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

API SPECIFICATION 20F
FIRST EDITION, XXX 201X
1. Scope

1.1 Purpose

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

Annex A contains supplemental requirements for the use of the API Monogram by licensees.

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 API Specification establishes requirements for two bolting specification levels (BSL). These two BSL designations define different levels of technical, quality and qualification requirements. The levels are designated as BSL-2 and BSL-3. BSL-2 includes requirements in addition to those stated in the ASTM A453 and API 6A718. BSL-3 adds technical, quality and qualification criteria to BSL-2. BSL-2 and BSL-3 are intended to be comparable to BSL-2 and BSL-3 as found in specification API 20E. BSL-1 is omitted from this standard.

1.4 Bolting Types

This specification covers the following product forms, processes and sizes

a. Machined Studs
b. Machined bolts, screws and nuts
c. Cold headed bolts, screws and nuts
d. Hot formed bolts and screws < 1.5in.(38.1mm) nominal diameter
e. Hot formed bolts and screws ≥ 1.5 in.(38.1mm) nominal diameter
f. Roll threaded studs, bolts, and screws < 1.5 in.(38.1mm) diameter
g. Roll threaded studs, bolts, and screws ≥ 1.5in.(38.1) diameter
h. Hot formed nuts < 1.5 in.(38.1mm) nominal diameter
i. Hot formed nuts ≥ 1.5in.(38.1) nominal diameter

2. References

The following documents contain provisions which, through reference in this text, constitute provisions of this specification. For dated references, only the edition cited applies. For undated references, the latest edition of the reference document (including amendments) applies.

ASTM A370, Standard Test Method and Definitions for Mechanical Testing of Steel Products
ASTM A453, Standard Specification High Temperature Bolting with Expansion Coefficients Comparable to Stainless Steels
ASTM A751, Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products
ASTM A962-14, Standard Specification for Common Requirements for Steel Fasteners or Fastener Materials, or Both, 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 Method for Rockwell Hardness of Metallic Materials
ASTM E1476 Standard Guide for Metals Identification, Grade Verification, and Sorting
3. Terms, Definitions, Acronyms and Abbreviations

3.1 Terms and Definitions:

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

3.1.2 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.

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

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

3.1.5 heat lot
a) Batch furnace: bolting or raw material of a single heat and diameter, heat treated together as a single solution annealing, quenching, precipitation hardening and stress relieving charge.
   b) Continuous furnace: bolting or raw material of a single heat and diameter heat treated without interruption in a continuous charge with testing as defined for bolts in ASTM A193.

3.1.6 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.

3.1.7 machined bolts, screws and nuts
Parts manufactured by machining from raw material to generate the bolt, screw head or the configuration of the nut.

3.1.8 manufacturing procedure specification
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 for review by customers or authorized third parties.
raw material
Bar, coil, rod or wire used to manufacture bolting.

3.1.10 raw material supplier
The manufacturer of raw material used to produce qualified bolting defined as the mill or forging supplier.
NOTE: A distributor is not considered a raw material supplier.

3.1.12 wrought structure
Structure that contains no cast dendritic elements.

3.2 Acronyms and Abbreviations
3.2.1 BSL
Bolting Specification Level
3.2.2 CRB
Corrosion Resistant Bolting
3.2.3 MPS
Manufacturing Procedure Specification

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 BSLs. 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.

4.2 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 Procedure Specification (MPS) from a bolting grade listed in 4.6.

4.3 Qualification bolting shall be tested and evaluated by the bolting manufacturer in order to establish qualification to the bolting types listed in 1.4. Qualification bolting shall meet all of the requirements indicated in Table 1 for the applicable paragraphs of this specification.

4.3.1 All required tests, including those certified by the steel producer, shall be performed by a laboratory qualified in accordance with an internationally recognized international standard for the qualification of test laboratories, such as ISO 17025.

4.3.2 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.

4.4 The manufacturer shall retain and have available a MPS and qualification records 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. The following manufacturing process steps shall be documented as a part of the qualification:
- Forming
- Heat treatment
- Machining
- Roll threading
4.5 Materials and Dimensions

4.5.1 The following bolting material categories are covered by this specification:

4.5.1.1 Precipitation Hardened Nickel Based Alloys in accordance with API 6A718
4.5.1.2 Precipitation Hardened Austenitic Iron Based A453 Grade 660 Class D

4.5.2 All requirements of API 6A718 or ASTM A453 Grade 660 Class D shall be met except as modified by this specification. In the case of conflict between the requirements of referenced specifications and this specification, the requirements of this specification shall apply.

4.6 Acceptance of qualification bolting

4.6.1 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.

4.6.2 Qualification Samples

4.6.2.1 Samples failing to meet acceptance criteria shall be cause for revaluation of the processes and procedures used and requalification is required.

