

Corrosion Resistant Bolting for Use in the Petroleum and Natural Gas Industries

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AMERICAN PETROLEUM INSTITUTE

Corrosion Resistant Bolting for Use in the Petroleum and Natural Gas Industries

1 Scope

1.1 Purpose

This standard specifies requirements for the qualification, production and documentation of corrosion resistant bolting used in the petroleum and natural gas industries.

1.2 Applicability

This standard applies when referenced by an applicable API equipment standard or otherwise specified as a requirement for compliance.

1.3 Bolting Specification Levels (BSL)

This standard establishes requirements for two bolting specification levels (BSL). These two BSL designations define different levels of technical, quality, and qualification requirements: BSL-2 and BSL-3. The BSL are numbered in increasing levels of requirements in order to reflect increasing technical, quality, and qualification criteria. BSL-2 and BSL-3 are intended to be comparable to BSL-2 and BSL-3 as found in API 20E. BSL-1 is omitted from this standard.

1.4 Bolting Types for Qualification

This standard covers the following product forms, processes, and sizes:

- a) machined studs;
- b) machined bolts, screws and nuts;
- c) cold formed bolts, screws and nuts with cut or cold formed threads;
- d) hot formed bolts and screws <1.5 in. (38.1 mm) nominal diameter;
- e) hot formed bolts and screws \geq 1.5 in. (38.1 mm) nominal diameter;
- f) roll threaded studs, bolts, and screws <1.5 in. (38.1 mm) diameter;
- g) roll threaded studs, bolts, and screws \geq 1.5 in. (38.1 mm) diameter;
- h) hot formed nuts <1.5 in. (38.1 mm) nominal diameter;
- i) hot formed nuts \geq 1.5 in. (38.1 mm) nominal diameter.

1.5 Application of the API Monogram

If product is manufactured at a facility licensed by API and it is intended to be supplied bearing the API Monogram, the requirements of Annex A apply.

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2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document applies (including any addenda/errata).

API Specification Q1, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*

API 6A, 20th Edition, *Specification for Wellhead and Christmas Tree Equipment*

API 6HT, *Heat Treatment and Testing of Carbon and Low Alloy Steel Large Cross Section and Critical Section Components*

API Standard 6ACRA, *Age-hardened Nickel-based Alloys for Oil and Gas Drilling and Production Equipment*

ANSI/NCSL Z540.3¹, *Requirements for the Calibration of Measuring and Test Equipment*

ASTM A370², *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A453, *Standard Specification for High-Temperature Bolting, with Expansion Coefficients Comparable to Austenitic Stainless Steels*

ASTM A751, *Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products*

ASTM A962-17, *Standard Specification for Common Requirements for Bolting Intended for Use at Any Temperature from Cryogenic to the Creep Range*

ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*

ASTM E18, *Standard Test Methods for Rockwell Hardness of Metallic Materials*

ASTM E354 *Standard Method for Chemical Analysis of High Temperature Electrical, Magnetic, and Other Similar Iron, Nickel and Cobalt Alloys*

ASTM E1476, *Standard Guide for Metals Identification, Grade Verification, and Sorting*

ASTM F788, *Standard Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series*

ASTM F812, *Standard Specification for Surface Discontinuities of Nuts, Inch and Metric Series*

NACE MR0175/ISO 15156³ – *Petroleum and Natural Gas Industries – Materials for Used in H₂S-containing Environments in Oil and Gas Production Parts 1, 2 and 3*

¹ NCSL International, 2995 Wilderness Place, Suite 107, Boulder, Colorado 80301-5404, www.ncsli.org.

² ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

³ NACE International, 15835 Park Ten Place, Houston, TX 77084, www.nace.org

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SAE AMS 2750⁴, *Pyrometry*

SAE AMS 5844, *Alloy, Corrosion-Resistant Round Bars 20Cr-35Ni-35Co-10Mo Vacuum Induction Plus Consumable Electrode Vacuum Remelted Solution Heat Treated and Work Strengthened*

SAE AMS 5845, *Alloy, Corrosion-Resistant Round Bars 20Cr-35Ni-35Co-10Mo Vacuum Induction Plus Consumable Electrode Vacuum Remelted Solution Heat Treated, Work Strengthened, and Aged*

SAE AMS H-6875, *Heat Treatment of Steel Raw Materials*

3 Terms, Definitions, Acronyms, and Abbreviations

3.1 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

bolting

All-thread studs, tap-end studs, double-ended studs, headed bolts, cap screws, screws, and nuts.

3.1.2

bolting manufacturer

An organization that, through the use of manufacturing equipment and processes appropriate for the bolting product form, transforms raw material into finished bolting.

3.1.3

cold formed bolts, screws, and nuts

Parts formed through the mechanical cold upsetting of wire, rod or bar in order to generate the bolt or screw head (cold heading) or the configuration of the nut.

3.1.4

corrosion resistant bolting

Bolting manufactured from metal that achieves improved resistance to corrosion through the addition of alloying elements.

3.1.5

heat

Material originating from a final melt, or for remelted alloys, the raw material originating from a single remelted ingot.

⁴ SAE International, www.sae.org

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3.1.6 heat lot

- a) Batch furnace: bolting or raw material of a single heat and diameter, heat treated together as a single solution annealing, quenching, and precipitation hardening charge;
- b) Continuous furnace (applies to ASTM A453 Grade 660 Class D only): bolting or raw material of a single heat and diameter heat treated without interruption in a continuous charge as defined in ASTM A453.

3.1.7 hot formed bolts, screws, and nuts

Parts formed through the mechanical hot upsetting of wire, rod or bar in order to generate the bolt or screw head (hot heading) or the configuration of the nut.

3.1.8 machined bolts, screws, and nuts

Parts manufactured by machining from raw material to generate the bolt, screw head, or the configuration of the nut.

3.1.9 manufacturing process specification MPS

A written document describing the complete production sequence and method.

NOTE: MPS are usually proprietary by manufacturer and not for general publication, but are available to customers or authorized third parties for information.

3.1.10 production lot

Bolting of a single nominal diameter and grade made from the same heat lot.

3.1.11 raw material

Bar, coil, rod, or wire used to manufacture bolting.

3.1.12 raw material supplier

The manufacturer of raw material used to produce qualified bolting defined as the mill.

NOTE: A distributor is not considered a raw material supplier.

3.1.13 technical authority

A competent and technically qualified person or organization with evidence to demonstrate the expertise, skills, and experience regarding quality and manufacturing processes necessary to perform the required verification(s).

3.1.14 wrought structure

Structure that contains no cast dendritic elements.

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3.2 Abbreviations

BSL	bolting specification level
MPS	manufacturing process specification
NDE	nondestructive examination
UT	ultrasonic testing

4 Qualification Bolting

4.1 General

4.1.1 This standard states the requirements for two bolting specification levels (BSL) and nine bolting types. The manufacturer may qualify to one or more of the bolting types listed in 1.4 and to one or both BSL. Each individual bolting type shall be qualified. Qualification to the higher BSL shall qualify to the lower BSL. The following paragraphs describe the conditions which, when met, allow the bolting to meet the appropriate bolting type and BSL classification level.

4.1.2 Qualification bolts and nuts shall be produced from raw material procured from an approved supplier as defined in 5.1 and manufactured in accordance with an applicable manufacturing process specification (MPS) for a bolting material.

4.2 Qualification Testing

4.2.1 Qualification bolting shall be tested and evaluated by the bolting manufacturer in order to establish qualification to the bolting types listed in 1.4 and a BSL. Qualification bolting shall meet all of the requirements indicated in Table 1 for the applicable sections of this standard.

4.2.2 All required tests, including those certified by the raw material supplier, shall be performed by a laboratory qualified in accordance with ISO 17025.

