov>.

Original Signed By

July 11, 2008

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NASA Chief Engineer

Approval Date

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NASA FASTENER PROCUREMENT, RECEIVING INSPECTION, AND STORAGE PRACTICES FOR SPACEFLIGHT HARDWARE

1. SCOPE

1.1 Purpose

This standard establishes fastener procurement, receiving inspection, and storage practices for all fasteners used for spaceflight hardware that are procured, received, tested, inventoried, or installed for space flight by a NASA Center, by a prime contractor, or by any other spaceflight hardware developer.

1.1.1 For the purposes of this document, spaceflight hardware shall include any government-furnished equipment (GFE) or payloads that are flown on spaceflight vehicles.

1.2 Applicability

The requirements set forth in this document are the baseline fastener procurement, receiving inspection, and storage requirements for all NASA spaceflight hardware.

This standard may be cited in contracts, program, and other Agency documents as a technical requirement. Requirements are numbered and indicated by the word “shall.” Explanatory or guidance text is indicated in italics beginning in section 4.

Individual NASA Centers may establish more restrictive program/project-specific requirements and/or guidelines, as appropriate. To do this, individual provisions of this standard may be tailored (i.e., modified or deleted) by contract or program specifications to meet specific constraints and program/project needs.

1.2.1 Deviations from this document or tailoring of this standard for application to a specific program or project shall be formally documented as part of program or project requirements and approved by the Technical Authority.

2. APPLICABLE DOCUMENTS

2.1 General

The documents listed in this section contain provisions that constitute requirements of this standard as cited in the text of section 4.

2.1.1 The latest issuances of cited documents shall be used unless otherwise approved by the assigned Technical Authority.

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The applicable documents are accessible via the NASA Technical Standards System at <http://standards.nasa.gov> or may be obtained directly from the Standards Developing Organizations or other document distributors.

2.2 Government Documents

National Aeronautics and Space Administration (NASA)

MSFC-STD-3029, Tables IA-E	Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments; Materials, Processes, and Manufacturing Department Metallic Materials and Processes Group (Multiprogram/Project Common-Use Document)
NASA-STD-5019	Fracture Control Requirements for Spaceflight Hardware
NPD 8730.5	NASA Quality Assurance Program Policy

2.3 Non-Government Documents

American Society for Mechanical Engineering (ASME)

ASME B1.3	Screw Thread Gaging Systems for Dimensional Acceptability - Inch and Metric Screw Threads, System 22
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American Society for Testing and Materials (ASTM)

ASTM F 606	Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
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Aerospace Industries Association/National Aerospace Standards (AIA/NAS)

NASM1312-6	Fastener Test Methods, Method 6, Hardness
NASM1312-8	Fastener Test Methods, Method 8, Tensile Strength
NAM1312-108	Fastener Test Methods, Metric, Method 108, Tensile Strength

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American National Standards Institute (ANSI)/American Society for Quality (ASQ)

ANSI/ASQ Z1.4-2003 Sampling Procedures and Tables for Inspection by Attributes

2.4 Order of Precedence

This document establishes requirements for fastener procurement, receiving inspection, and storage practices but does not supersede nor waive established Agency requirements found in other documentation.

2.4.1 Conflicts between this standard and other requirements documents shall be resolved by the responsible Technical Authority.

3. ACRONYMS AND DEFINITIONS

3.1 Acronyms

AIA	Aerospace Industries Association
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASQ	American Society for Quality
ASTM	American Society for Testing and Materials
COC	Certificate of Conformance
COTS	Commercial Off-the-Shelf
CVT	Certification Validation Testing
FC	Fracture-critical
GFE	Government-furnished Equipment
LRF	Low-Risk Fracture
M&P	Materials and Processes
MSFC	Marshall Space Flight Center
MTR	Manufacturer's Test Report
MUA	Materials Usage Agreement
NAS	National Aerospace Standard
NASA	National Aeronautics and Space Administration
NASM	National Aerospace Standard Military
NPD	NASA Policy Directive
OES	Optical Emission Spectroscopy
SI	Système Internationale, or metric system of measurement
STD	Standard

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3.2 Definitions

Accredited Laboratory: A laboratory that has been recognized by the national and/or international standard-setting organizations to carry out specific tests competently according to established quality, management, administrative, and test method accreditation criteria.