4.6.2.2 When a qualification sample is selected from a production lot, as defined in 4.4.2 fails to meet acceptance criteria, the entire lot shall be rejected.

4.6.2.3 Should the manufacturer chose to continue the qualification process with the same lot, the entire lot shall be 100% inspected and sorted or reprocessed to correct the deficiencies.

4.6.2.4 For reprocessed lots, the qualification tests that failed and any qualification tests that could be affected by reprocessing shall be repeated. Should the second sample fail to meet the acceptance criteria, the entire lot shall be scrapped.

4.7 Records of qualification
The following records are required to document the qualification of bolting.

a. API 6A718 or ASTM A453 Grade 660 Class D
b. heat number;
c. raw material manufacturer;
d. raw material refining method;
e. size;
f. process control variables;
g. manufacturing procedure specification;
h. forming, as applicable;
i. heat treatment;

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<table>
<thead>
<tr>
<th>BSL</th>
<th>Material</th>
<th>Heat Treatment</th>
<th>Chemistry</th>
<th>Mechanical</th>
<th>Metallurgical</th>
<th>Hardness</th>
<th>NDE Surface</th>
<th>NDE Volumetric</th>
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<tr>
<td>BSL-2</td>
<td>5.5.1</td>
<td>5.4.1</td>
<td>5.6</td>
<td>5.7.1</td>
<td>5.8.1</td>
<td>5.9.1.1</td>
<td>5.10.1</td>
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</tr>
<tr>
<td>BSL-3</td>
<td>5.5.2</td>
<td>5.4.2</td>
<td>5.6</td>
<td>5.7.2</td>
<td>5.8.2</td>
<td>5.9.1.2</td>
<td>5.10.2</td>
<td>5.10.2.2</td>
</tr>
</tbody>
</table>

Table 1
Bolting Test Requirements
j. machining, as applicable;
k. thread rolling, as applicable;
l. record of test results, as applicable, in Sections 4 and 5;
m. inspection;
n. personnel qualifications;
f. test laboratory qualification; and
g. records of qualification test failures and corrective action.

4.8 Limits of bolting qualification

4.8.1 BSL-2
4.8.1.1 A change of heat treat method (type of equipment, furnace control method, cooling methods) requires requalification.

4.8.2 BSL-3
Limits of bolting qualification for BSL-2 are required for BSL-3. Additionally, the following requires requalification:
4.8.2.1 Change of raw material supplier.
4.8.2.2 Change of machining or threading methods – type of equipment, control.
4.8.2.3 Change of hot forming practice – type of equipment, heating method, temperature control method.

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 procedure, fully implemented, 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 program 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 specification 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 PSLs are the following:
5.1.2.1 BSL-2
Use of one or more of the following four methods
− material receipt inspection that includes NDE, chemistry check, microstructure, etc. on a routine basis;
− material first article evaluation;
− supplier experience over an extended period of time. Demonstration of acceptable experience shall include tests/inspections, quantity of material received, nonconformance analysis etc.;
− physical technical audits at scheduled 3 year intervals.

5.1.2.2 BSL-3
All of the four methods listed in 5.1.2.1 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, etc. as applicable);

g) no welding.

5.2 Material Specifications

5.2.1 The bolting manufacturer shall 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 or ASTM Standard:

− material grade, including element chemistry and allowable ranges;
− acceptable melt practices and ladle refinement;
− acceptable hot work reduction;
− acceptable microstructure; (API 6A718 only)
− heat treatment requirements including mill heat treatments;
− acceptable inspection practices and criteria.

5.2.2 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.

5.3 Manufacturing Procedure Specification

The bolting manufacturer shall prepare a Manufacturing Procedure Specification (MPS) to include, as minimum allowable levels for all bolting manufacturing parameters including the process control variables listed in 5.3.1 and the heat treatment parameters listed in 5.3.2.

5.3.1 General Variables

a) heading equipment

b) hot forming heating method

c) hot forming temperature control method

d) machining and threading equipment: single point (lathe), multiple chaser, roll, tap

e) machining and threading control methods

5.3.2 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)

d) control and calibration methods

e) furnace loading (fixturing, separation of pieces)

5.4 Heat Treatment Requirements

5.4.1 BSL-2

5.4.1.1 Heat Treatment shall be in accordance with the relevant API or ASTM standard.

5.4.1.2 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. Unified National Threads shall be "R" (UNR controlled radius root) series.

5.4.1.3 Furnace calibration shall be in accordance with API 6A, Annex M, SAE AMS 2750 or SAE-AMS-H-6875.
5.4.2. BSL-3

5.4.2.1 Requirements specified for BSL-2 are required for BSL-3.

5.5. Raw Material

5.5.1 BSL-2

5.5.1.1 The metal shall be fully wrought.

5.5.1.2 The reduction ratio based on starting material diameter shall be a minimum of 4.0:1.0.

5.5.1.3 The metal shall conform to the requirements of the relevant API or ASTM Standard.

5.5.1.5 All elements intentionally added to the heat 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 or API 6A718.

5.6 Chemical Analysis

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

5.7 Mechanical Properties

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. Results shall be documented on the test report.