4.2.3 Qualification may be performed on parts specifically manufactured for qualification or random parts selected from a production lot. A sufficient number of parts shall be used to provide adequate material for all required tests.

4.2.4 The manufacturer shall have a quality management system that at a minimum meets the requirements of API Q1.

4.2.5 The manufacturer shall retain and have available an MPS (see 5.3) and qualification records (see 4.5) for each product qualified. The qualification records shall show all of the products, processes and sizes qualified and all of the Table 1 requirements for each qualification including the results of tests and inspections.

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Table 1—Bolting Test Requirements

BSL	Material	Heat Treatment	Chemistry	Mechanical	Metallurgical	Hardness	NDE Surface	NDE Volumetric
BSL-2	5.5.1	5.4.5	5.6	5.7.2	5.8	5.9.2	5.10.1.1	5.10.1.2
BSL-3	5.5.2	5.4.5	5.6	5.7.3	5.8	5.9.2	5.10.2.1	5.10.2.2

4.3 Materials and Dimensions

4.3.1 The following bolting materials are covered by this standard:

- precipitation hardened nickel based alloys in accordance with API 6ACRA;
- precipitation hardened austenitic iron based ASTM A453 Grade 660 Class D;
- cold reduced only or cold reduced and high-temperature aged heat treated condition cobalt based alloy UNS R30035.

4.3.2 All requirements of API 6ACRA, ASTM A453 or UNS R30035 shall be met except as modified by this standard. In the case of conflict between the requirements of referenced specifications and this standard, the requirements of this standard shall apply.

4.3.3 For UNS R30035, the manufacturer shall have a written specification compliant with SAE AMS 5844 or SAE AMS 5845 as specified in ISO 15156-3 / NACE MR0175-3 supplied in the cold-reduced and aged condition with a maximum hardness of 51 HRC or supplied in the cold-reduced only condition with a maximum hardness of 35 HRC and not subsequently aged.

UNS R30035 shall not be heat treated by the bolting manufacturer since it cannot be heat treated by the bolting manufacturer to meet the requirements of ISO 15156-3 / NACE MR0175-3.

4.3.4 Oversizing of nut threads or under sizing of bolt threads is not permissible.

4.3.5 Welding is not permitted.

4.4 Acceptance of Qualification Bolting

4.4.1 General

Results of the tests specified in Table 1 shall comply with the acceptance criteria specified in Section 5 and the bolting manufacturer's written specification. Results shall be documented in accordance with 4.5.

4.4.2 Qualification Samples

4.4.2.1 Samples failing to meet acceptance criteria shall be cause for re-evaluation of the MPS and the processes and procedures used. Requalification is required.

4.4.2.2 When a qualification sample is selected from a production lot, as defined in 3.1.10, fails to meet acceptance criteria, the entire lot shall be rejected.

4.4.2.3 Should the manufacturer choose to continue the qualification process with the same lot, the

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entire lot shall be reprocessed. A maximum of two full reheat treatment cycles is permitted for API 6ACRA alloys and ASTM A453 Grade 660 Class D.

4.4.2.4 For reprocessed lots, all qualification tests shall be repeated. Should any of the qualification tests fail to meet the acceptance criteria, the entire lot shall be rejected.

4.4.2.5 If reprocessing results in any changes to the MPS, the MPS shall be revised to reflect the new process control variables.

4.5 Records of Qualification

The following records are required to document the qualification of bolting:

- a) API 6ACRA Edition and Alloy, ASTM A453 Grade 660 Class D, including revision level, or applicable manufacturer specification for UNS R30035, including revision level;
- b) heat number for API 6ACRA alloys and ASTM A453 Grade 660 Class D; heat number and production lot number for UNS R30035;
- c) raw material manufacturer;
- d) raw material refining method;
- e) size;
- f) process control variables;
- g) MPS;
- h) forming, as applicable;
- i) heat treatment;
- j) machining, as applicable;
- k) thread rolling, as applicable;
- l) record of test results, as applicable, in Section 4 and Section 5;
- m) inspection;
- n) personnel qualifications;
- o) test laboratory qualification;
- p) records of qualification test failures and corrective action; and
- q) subcontractor(s) name and address and records of qualification (as specified in 5.2) for each subcontracted process.

