

# **SPECIFICATION FOR LOW ALLOY STEEL BOLTING FOR PRESSURE CONTAINING UPSTREAM DRILLING AND COMPLETION EQUIPMENT**

**TECHNICAL REPORT TR 1001**

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# AWHEM SPECIFICATION

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## Specification for Low Alloy Steel Bolting for Pressure Containing Upstream Drilling and Completion Equipment

### 1. Scope

This specification provides requirements for alloy steel bolting intended for pressure containing upstream drilling and completion equipment. Grades covered are ASTM B7 and B7M, ASTM A194 Grades 2H, 4, 7, 2HM, and 7M, ASTM A320 Grades L7, L7M, and L43, and ASTM A540 Grades B22 and B23.

Annexes for supplemental requirements that may be invoked by the purchaser are included.

All requirements of the referenced ASTM specifications 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.

### 2. Referenced Documents - For undated referenced documents the current edition applies

**ASTM A193** – Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.

**ASTM A194** – Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure on High Temperature Service, or Both

**ASTM A320** – Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for Low Temperature Service

**ASTM A370** – Standard Test Method and Definitions for Mechanical Testing of Steel Products.

**ASTM A540** – Standard Specification for Alloy Steel Bolting for Special Applications

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

**ASTM A962** - 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 E45** - Standard Test Method for Determining the Inclusion Content of Steel

**ASTM E92** - Standard Test Method for Vickers Hardness of Metallic Materials

**ASTM E110** - Standard Test Method Indentation Hardness of Metallic Materials by Portable Hardness Testers

**ASTM E112** - Standard Test Method for Determining Average Grain Size

**ASTM E140** –Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, and Scleroscope Hardness

**ASTM E381** - Standard Method of Macroetch Testing Steel Bars, Billets, Blooms, and Forgings

**ASTM E384** – Knoop and Vickers Microindentation of Materials

**ASTM A941**- Standard Terminology Relating to Steel, Stainless Steel, Related Alloys and Ferroalloys

**ASTM E1268** – Standard Practice for Assessing Degree of Banding or Orientation of Microstructure

**ASTM F1470** – Fastener Sampling for Specified Mechanical Properties and Performance Inspection

**API 6A** - Specification for Wellhead and Christmas Tree Equipment

**ANSI Z1.4** – Sampling Procedures and Tables for Inspection by Attributes

**ASNT-TC-1A** – Recommended Practice for Personal Qualification and Certification in Nondestructive Testing

**SAE AMS 2750** – Pyrometry

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

### **3. Terminology**

#### **Definitions:**

#### **Bolting:**

All thread studs, tap end studs, headed bolts, screws, and nuts

#### **Heat:**

A single, final melt of steel

#### **Heat lot:**

Bolting of a single heat and diameter processed together as a single austenitizing, quenching and tempering charge. For material processed in continuous furnaces, a heat lot shall consist of a maximum weight as specified for bolts in A193.

### **Forged bolts, screws, and nuts:**

Parts formed through the mechanical hot or cold upsetting of wire or bar in order to generate the bolt or screw head or the configuration of the nut.

### **4. Materials and Manufacture:**

4.1 Melting method shall be fine grain practice as defined by ASTM A941. Steel shall be produced by electric furnace or vacuum induction melting followed by secondary practices or ladle refining.

4.2 Bars shall be fully wrought. The reduction ratio based on starting material diameter shall be 8:1 minimum.

4.3 Heat Treatment shall be per ASTM A193, A194, A320, or A540 except for the following: Grades L43 and B23 shall be double tempered. Furnace calibration shall be in accordance with documented procedures such as API 6A Annex P, SAE AMS 2750, or SAE AMS –H-6875.

4.4 Manufacturing processes shall be performed so as to avoid the introduction of stress risers such as can occur from sharp angles and tool marks. Threads may be cut or rolled. When threads are rolled, parts shall subsequently be stress relieved at temperature not less than 100°F below the final tempering temperature.

4.5 Coating and Plating: Plating and coating shall be provided only when the supplementary requirement in A.1 (SR1) is specified on the purchase agreement.

## 5. Chemical Composition

5.1 The steel shall conform to the requirements of ASTM A193, A194, A320, or A540 and A962 as applicable except that the allowable sulfur content shall be .025% maximum and phosphorus content shall be .025% maximum. Intentional additions of boron are not allowed.

5.2 Methods of Analysis: Methods and practices relating to chemical analysis shall be in accordance with ASTM A751. In addition to the heat analysis performed by the mill, the bolting manufacturer shall perform a product analysis.

5.3 Frequency: One per heat.

5.4 Documentation: Results shall be documented on the test report.

**6. Mechanical Properties** Testing for mechanical properties shall be performed by the bolting manufacturer after all thermal treatments including stress relief. When any of the testing has been performed by the mill, the bolting manufacturer shall perform a retest.

**7. Metallurgical Requirements** Any of the following tests not performed by the mill shall be performed by the bolting manufacturer.