Approved Manufacturer: A manufacturer that has passed an audit intended to verify that a company has the manufacturing capability and implemented quality management system with controlled processes that will ensure that products meet the requirements of applicable specifications.

Audit: A systematic, independent, and documented process to verify that a company has the capability to manufacture fasteners with documented and controlled processes that meet the requirements of this standard.

Catastrophic Hazard: A hazard that can result in loss of life, a disabling injury, or the loss of spaceflight hardware (Space Shuttle, Space Station, Crew Launch Vehicle, Crew Exploration Vehicle, or Government-furnished Equipment), ground support equipment, ground facilities, or program-critical equipment.

Certificate of Conformance (COC): A document that is signed by the fastener supplier to affirm that the product has met the requirements of the relevant specification(s), contractual requirements, and any other applicable regulations.

Certification Validation Test (CVT): Receiving inspection test(s) that are performed to assure conformance to the procurement specification requirements. For fasteners, this includes elemental analysis and mechanical property testing and inspection.

Commingled: A storage state where hardware (e.g., fasteners, inserts, etc.) from two or more different lots are co-located or stored in the same bin or other holding container.

Complete Traceability: Documentation that demonstrates a solid chain of custody from the original fastener manufacturer through all intermediate distributors down to the buyer.

Contained Fastener: A fastener that meets the criteria specified in NASA-STD-5019, Fracture Control Requirements for Spaceflight Hardware, paragraph 4.1.1.2.

Developer: Contractors who are not prime contractors and who design or build flight hardware. Examples include NASA-agreement entity organizations, colleges, schools, and universities.

Distributor: An enterprise that stocks the products of various manufacturers for resale and does not engage in manufacturing activity.

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Fail Safe: A fracture control classification based on redundancy where, after failure of a single fastener, the remaining structure can withstand the redistributed loads and the failure will not release a potentially catastrophic free body. A fail safe fastener meets the criteria specified in NASA-STD-5019, section 4.1.1.3.

Fastener: An item such as a bolt (could be a tensile or shear bolt, shoulder bolt, screw, HiLok®, HiTigue®, or lockbolt), nut, nut plate or anchor nut, rivet, shear pin, helical or cylindrical insert, setscrew, washer, safety wire, cotter pin, etc., which joins or retains components or structural elements.

Fracture-Critical Fastener: A classification that assumes that fracture or failure of the fastener resulting from the occurrence of a crack will result in a catastrophic hazard, as specified in NASA-STD-5019.

Lot: A collection of units or items (e.g., fasteners or inserts) manufactured from a homogeneous batch of material of the same continuous, uninterrupted production.

Low Released Mass: A fastener that meets the criteria specified in NASA-STD-5019, paragraph 4.1.1.1.

Low-Risk Fracture Fastener (or Low-Risk Fastener): A fastener that meets the criteria specified in NASA-STD-5019, paragraph 4.1.1.12.

Manufacturer's Test Report (MTR): A document that is produced by the fastener manufacturer that certifies information required by the applicable fastener specification.

Partial Traceability: Documentation from a supplier or vendor that does not necessarily include the full chain of custody back to the original fastener manufacturer.

Prime Contractor: A contractor who has been given responsibility through NASA to manage a major flight-level program that may involve development through design, manufacture, testing and integration, launch, and post-launch activities.

Screening: An in-house receiving inspection that verifies that requested procurement documentation has been received and that procurement requirements have been met. This is intended to be done in addition to the CVT required.

Specialized Fasteners: Fasteners that fall under categories such as custom-designed and manufactured fasteners; pyrotechnic fasteners; non-metallic fasteners or commercial fasteners such as eyebolts, clevises, hooks, wire rope, turnbuckles, and continuous threaded rods; as well as those not otherwise specified.