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4.6 Limits of Bolting Qualification – BSL-2 and BSL-3

The following are the limits of bolting qualification. A change in any of these variables requires requalification:

- a) change of heat treat method (type of equipment, furnace control method, cooling methods);
- b) addition of raw material supplier not previously qualified in accordance with Section 5;
- c) change of machining or threading methods (type of equipment, control);
- d) change of hot forming practice (type of equipment, heating method, temperature control method);
- e) for UNS R30035, change in the amount of cold reduction (work strengthening);
- f) subcontractor of processes listed in 5.2.1.

5 Production of Qualified Bolting

5.1 Qualification of Procurement Sources for Raw Material

5.1.1 Only sources for raw material that are approved by the bolting manufacturer are to be used to supply raw material. The bolting manufacturer shall have a documented and fully implemented procedure for qualifying raw material suppliers for each grade and heat treat condition of material. The approval process shall be based on both a quality assurance and a technical evaluation. The approval process shall establish the methodology by which the raw material supplier will be evaluated on an ongoing basis to maintain their status as an approved supplier.

5.1.2 In addition to the maintenance of a quality management system meeting an applicable standard, such as API Q1 or ISO 9001, the raw material supplier shall maintain documented evidence of their technical capability to produce materials meeting this standard, and shall have documented procedures that demonstrate their capability to consistently produce acceptable product. The methods for the technical approval of a raw material supplier for the two BSL are the following:

- a) BSL-2

Use of two or more of the following four methods:

- 1) raw material receipt inspection that includes volumetric and surface NDE, chemistry check, metallurgical properties, mechanical properties and dimensions, as applicable;
- 2) raw material first article evaluation;
- 3) demonstration of technical capability, such as tests/inspections, quantity of material received, nonconformance analysis;
- 4) on-site technical audits at scheduled 3 year intervals, at a minimum.

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b) BSL-3

All of the four methods listed in 5.1.2.a) shall be used.

5.1.3 The bolting manufacturer is responsible for ensuring that a raw material supplier has implemented controls addressing the following for each grade of raw material ordered:

- a) chemistry controls;
- b) melting practice controls;
- c) pouring practice;
- d) hot work practice controls;
- e) heat treatment controls, as applicable;
- f) raw material inspection and acceptance criteria (cleanliness requirements, limitations on porosity or inclusions, grain size, secondary phases, microstructure, as applicable);
- g) controls to assure that no welding was performed.

5.2 Qualification of Suppliers for Subcontracted Operations

5.2.1 General

If any of the following operations are subcontracted, the suppliers of the subcontracted operations shall be qualified, by the manufacturer, in accordance with this section:

- a) head forging/head forming of individual fasteners;
- b) heat Treatment;
- c) threading;
- d) plating/coating;
- e) NDE;
- f) mechanical and hardness testing;
- g) metallurgical examination as specified in 5.8;
- h) chemical analysis.

5.2.2 Qualification Requirements

5.2.2.1 Only qualified suppliers shall be used to perform subcontracted operations. The bolting manufacturer shall have a documented and fully implemented procedure for qualifying subcontracted suppliers for operations performed. The qualification process shall be based on:

- a) A quality management system evaluation in accordance with ISO 9001, API Q1, or ISO 17025 for all Bolting Specification Levels, and

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- b) An onsite process evaluation performed by a technical authority per methods listed in 5.2.3.

5.2.2.2 Suppliers of subcontracted operations shall have an onsite technical authority available and the technical authority's competency shall be documented.

5.2.3 Technical Evaluation

The methods for the technical evaluation of a subcontractor for the various BSLs are listed in a) and b) below.

a) BSL-2 Requirements

- 1) A quality management system evaluation, ensuring that the subcontractor's QMS is compliant with ISO 9001, API Q1 or ISO 17025.
- 2) Onsite process audit performed by a technical authority at an interval no greater than 3 years.
- 3) Evaluation of the supplier's documented evidence of technical capability to perform subcontracted operations in accordance with 5.2. At a minimum, the evaluation shall include certifications, production logs, written procedures, and nonconformance analyses.

b) BSL-3 Requirements

- 1) Requirements specified for BSL-2 are required for BSL-3.
- 2) First article evaluation of each subcontracted process per manufacturer's documented procedure.

5.3 Material Specifications

5.3.1 The bolting manufacturer shall prepare and document raw material requirements in the form of a material specification. For BSL-2 this may be the applicable API or ASTM specification. For BSL-3, material specifications shall include as applicable per the referenced API, ASTM or purchaser's standard:

- a) material grade, including element chemistry and allowable ranges;
- b) acceptable melt practices and ladle refinement;
- c) acceptable hot work reduction range (not required for cold reduced UNS R30035 material);
- d) acceptable microstructure (applicable to alloys covered by API 6ACRA only);
- e) heat treatment requirements including mill heat treatments;
- f) mechanical properties;
- g) acceptable inspection practices and criteria, as applicable per BSL.

5.3.2 The bolting manufacturer shall document acceptance of incoming raw material to the requirements of the material specification prior to use in the production of bolting.

5.4 Manufacturing Process Specification

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5.4.1 General

The bolting manufacturer shall prepare an MPS to include, as minimum allowable levels for all bolting manufacturing parameters including the process control variables listed in 5.4.2, the forging/hot heading parameters listed in 5.4.3 and the heat treatment parameters listed in 5.4.4.

The requirements of Annex B shall be followed during processing to prevent embrittlement of the bolting.

5.4.2 General Variables

The following are general variables, as applicable:

- a) heading equipment;
- b) hot forming heating method;
- c) hot forming temperature control method;
- d) heat treating equipment and processes;
- e) machining and threading equipment: single point (lathe), multiple chaser, roll, cutting tap; form tap;
- f) machining and threading control methods;
- g) mill source (name and address); and
- h) outsourced activity supplier (name and address).

5.4.3 Forging/Hot Heading Parameters

The following are forging/hot heading parameters, as applicable;

- a) equipment;
- b) heating method (furnace, induction);
- c) temperature control (thermocouple, optical or infrared pyrometer, fail safe cut-off);
- d) times and temperatures; and
- e) dimensional control.

5.4.4 Heat Treatment Parameters

The following are heat treat parameters, as applicable:

- a) equipment (batch, continuous);
- b) times and temperatures;
- c) cooling media (e.g. type, polymer concentration, quench temperature, agitation);
- d) control and calibration methods;
- e) furnace load diagram. For mill produced products, this requirement is waived provided the following is applied:
 - material is heat treated in a single layer load;

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- a maximum of 2.00 inch diameter difference between the smallest and the largest diameter when heat treating different diameters in the same heat treat batch;
- a minimum of two contact or heat sink thermocouples per batch.

5.4.5 BSL-2 and BSL-3 Requirements

5.4.5.1 Forging and hot heading shall be in accordance with the manufacturer's standard procedure.

5.4.5.2 Heat treatment shall be in accordance with the relevant API, NACE or ASTM standard.

5.4.5.3 Heat treatment of API Standard 6ACRA material shall be performed and qualified after the material's final hot forming operation. Heat treatment equipment qualification and calibration, temperature monitoring, and solution annealing and age hardening times and temperature shall be in accordance with the requirements API Standard 6ACRA.

5.4.5.4 Heat treatment of ASTM A453 660 Class D shall be in accordance with ASTM A453.

5.4.5.5 Heat treatment of UNS R30035 shall be in accordance with ISO 15156-3 / NACE MR0175-3. Furnace qualification shall be in accordance with API 6A, SAE AMS 2750, or SAE AMS H-6875. Solution annealing furnace tolerance shall be +/- 25F. Aging furnace tolerance shall be +/- 15F.