5.7.1 BSL-2

5.7.1.1 The results shall conform to the requirements of the relevant API or ASTM standard.

5.7.2 BSL-3

5.7.2.1 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 following tests shall be performed by the raw material supplier or bolting manufacturer after all thermal treatments including precipitation hardening as well as any strain hardening. Results shall be documented on the test report.

5.8.1 BSL-2

5.8.1.1 The microstructure shall conform to the requirements of the API 6A718.

5.8.2 BSL-3

5.8.2.1 When microstructure examination has been performed by the raw material supplier, the bolting manufacturer shall perform a re-examination.

5.9 Examination and Test Requirements

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 or reworked. In the case of rework, the entire lot shall be re-inspected or tested for the failed characteristic and any characteristic affected by rework.
5.9.1 Hardness Test Requirements

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. Test frequency shall conform to ASTM F1470 Table 3, Sample size A. Results shall be documented on the test report.

5.9.1.1 BSL-2

The hardness test shall conform to the requirements of the API 6A718 or ASTM A453.

5.9.1.2 BSL-3

5.9.1.2.1 The hardness testing requirements specified for BSL-2 are required for BSL-3.

5.9.1.2.3 Each piece shall be inspected.

5.10 Nondestructive Examination Requirements

5.10.1 BSL-2

No requirements except as required by the referenced API or ASTM specification.

5.10.2 BSL-3

5.10.2.1 Surface NDE is required. Liquid penetrant examination is required for ASTM A453 Grade 660, and API 6A718. Liquid penetrant examination shall be in accordance with ASTM A962 S56. Acceptance criteria shall be per ASTM A962 S57 100% of the pieces shall be examined. Results shall be documented on an examination report.

5.10.2.2 Volumetric NDE is required on bar, rod, wire or on bolting 1” or greater nominal diameter prior to threading and after any heading operation. Ultrasonic examination shall be performed in accordance with API Specification 6A, volumetric NDE examination of stems (PSL-3 and PSL-4). Each piece shall be examined. Results shall be documented on the test report.

5.11 Dimensional Inspection and Visual Inspection

All dimensions shall meet the requirements of the applicable ASTM specification. Dimensions not specified by the relevant specification shall be specified by the purchaser. Results shall be documented on an inspection report. Oversizing of nut threads of nut threads or undersizing of bolt threads is not permissible.

5.11.1 BSL-2 Sample Size

Sample size shall be in accordance with Table 2

5.11.2 BSL-3 Sample Size

Each piece shall be dimensionally inspected.

<table>
<thead>
<tr>
<th>Lot Size</th>
<th>Sample Size</th>
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<tr>
<td>2-8</td>
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<tr>
<td>151-280</td>
<td>32</td>
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<tr>
<td>281-500</td>
<td>50</td>
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</tbody>
</table>
5.12 Final PMI Examination

Pieces shall be tested using methods conforming to ASTM E1476 to confirm the material type.

5.12.1 BSL-2 Sample Size

10% of the pieces shall be tested.

5.12.2 BSL-3 Sample Size

100% of the pieces shall be inspected.

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 specification. 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 include the following as applicable:

- mill chemistry;
- hot work reduction ratio;
- heat treat procedure including times, temperatures and quench media;
- results of mechanical tests;
- results of microstructure evaluations;
- results of dimensional inspection;
- results of NDE inspections;
- qualification level;
- certification that the product meets the requirements of this specification.

8. Marking Requirements

8.1 Product Marking

Product marking for Grade 660D shall be in accordance with ASTM A453 for Grade 660D. Product marking for API 6A718 shall consist of the manufacturer’s identification and “6A718” as the grade identification.

8.2 Additional Marking Required by this Standard

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

a) “API 20F-2” for BSL-2
b) “API 20F-3” for BSL-3

Each piece 1 in. nominal diameter and larger shall be marked. For bolting less than 1 in. 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 and this standard.

9. Record Retention

The bolting manufacturer shall establish and maintain documented procedures to control all documents and data required by this specification. Records required by this specification shall be maintained for 10 years. Documents and data may be in any type of media (hard copy or electronic) and shall be:
- maintained to demonstrate conformance to specified requirements
- legible
- retained and readily retrievable
- stored in an environment to prevent loss
- available and auditable by user/purchaser

10. Storage and Shipping

Bolting shall be packaged for storage and shipping in accordance with the written specifications of the bolting manufacturer.
Annex A
(informative)

API Monogram Program

Will be added prior to publishing.
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ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories