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Standard Specification for Load-Indicating Externally Threaded Fasteners¹

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1. Scope

1.1 This specification covers externally threaded bolts, studs, and cap screws as defined in **Table 1**, herein called fasteners, capable of indicating clamping forces up to yield strength during the tightening process or post installation residual tension, or both. Load-indicating fasteners utilize mechanical, electronic, or ultrasonic means to indicate fastener tension.

1.2 This specification covers bolt diameters $\frac{1}{4}$ to 7 in. inclusive.

1.3 These fasteners provide a means to verify the desired clamp load in critical applications upon installation and in service.

1.4 The following precautionary statement pertains only to the test method portion, Section 11, of the specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

- A 193/A 193M Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
- A 325 Specification for Structural Bolts, Steel, Heated, 120/105 ksi Minimum Tensile Strength
- A 354 Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners
- A 449 Specification for Quenched and Tempered Steel Bolts and Studs
- A 490 Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength

¹ This specification is under the jurisdiction of ASTM Committee F16 on Fasteners and is the direct responsibility of Subcommittee F16.02 on Steel Bolts, Nuts, Rivets, and Washers.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- E 4 Practices for Force Verification of Testing Machines
- E 1685 Practice for Measuring the Change in Length of Fasteners Using the Ultrasonic Pulse-Echo Technique
- F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
- F 1789 Terminology for F16 Mechanical Fasteners

3. Terminology

3.1 Terms used in this specification are defined in Terminology **F 1789**, unless otherwise specified herein.

3.2 *Definitions:*

3.2.1 *calibration of accuracy lot*—lot shall consist of all load-indicating fasteners processed essentially together through all operations to the shipping container that are of the same nominal size, the same nominal length, and manufactured/calibrated from the same mill heat of steel. This lot is used for the purpose of assigning an identification number and from which calibrated samples shall be selected.

3.2.2 *load-indicating fastener*—externally threaded fastener equipped with a load indicating device capable of measuring fastener tension during the tightening process or residual tension after tightening, or both.

4. Classification

4.1 This specification covers the following four different types of load-indicating fasteners:

4.1.1 *Mechanical Dial Type (MT)*—This type of fastener incorporates a dial on the head of the bolt or end of the stud that continuously displays the tension in the fastener.

4.1.2 *Electronic Type (ET)*—This type of fastener employs an electronic measuring device attached to the head or end to obtain readings indicating the tension in the fastener.

4.1.3 *Strain Gauge Type (ST)*—This type of fastener incorporates a bonded device wired in a wheatstone bridge configuration which, through changes in relative resistance, reports tension in the fastener.

4.1.4 *Ultrasonic Type (UT)*—This type of fastener incorporates an acoustic coupling device using pulse-echo technique capable of converting time-of-flight (TOF) measurements into existing fastener tension.

4.2 Various grades are listed in **Table 1**.

TABLE 1 Grades and Classification

Load-Indicating Fastener Grade/Head Marking	Bolt Diameter, in.	Min. Tensile Strength Classification	Mechanical/Chemical/Testing Requirements In Accordance With:
325-1	½ to 1, incl.	120 000 psi	Specification A 325 Type 1
325-3	1⅞ to 1½, incl.	105 000 psi	Specification A 325 Type 3
	½ to 1, incl.	120 000 psi	
490-1	1⅞ to 1½, incl.	105 000 psi	Specification A 490 Type 1
	½ to 1½ in., incl.	150 000 psi	
490-3	½ to 1½ in., incl.	150 000 psi	Specification A 490 Type 3
449	¼ to 1, incl.	120 000 psi	Specification A 449 Type 1
	1⅞ to 1½, incl.	105 000 psi	
354-BC	1¾ to 3, incl.	90 000 psi	Specification A 354 Grade BC
	¼ to 2 ½, incl.	125 000 psi	
354-BD	2½ to 7, incl.	115 000 psi	Specification A 354 Grade BD
	¼ to 2½, incl.	150 000 psi	
193B7	2½ to 7, incl.	140 000 psi	Specification A 193/A 193M B7
	¼ to 2½, incl.	125 000 psi	
193B7M	2½ to 4, incl.	115 000 psi	Specification A 193/A 193M B7M
	4 to 7, incl.	100 000 psi	
193B5	¼ to 4, incl.	100 000 psi	Specification A 193/A 193M B5
	4 to 7, incl.	100 000 psi	
193B6	¼ to 4, incl.	100 000 psi	Specification A 193/A 193M B6
	¼ to 2½, incl.	110 000 psi	
193B16	¼ to 2½, incl.	125 000 psi	Specification A 193/A 193M B16
	2½ to 4, incl.	110 000 psi	
	4 to 7, incl.	100 000 psi	

5. Ordering Information

5.1 Orders for load indicating fasteners shall include the following:

- 5.1.1 Quantity;
- 5.1.2 Size, including nominal diameter, thread pitch and length;
- 5.1.3 Head style of fastener component;
- 5.1.4 ASTM designation, grade, and type, as applicable for fastener component (see 4.1 and Table 1);
- 5.1.5 Coating or finish, if required;
- 5.1.6 Test report or certificate of compliance, if required;
- 5.1.7 Special requirements, if required.

NOTE 1—A typical ordering information follows: 1000 pieces, 1-8 × 8 Heavy Hex Structural Bolt ASTM XXXX Grade. 325-1, Mechanical Dial, Electrodeposited Zinc Coating ASTM F 1941 Coating FeZn, Thickness 5. Include Test Report required.

6. Materials and Manufacture

6.1 All load-indicating fasteners shall be manufactured or processed to ensure no degradation of the mechanical properties of the fastener component from which the load-indicating fastener is derived (see Section 7).

6.1.1 Type MT load-indicating fasteners shall incorporate a calibrated dial capable of displaying fastener tension readings up to the yield strength of the fastener.

6.1.2 Type ET load-indicating fasteners shall incorporate a measuring device capable of displaying load indications up to the yield strength on a digital readout.

6.1.3 Type ST load-indicating fasteners shall incorporate permanently bonded electronic-resistance devices configured in a Wheatstone Bridge configuration. The fastener shall then be capable of being connected to an electronic unit to measure installed tension between 0 and 100 % of the proof-load of the fastener.

6.1.4 Type UT load-indicating fasteners shall incorporate an acoustic coupling device to the end of the fastener, using a pulse-echo technique capable of converting time-of-flight (TOF) measurements into existing fastener tension (see Practice E 1685).

7. Chemical and Mechanical Properties

7.1 The chemical and mechanical properties shall be dictated by the associated ASTM specification to which the load-indicating features are being added. See Table 1.

8. Performance Requirements

8.1 *Calibration of Accuracy*—The load-indicating fastener shall be calibrated to ±5 % accuracy up to the proof load of the fastener unless otherwise specified at the time of order.

8.2 *Field Tests*—The purchaser shall have the option of performing field tests to verify calibration accuracy. When exercised, the load-indicating fasteners and all lots shall demonstrate an accuracy of ±5 % when tested in accordance with Appendix X1.

9. Dimensions

9.1 All dimension requirements with the exception of head-height on bolts and cap screws shall be in conformance with the requirements of the applicable dimensional specification of the fasteners. Head height may be increased by 1.0 in. max. to incorporate load-indicating features as specified by the manufacturer.

10. Number of Tests and Retests

10.1 Number of Tests:

10.1.1 The minimum number of pieces for calibration of accuracy tests from each calibration lot shall conform with Table 2.