5.4.5.6 Manufacturing processes shall be performed so as to avoid the introduction of stress risers that can occur from sharp angles and tool marks. Threads may be cut or rolled. External Unified National Threads shall be "R" (UNR controlled radius root) series.

5.4.5.7 The following apply to material not heat treated by the raw material supplier:

- a) Furnace loading shall be in accordance with API 6HT; Section 6.3.3.
- b) A furnace loading diagram shall be prepared for each load configuration.
- c) Temperature shall be monitored using a contact thermocouple or a heat sink placed at the center of the load.
- d) Water, oil, and polymer quenching media shall be controlled in accordance with API 6HT.
- e) The manufacturer shall have a written forging procedure defining at a minimum, the parameters defined in 5.4.3. When induction heating is used for forging, the manufacturer's procedure shall include temperature monitoring equipment and an automatic fail-safe system to prevent overheating.

5.4.6 Plating and Coating

5.4.6.1 Plating and coating shall be provided only when specified in the purchase agreement.

5.4.6.2 Plating and coating shall be specified in accordance with industry or the equipment manufacturer's proprietary bolting material specification.

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5.4.6.3 The following shall be specified when ordering plating and coating:

- a) part description;
- b) specification number and revision (year date for ASTM specifications);
- c) description of plating/coating including type, thickness, finish, and other applicable requirements;
- d) requirement for supplier's statement of conformance.

5.5 Raw Material

5.5.1 BSL-2

5.5.1.1 The metal shall have a fully wrought structure.

5.5.1.2 The hot work reduction ratio based on starting material diameter shall be a minimum of 4.0:1. This requirement does not apply to UNS R30035.

5.5.1.3 The metal shall conform to the requirements of the relevant API, ASTM Standard or to AMS 5844 or AMS 5455 for UNS R30035.

5.5.1.4 All elements intentionally added to the heat except those used for processing shall be reported.

5.5.2 BSL-3

5.5.2.1 The requirements specified for BSL-2 are required for BSL-3.

5.5.2.2 In addition to the heat analysis performed by the mill, the bolting manufacturer shall perform a product analysis in accordance with ASTM A453 Grade 660 Class D, API 6ACRA or UNS R30035.

5.6 Chemical Analysis

Methods and practices relating to chemical analysis shall be in accordance with ASTM A751 or ASTM A354 as applicable. The frequency for chemical analysis shall be one per heat. Results shall be documented on the test report.

5.7 Mechanical Properties

5.7.1 General

Mechanical properties testing shall be performed by the raw material supplier or bolting manufacturer after all thermal treatments including precipitation hardening as well as any strain hardening. All mechanical property tests required by the applicable API, NACE, ASTM standard, or manufacturer's specification shall be performed on each heat lot. Results shall be documented on the test report.

5.7.2 BSL-2

The results shall conform to the requirements of the relevant API, NACE, ASTM standard or manufacturer's specification for UNS R30035.

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5.7.3 BSL-3

The requirements for BSL-2 are required for BSL-3. When any of the testing has been performed by the raw material supplier, the bolting manufacturer shall perform a retest.

5.8 Metallurgical Requirements

The microstructure of nickel alloys shall conform to the requirements of the API 6ACRA.

5.9 Examination and Test Requirements

5.9.1 General

When inspecting or testing production lots, a sample that fails to meet the applicable requirements shall result in rejection of the entire lot. The rejected lot shall be scrapped, reworked, or, where practical, inspected 100% and the defective parts removed. In the case of rework or 100% inspection, the lot shall be re-inspected or tested for the failed characteristic and any characteristic affected by rework.

5.9.2 Hardness Test Requirements

5.9.2.1 General

Hardness testing, including specimen preparation, shall be performed in accordance with ASTM A370 including Annex A3 except that testing shall also be in conformance with ASTM E10 or E18. Results shall be documented on the test report.

5.9.2.2 BSL-2 and BSL-3

The hardness test results shall conform to the requirements of API 6ACRA, ASTM A453 or ISO 15156-3 / NACE MR0175-3 for UNS R30035. Each piece shall be tested.

5.10 Nondestructive Examination (NDE) Requirements

5.10.1 BSL-2

5.10.1.1 Surface NDE is required. Liquid penetrant examination is required for ASTM A453 Grade 660 Class D, the alloys covered by API 6ACRA, and UNS R30035. Liquid penetrant examination shall be in accordance with ASTM A962 S56. Acceptance criteria shall be per ASTM A962 S57. Number of pieces examined shall be as stated in Table 2. Results shall be documented on an examination report.

5.10.1.2 Volumetric NDE is required on bar, rod, wire and on bolting 2.5 inch (63.5 mm) or greater nominal diameter prior to threading and after any heading and heat treat operations, with the exception of aging performed after threading. Ultrasonic examination shall be performed in conformance to the methods and acceptance criteria of API 6A, volumetric NDE examination of stems (PSL-3). Each piece shall be examined. Results shall be documented on the test report.

5.10.2 BSL-3

5.10.2.1 Surface NDE is required. Liquid penetrant examination is required for ASTM A453 Grade 660 Class D, the alloys covered by API 6ACRA, and UNS R30035. Liquid penetrant examination shall be in accordance with ASTM A962 S56. Acceptance criteria shall be per ASTM A962 S57. Each piece shall be examined. Results shall be documented on an examination report.

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5.10.2.2 Volumetric NDE is required on bar, rod, wire and on bolting 1 in. (25.4 mm) or greater nominal diameter prior to threading and after any heading or heat treat operations, with the exception of aging performed after threading. Ultrasonic examination shall be performed in conformance to the methods and acceptance criteria of API 6A, volumetric NDE examination of stems (PSL-3). Each piece shall be examined. Results shall be documented on the test report.

5.11 Dimensional Inspection and Visual Inspection

5.11.1 General

All dimensions shall meet the requirements of ASTM A962. Visual inspection shall be performed in accordance with ASTM F788 and ASTM F812. Dimensions not specified by ASTM A962 shall be as specified by the purchaser. Results shall be documented on an inspection report. Oversizing of nut threads or under sizing of bolt threads is not permissible.

5.11.2 BSL-2 Sample Size

Sample size shall be in accordance with Table 2.

5.11.3 BSL-3 Sample Size

Each piece shall be dimensionally inspected.

Table 2—Sampling for Dimensional, Surface NDE and Visual Inspection

Lot Size	Sample
2 to 8	ALL
9 to 50	8
51 to 90	13
91 to 150	20
151 to 280	32
281 to 500	50
501 to 1200	80
Based on ANSI/ASQ Z1.4 Table 1	General Inspection Level II
NOTE 1 Acceptance number is zero.	
NOTE 2 Sample shall be random.	

5.12 Final Positive Material Identification

5.12.1 General

Pieces shall be examined using methods conforming to ASTM E1476 and ASTM A751 to confirm the material type.

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5.12.2 BSL-2 Sample Size

Sample size shall be in accordance with Table 2. If any of the samples fail, the entire lot shall be examined.

5.12.3 BSL-3 Sample Size

Each piece shall be examined.

6 Calibration Systems

Inspection, measuring and testing equipment used for acceptance shall be identified, inspected, calibrated and adjusted at specific intervals in accordance with ANSI/NCSL Z540.3 and this standard. Calibration standards shall be traceable to the applicable national or international standards agency and shall be no less stringent than the requirements included herein. Inspection, measuring, and testing equipment shall be used only within the calibrated range. Calibration intervals shall be established based on repeatability and degree of usage.

7 Test Report

The test report shall be supplied to the purchaser and shall include the following as applicable:

- copy of original mill certificate;
- cold reduced production run number (for UNS R30035 only);
- chemistry check analysis;
- hot work reduction ratio (not required for UNS R30035);
- heat treat procedure including times, temperatures and quench media, and diagram or photo of furnace loading (diagram or photo exception for mill heat treated bar – see 5.4.4.e);
- results of mechanical tests;
- results of macrostructure evaluations(not required for Grade 660D or UNS R30035) ;
- results of microstructure evaluations (not required for Grade 660D or UNS R30035);
- results of dimensional inspection;
- results of NDE inspections;
- BSL qualification level;
- certification that the product meets the requirements of this standard;
- results of Positive Material Identification;
- additional certification requirements stated in API 6ACRA and ASTM A453 and the manufacturer specification for UNS R30035;
- statement of no weld repair.

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8 Marking Requirements

8.1 Product Marking

8.1.1 Product marking for Grade 660 Class D shall be in accordance with ASTM A453 for Grade 660 Class D.

8.1.2 Product marking for API 6ACRA and UNS R30035 shall consist of the manufacturer's identification and the grade identification listed in Table 3.

Table 3 - API 6ACRA and UNS R30035 Grade Identification Markings

API 6ACRA or UNS and Material Designation	Marking	Alternative Marking
N07716 120K	71620	N1A
N07716 140K	71640	N1B
N07718 120K	71820	N2A
N07718 140K	71840	N2B
N07725 120K	72520	N3A
N09925 110K	92510	N4A
N09935 110K	93510	N5A
N09945 125K	94525	N6A
N09945 140K	94540	N6B
UNS R30035 work strengthen only	R35-1	N/A
UNS R30035 work strengthen and aged	R35	N/A

8.2 Additional Marking Required by this Standard

Bolting shall be marked with unique heat lot identification and the following:

- a) "API 20F2" for BSL-2,
- b) "API 20F3" for BSL-3.

Each piece 1 inch (25.4 mm) nominal diameter and larger shall be marked. For bolting less than 1 inch (25.4 mm) nominal diameter, the bolting shall be securely containerized to maintain heat lot identification and traceability. Multiple heat lots shall not be mixed in a single container. Containers used in the processing, storing and shipping of bolting not individually marked shall be clearly labeled with all marking information required by the ASTM specification, as applicable, and this standard.

9 Record Retention

The bolting manufacturer shall establish and maintain documented procedures to control all documents and data required by this standard. Records required by this standard shall be maintained for a minimum of 10 years from the date of manufacture. Documents and data may be in any type of media (hard copy or electronic) and shall be:

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- maintained to demonstrate conformance to specified requirements;
- legible;
- retained and readily retrievable;
- stored in an environment to prevent loss.

10 Storage and Shipping

Bolting shall be packaged for storage and shipping in accordance with the written specifications of the bolting manufacturer.

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Annex A
(informative)

API Monogram Program

BALLOT DRAFT

Annex B (Normative)

Avoidance of Contamination of Nickel Alloys

B.1 Introduction

Nickel alloys may become contaminated during various manufacturing operations. Contamination with some substances may result in embrittlement and cracking failures, while contamination with other substances may result in pitting and corrosion failures.

B.2 Lubricants

Sulfur can embrittle nickel alloys at elevated temperatures, such as those used for heat treating or forging the nickel alloys. Sulfur containing lubricants may be used during manufacturing, but shall be completely removed prior to any hot forging or heat treatment operations.

Chlorine can promote pitting corrosion of nickel alloys after long exposure. Chlorine containing lubricants may be used for cold forming but shall be completely removed after the forming operations.

Pigmented oils and greases should be selected with care. Oils and greases with lead carbonate, zinc oxide, or other low melting point metals shall not be used. These low melting point metallic compounds can embrittle nickel alloys during exposure to elevated temperatures, such as those used for heat treating or forging nickel alloys.

B.3 Marking Materials

Markers containing sulfur, chlorine, phosphorus, and low melting point metals can cause embrittlement or corrosion issues as described above and shall not be used.

Bibliography

- [1] ASTM A193-15 *Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications*, 2015

BALLOT DRAFT