Microstructure Testing: Microstructure specimens shall be prepared in accordance with E45 for inclusion content. For other microstructure evaluations, the specimens shall be taken in the longitudinal direction at 1/4T. The microstructure shall be:

7.1 Inclusion Content: E45 Method A, 2 for thin, 1.5 for thick, all categories.

7.1.1 Frequency: One per heat

7.1.2 Documentation: Results shall be documented on the test report.

7.2 Grain Size: E112, size 5 or finer.

7.2.1 Frequency: One per each heat lot.

7.2.2 Documentation: Results shall be documented on the test report.

7.3 Predominately tempered martensite.

7.3.1 Frequency: One per each heat lot.

7.3.2 Documentation: Results shall be documented on the test report.

7.4 Banding: E1268, heavily banded microstructures such as shown in E1268 Fig. A1.20 are not permitted. When a questionable banded structure is observed, a minimum of 5 microhardness readings shall be taken wholly within the most severe bands. The test load shall be 500g unless extremely thin bands are observed in which case it is permissible to reduce the test load to as low as 50g to obtain an accurate reading. Individual readings shall not exceed 450 Hv.

7.4.1 Frequency: One per each heat lot.

7.4.2 Documentation: Results shall be documented on the test report and when microhardness is taken shall include the hardness readings and a photomicrograph demonstrating the indentation locations.

#### Macrostructure Testing

Macrostructure specimens shall be prepared in accordance with ASTM E381. Macrostructure results shall be:

7.5 ASTM A962 except acceptance shall be S1, R1, C2.

7.5.1 Frequency: One per heat.

7.5.2 Documentation: Results shall be documented on the test report.

## **8. Nondestructive Examination Requirements**

8.1 Hardness Requirements – The hardness shall conform to the requirements of ASTM A193, A194, A320, or A540 as applicable except that maximum hardness for Grades B7, L7, 2H, 4, 7, L43, B22 and B23 shall be 34 HRC (321HBW). For bar heated by induction or electric resistance methods, a cross section of the bar shall be taken at the same test frequency as the required lot testing of the heat treated bar per ASTM A193. The cross section shall be ground and Rockwell hardness tested in accordance with ASTM E18. The cross section shall have the OD (as close to the edge as permitted by ASTM E18), mid radius, and center tested. All hardness measurements must meet the specification and be within 3 HRC of each other. All values shall be reported on the test report.

8.1.1 Method: Hardness testing, including specimen preparation, shall be performed in accordance with ASTM A370 including Annex A3 except that testing must also be in conformance with ASTM E10 or ASTM E18 unless otherwise stated on the purchasing documents. Electromagnetic sorting in accordance with ASTM A193 is permitted. Alternative hardness inspection methods shall be provided only when specified on the purchase agreement and the allowable inspection method is specified.

8.1.2 Frequency: Per ASTM F1470 Table 3, Sample size A except when 100% hardness testing is required by the ASTM specification for the grade. Parts intended for use on subsea applications shall also be 100% hardness tested.

8.1.3 Results shall be documented on the test report.

8.2 Magnetic Particle Inspection for forged bolts, screws and nuts: Magnetic particle inspection shall be in accordance with ASTM A962 S55 except that acceptance criteria shall be per API 6A PSL3. See also Annex A.2.

8.2.1 Frequency: Each piece shall be inspected.

8.3 Documentation: Results shall be documented on the test report.

8.4 Dimensional inspection: The manufacturer shall have an appropriate inspection plan to verify dimensional requirements.

8.4.1 Documentation: Results shall be documented on the test report.

## **9. Certification**

9.1 All required tests not performed by the steel producer shall be performed by the bolting manufacturer.

9.2 The certification shall report the following:

- mill chemistry,
- heat treat procedure,
- results of mechanical tests,
- results of macrostructure evaluations,
- results of microstructure evaluations,
- results of dimensional inspection,
- results of NDE inspection.
- verification of dimensional requirements



## 10. Product Identification

Product marking shall be in accordance with ASTM A193, A194, A320, or A540 and A962 as applicable. In addition each piece shall have the suffix “- SB” added to the grade symbol and shall be marked with a unique heat lot identification. Example: B7 – SB XXX.

### Annex A

This annex describes supplementary requirements that may be specified by the purchaser or agreed upon between the purchaser and manufacturer. These requirements apply only when stated on the purchase agreement.

A.1 SR1 – Plating and coating shall be applied only when specifically stated in the purchasing documents. Any dimensional deviation from the requirements stated and referenced in ASTM A193, A194, A320, or A540 and A962 as applicable, such as tapping threads oversize or undersize must be explicitly stated as a part of the purchasing documents. Instructions for plating or coating shall consider the effect of build-up on threads. Low temperature bake shall be specified as required for prevention of embrittlement.

A.2 SR2 - Magnetic particle inspection for bolting with fatigue applications: Magnetic particle inspection shall be performed in accordance with ASTM A962 S55 except that acceptance criteria shall be per API 6A PSL3.

10.1.1 Frequency: Each piece shall be inspected.