Supplier: A fastener manufacturer or distributor.

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Technical Authority: The agency or organization that is responsible for the technical details of a particular design and the resolution of any associated technical issues.

4. REQUIREMENTS

The requirements set forth in this document are the baseline fastener management and control requirements for all spaceflight hardware. Fastener management and control pertains to the procurement, receiving inspection, and storage of fasteners.

Any deviations from these requirements shall be approved by the governing Technical Authority for the program/project.

Specific requirements for fastener control are contained in this section. In addition, the majority of the requirements are summarized in tables 1 and 2. Specialized fastener requirements are provided in section 4.8.

4.1 Fastener Selection

4.1.1 All fasteners used on spaceflight hardware shall be selected so that they are controlled by government or industry specifications that include design, performance, and quality assurance requirements.

4.1.2 Metallic fastener materials shall be selected from tables IA-E of MSFC-STD-3029, Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments.

These “table I” alloys exhibit a high resistance to stress corrosion cracking.

4.1.3 Use of other (non-table I) metallic materials shall require documentation of acceptance rationale in a Material Usage Agreement (MUA) that is approved by the responsible NASA materials and processes (M&P) organization.

4.2 Approved Manufacturers and Distributors

4.2.1 Fracture-critical fasteners, low-risk fasteners, and nuts and inserts used with such fasteners shall be obtained from manufacturers and distributors who have been approved by an on-site quality or product audit conducted by the procuring organization (see section 4.7).

4.2.2 NASA Centers, developers, and prime contractors that do not audit their manufacturers and distributors shall be permitted to procure fasteners from a list of NASA-approved vendors that have been audited according to sections 4.2.1 and 4.7.

Distributors or vendors that are on a list that has been audited and approved by any of the prime contractors are also acceptable.

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Fasteners that are not listed in section 4.2.1 may be procured from non-audited distributors or manufacturers, provided the screening requirement in table 1 and the certification validation test (CVT) requirements specified in table 2 are performed.

4.2.3 All fasteners shall be procured in lots.

4.2.4 A single lot of fasteners shall not include fasteners that have traceability to different material batches/lots.

Traceability requirements are discussed in section 4.6.

4.3 Receiving Inspection: Screening and CVT

All fasteners shall be subjected to a receiving inspection that includes a documentation screening per table 1 and the CVT that is required by table 2 to check for conformity with specification requirements.

4.4 Manufacturer's Test Report (MTR)

An MTR is a document that is produced by the fastener manufacturer to certify information required by the applicable fastener specification. The information typically includes fastener lot number, manufacturing date, lot quantity, raw material heat number, chemical composition, and mechanical and metallurgical test results.

4.4.1 An MTR shall be obtained for each fracture-critical, low-risk, and fail safe fastener purchased.

4.4.2 In addition, all rivets, shear pins, inserts, and retention devices (such as cotter pins, hitch pins, safety wires, and ties) shall have MTR documentation.

4.5 Certificate of Conformance (COC)

A COC is a document that is signed by the fastener supplier to affirm that the product has met the requirements of the relevant specification(s), contract(s), and any other applicable regulations. It attests that the fasteners are of the quality specified in the acceptance document and conform in all respects with contractual requirements, including specifications, drawings, preservation, packaging, packing, marking requirements, applicable heat/lot number, and physical item identification part number.

4.5.1 A COC to the applicable fastener specification is required for every fastener lot and shall be obtained from the manufacturer or distributor selling the fasteners.

4.5.2 The COC shall be provided to the program/project organization.

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4.6 Traceability

Traceability is the concept that a buyer can trace the history of a given lot of fasteners back through any number of distributors or vendors to the original manufacturer(s).

- a. Either complete or partial traceability shall be maintained for all spaceflight fasteners.
- b. Traceability documentation shall be maintained for all flight hardware, as specified by the appropriate program/project requirements documents.

4.6.1 Complete Traceability

Complete traceability is required for all fracture-critical fasteners and all inserts and nuts that are used with fracture-critical fasteners.

Complete traceability is documentation that demonstrates a solid chain of custody from the original fastener manufacturer through all intermediate distributors down to the buyer. Normally, it consists of a string of purchase orders from the original manufacturer down through each distributor or vendor, linking the sale of a particular lot of fasteners with a unique fastener manufacturer's lot number.

Complete traceability documentation includes the entire chain of custody and all of the following stipulations:

- a. The original manufacturer shall have lot traceability back through the manufacturing process to the raw material test certifications.
- b. Any subsequent manufacturer that modifies a given fastener shall have lot traceability to the manufacturing process performed and back through to the original manufacturer.
- c. Any subsequent supplier(s) or vendor(s) shall have lot traceability back through to the original manufacturer.

4.6.2 Partial Traceability

Partial traceability can be utilized in some cases when complete traceability cannot be achieved. It consists of documentation from a supplier or vendor that does not necessarily include the full chain of custody back to the original fastener manufacturer.

Partial traceability is acceptable for all non-fracture-critical fasteners, including low-risk and fail safe fasteners, provided that lot testing (CVT) is performed for verification according to section 4.11.2.

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4.7 Audits and Storage

4.7.1 Audits shall be used to verify that a company's processes and products meet the requirements of applicable specifications in accordance with NPD 8730.5, NASA Quality Assurance Program Policy.

Audit approval is limited to the audited location and its product and not to affiliated companies or dissimilar products.

4.7.2 The supplier shall be audited, approved, and maintained based on the NASA Center's supplier approval and surveillance process for a maximum of 3 years before being re-audited.

A given NASA Center may utilize the audits and approved vendor lists from any other NASA Center or from any NASA prime contractor. Once NASA has approved the audit results, the manufacturer is placed on the approved vendor list.

4.7.3 Fasteners shall be maintained in storage according to program requirements until issued for use.

Utilization of a storage system where fasteners or inserts from two or more different lots are commingled (co-located or stored in the same bin or other holding container) is expressly prohibited.

4.8 Specialized Fasteners

4.8.1 Appropriate material, design, processing, and screening requirements shall be developed for specialized fasteners on a case-by-case basis by the responsible engineering and M&P organizations.

4.8.2 These requirements shall be approved by the governing Technical Authority and placed in the program/project requirements document(s).

4.8.3 Non-metallic fasteners shall be considered specialized fasteners.

4.9 Fasteners Critical for Mission Success

If the Technical Authority determines that a fastener is critical for mission success, they may impose on it the same traceability and receiving inspection requirements as a fracture-critical fastener, even when the actual fracture classification is of a less critical nature.

4.10 Fasteners in Commercial-Off-The-Shelf (COTS) Hardware

Fracture-critical, low-risk, and fail safe fasteners used in COTS hardware shall meet the traceability requirements of this standard.

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Low released mass and contained fasteners used in COTS hardware are exempt from the requirements of this standard.

4.11 Quality Assurance Provisions

4.11.1 Discrepant/Nonconforming Fasteners

a. Any nonconformance to the quality assurance provision detailed in sections 4.11.2 through 4.11.8 shall result in the lot being categorized as nonconforming.

b. These fastener lots shall be dispositioned according to the quality management system nonconformance procedures of the responsible NASA, prime contractor, or developing organization.

c. Appropriate technical rationale for acceptance of a discrepant condition shall be documented.

4.11.2 Certification Validation Testing (CVT) Inspections

a. CVT inspections are summarized in tables 1 and 2 and shall be conducted on the specified fastener types by an accredited laboratory or by using NASA Center-approved processes that are independent of the manufacturer and distributor.

When the CVT defined in table 2 refers to “sampling basis,” that indicates that every fastener does not need to be tested. The sample size for CVT inspection depends on lot size and whether or not the manufacturer is approved. It should be noted that if any failures or defective components are found, the entire lot will be rejected. The sample size required for testing done on a “sampling basis” is defined below in sections 4.11.2.1 and 4.11.2.2.

With respect to the sampling plans shown in 4.11.2.1 and 4.11.2.2, it is assumed that the supplier’s quality systems are correct and efficient and that the fasteners’ production is in both engineering and statistical control. It should be noted that these sampling plans are meant to catch only gross departures from requirements that affect the entire fastener lot, such as an incorrect material. The sampling plans specified will not routinely find subtle problems or problems affecting even substantial portions of a lot.

b. If it is necessary to statistically assess the quality of a lot, a larger number of samples, a more complex sampling plan, and/or continuing assessment of statistical control shall be considered (see ANSI/ASQ Z1.4-2003 for additional information).

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4.11.2.1 Sample Size for Approved Manufacturer's Products

Sample size and acceptance criteria shall be as follows for approved manufacturer's products:

Lot Size	Sample Size	Acceptance Criteria
3 to 50	2	0 failures
51 to 100	3	0 failures
101 to 500	5	0 failures
501 to 1200	6	0 failures
1201 and over	7	0 failures

4.11.2.2 Sample Size for Non-Approved Manufacturer's Products

Sample size and acceptance criteria shall be as follows for non-approved manufacturer's products:

Lot Size	Sample Size	Acceptance Criteria
4 to 50	3	0 failures
51 to 100	5	0 failures
101 to 500	7	0 failures
501 to 1200	8	0 failures
1201 and over	9	0 failures

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Table 1—Fastener Procurement, Documentation, and Screening Requirements

Fastener Type (Male and Female)	Approved Manufacturer Required	COC	MTR	CVT	Complete Traceability	Partial Traceability
Fracture-critical (FC)	X	X	X	X	X	
Inserts and Nuts used with FC Fasteners	X	X	X	X	X	
Low-Risk Fracture (LRF)	X	X	X	X		X ⁽¹⁾
Inserts and Nuts used with LRF Fasteners	X	X	X	X		X ⁽¹⁾
Fail Safe		X	X	X		X ⁽¹⁾
Low Released Mass		X		X		X ⁽¹⁾
Contained		X		X		X ⁽¹⁾
Retention Devices Like Cotter Pins, Hitch Pins, Safety Wires, and Ties		X	X	X		X ⁽¹⁾

- (1) If complete traceability, as-defined in section 4.6.1, is obtained through procurement, the CVT requirements may be reduced (see table 2).
- (2) Fail-safe fasteners include rivets, shear pins, setscrews, and washers when determined to be so by structural analysis.

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Table 2—CVT and Inspection Requirements for Fasteners

Fastener Type (Male and Female)	Visual ³	100% Dimensional ⁴	Dimensional (Sampling Basis)	Tensile (Sampling Basis)	Hardness (Sampling Basis)	Chemical Analysis (Sampling Basis)
Fracture-critical (FC)	X	X		O ¹		O ¹
Inserts and Nuts used with Fracture-Critical Fasteners	X	X		O ¹		O ¹
Low-Risk Fracture (LRF)	X	X		X		X
Inserts and Nuts used with Low-Risk Fracture Fasteners	X	X		X		X
Fail Safe	X		X	X ⁵	O ²	X ⁵
Low Released Mass	X		X			
Contained	X		X			
Retention Devices Like Cotter Pins, Hitch Pins, Safety Wires, and Ties	X					X ⁵

X – Required testing, O – Optional test method (see notes below)

- 1 Tensile and chemical analysis may be performed as an option by the user to maintain consistency in the incoming inspection process, but these tests are not required for these categories of fasteners.
- 2 Option to substitute hardness testing on bolts or screws if they are too short to tensile test, provided they meet the requirements of section 4.11.4.2. Fail safe rivets, shear pins, set-screws, and washers used with fail safe (or higher) fasteners shall be hardness tested in lieu of tensile testing.
- 3 Per section 4.11.3, 100% of each lot must receive an unaided visual inspection (1X magnification). Also, a sample of each lot shall be inspected at 10X magnification.
- 4 One hundred percent (100%) means that every fastener must be inspected, not that every dimensional characteristic of each fastener must be inspected.
- 5 If complete traceability to the original manufacturer, as defined in section 4.6, can be obtained, then it is optional to perform in-house tensile tests and chemical analysis. Individual projects have the option to perform in-house sampling, but it is not a requirement of this document.

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4.11.3 Visual Inspection

4.11.3.1 Preliminary Visual Inspection

A preliminary visual inspection to assure lot uniformity shall be performed at 1X magnification (unaided eye) on every fastener in a given lot.

4.11.3.2 Visual Inspection for Finish

Visual inspection for finish and other characteristics requiring visual inspection by the appropriate procurement specification shall be performed at 10X minimum magnification, on a sampling basis that is specified in section 4.11.2.1 or 4.11.2.2.

4.11.4 Hardness and Tensile Tests

4.11.4.1 Hardness Test Performance

a. Hardness testing according to NASM1312-6, Fastener Test Methods, Method 6, Hardness, shall be performed on fail safe fasteners as required and specified in table 2, footnote 2.

Superficial hardness or microhardness testing may be employed in lieu of Rockwell hardness testing only for fasteners that are #8 or smaller.

b. In order to eliminate the effects of cold work, superficial and microhardness measurements shall be made on a cross section of the shank or threaded areas.

c. Hardness test acceptance values shall be in accordance with the applicable fastener procurement specification.

4.11.4.2 Tensile Test Performance

a. Tensile testing shall be performed on a sampling basis (as defined in section 4.11.2.1 or 4.11.2.2) for threaded fasteners according to one of the following three standards: NASM1312-8, Fastener Test Methods, Method 8, Tensile Strength; NAM1312-108, Fastener Test Methods, Metric, Method 108, Tensile Strength; ASTM F 606, Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets, or a NASA-approved equivalent standard.

b. The location of the tensile break and the ultimate load or ultimate strength (whichever is required by the specification) determined shall be recorded.

c. The specification minimum value shall also be recorded for comparison.

Load extension curves are not required.

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4.11.4.3 Hardness Substitution for Tensile Test

Hardness testing may be substituted for tensile testing (for fail safe fasteners only) if the fastener is too short for tensile testing.

a. When choosing hardness testing as a substitution, consideration shall be given to the correlation between hardness and tensile data.

In addition, when hardness testing is substituted, a microstructural evaluation of the fastener lot is required to demonstrate that it meets the requirements of the applicable fastener procurement specification.

b. This microstructural examination shall consist of inspection for gross defects or anomalies, a check of the flow lines pertaining to forging and/or rolling operation(s), and a grain size determination.

4.11.5 Dimensional Inspection

4.11.5.1 One hundred percent (100%) dimensional inspection shall be required for fracture-critical, mission-critical, and low-risk fasteners for conformance to dimensional requirements.

One hundred percent (100%) indicates that every fastener must be inspected, not that every dimensional characteristic of each fastener must be inspected.

4.11.5.2 The dimensional characteristics of the remaining categories of fasteners, with the exception of retention devices, shall be inspected on a sampling basis as specified in table 2.

4.11.5.3 For threaded products, dimensional inspection of the threads shall be performed according to ASME B1.3, Screw Thread Gaging Systems for Dimensional Acceptability - Inch and Metric Screw Threads, System 22.

4.11.5.4 Dimensional inspection shall also include verification of the head height, fillet radius, thread length, and shank length.

4.11.6 Chemical/Elemental Analysis

Chemical/elemental analysis shall be performed on fastener materials on a sampling basis, using any quantitative or semi-quantitative chemical/elemental analysis technique, as specified for the fastener types listed in table 2.

A quantitative Optical Emission Spectroscopy (OES) analysis is destructive to the fastener but is the preferred test method.

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