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Standard Specification for Load-Indicating Externally Threaded Fasteners[1]

This standard is issued under the fixed designation F2482; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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 ¼ 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 values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 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]

A193/A193M Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

A325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

A354 Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners

A449 Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use

A490 Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength

E4 Practices for Force Verification of Testing Machines

E1685 Practice for Measuring the Change in Length of Fasteners Using the Ultrasonic Pulse-Echo Technique

F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

F1789 Terminology for F16 Mechanical Fasteners

3. Terminology

3.1 Terms used in this specification are defined in Terminology F1789, 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.

[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.

***A Summary of Changes section appears at the end of this standard**

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 A325 Type 1
	1⅛ to 1½, incl.	105 000 psi	
325-3	½ to 1, incl.	120 000 psi	Specification A325 Type 3
	1⅛ to 1½, incl.	105 000 psi	
490-1	½ to 1½ in., incl.	150 000 psi	Specification A490 Type 1
490-3	½ to 1½ in., incl.	150 000 psi	Specification A490 Type 3
449	¼ to 1, incl.	120 000 psi	Specification A449 Type 1
	1⅛ to 1½, incl.	105 000 psi	
	1¾ to 3, incl.	90 000 psi	
354-BC	¼ to 2 ½, incl.	125 000 psi	Specification A354 Grade BC
	2½ to 7, incl.	115 000 psi	
354-BD	¼ to 2½, incl.	150 000 psi	Specification A354 Grade BD
	2½ to 7, incl.	140 000 psi	
193B7	¼ to 2½ , incl.	125 000 psi	Specification A193/A193M B7
	2½ to 4, incl.	115 000 psi	
	4 to 7, incl.	100 000 psi	
193B7M	¼ to 4, incl.	100 000 psi	Specification A193/A193M B7M
	4 to 7, incl.	100 000 psi	
193B5	¼ to 4, incl.	100 000 psi	Specification A193/A193M B5
193B6	¼ to 4, incl.	110 000 psi	Specification A193/A193M B6
193B16	¼ to 2½, incl.	125 000 psi	Specification A193/A193M B16
	2½ to 4, incl.	110 000 psi	
	4 to 7, incl.	100 000 psi	

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.

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; and

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 F1941 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 E1685).

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.

10.1.2 When calibrating in accordance with the required sampling plan, a lot shall be rejected if any of the test specimens fail to meet the calibration requirements.

11. Test Methods

11.1 For mechanical and chemical requirements, refer to parent specification in Table 1.

11.2 *Test Device:*

11.2.1 The tension measuring device shall be capable of measuring the assembly tension during calibration of the load indicating fasteners.

11.2.2 The testing apparatus shall conform to the requirements of Practices E4. The loads used in determining tension loads shall be within the verified loading range of the testing machine in accordance with Practices E4.

11.2.3 The tension measuring device shall be calibrated in 25 % increments, as a minimum, up to the maximum load capacity of the device.

11.2.4 Calibrate the tension measuring device (and any other equipment) based on the frequency of use and the equipment manufactures recommendation, but not less than one time per year.

11.3 *Accuracy Calibration of Load-Indicating Fasteners:*

11.3.1 Install the load indicating fastener, nut, washer, and appropriate spacer washer(s) in the tension measuring device. The device shall not restrain the top of the measuring device on the load indicating fastener.

11.3.2 The bolts shall be tightened to ≤2 % of the test sample proof load.

11.3.3 Apply tension force at 25 % increments up to the proof load requirement of the parent specification. The load-indicating fastener must exhibit accuracy to ±5 % of the test device in Section 11.2.

11.3.4 Tension values shall be recorded from the load-indicating fastener for certification purposes.

11.4 *In-Field Testing*— Field tests, when required to verify manufacturer's certification, shall be conducted in accordance with Appendix X1.

12. Inspection

12.1 When required by the purchaser, the inspection described in 12.2 shall be specified in the inquiry and contract or order.

TABLE 2 Calibration Table

Test	Number of Pieces in Calibration Lot	Number of Tests	Acceptance Number
Calibration of Accuracy	100 and less	10	0
	101 to 500	25	0
	501 to 1000	50	0
	1001 and greater	100	0