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Standard Specification for Load-Indicating Externally Threaded Fasteners¹

This standard is issued under the fixed designation ~~F2482~~;F2482/F2482M; 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 screws, 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~~ a variety of sensor types to indicate fastener tension. This specification outlines the various types of load indication technologies available and defines their performance requirements.

1.2 This specification covers ~~bolt~~fastener diameters $\frac{1}{4}$ to 7 in. ~~inclusive.~~[M6 to M180] inclusive. Fasteners are manufactured from a variety of material types and grades. All fastener materials shall be defined by a governing engineering standard or specification for strength and performance values (see 6.1). Fasteners governed by this specification shall maintain traceability of material test records throughout the manufacturing process to verify conformance with the applicable fastener standards.

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 either SI units or inch-pound units are to be regarded as standard. No other units of measurement are included in this standard. separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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~~safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

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~~

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

- ~~A325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength (Withdrawn 2016)³~~
- ~~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 (Withdrawn 2016)³~~
- E4 Practices for Force Calibration and Verification of Testing Machines
- E1685 Practice for Measuring the Change in Length of Bolts Using the Ultrasonic Pulse-Echo Technique
- F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
- F1789 Terminology for F16 Mechanical Fasteners

2.2 ASME Standard:³

B18.2.1 Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)

2.3 ISO Standard:⁴

ISO 898-1 Mechanical Properties of fasteners made of carbon or alloy steel Part -1

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.

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.

4.1.5 *Optical Type (OT)*—This type of fastener incorporates an optical indicator in the head of the bolt that can indicate tension visually and/or by fiber optic sensor measurement.

4.1.6 *Electronic Wireless (EW)*—This type of fastener employs an electronic measuring device attached to the head or end that can indicate and transmit fastener tension wirelessly.

4.2 Various grades are listed in Table 1.

³ The last approved version of this historical standard is referenced on www.astm.org. Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁴ Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

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 F2482/F2482M designation, Type XX (Section 4), full-scale load value (6.2), and load tolerance (8.2);

5.1.5 ASTM designation, grade, and type, Material Grade or Engineering Specification, as applicable for fastener component (see component; 4.1 and Table 1);

5.1.6 Coating or finish, if required;

5.1.7 Test report report(s) or certificate of certificate(s) (Section 14 compliance);, if required; and

5.1.8 Special requirements, if required.

NOTE 1—A typical ordering information follows: 1000 pieces, ~~1-8 × 8-1 in.-8 in. × 8 in. Heavy Hex Structural Bolt ASTM XXXXF2482/F2482M Grade: 325-1, Mechanical Dial, Electrodeposited Zinc Coating Type MT, Proof Load, LT1, Grade A325-1, ASTM F1941 Coating FeZn, Thickness 5-include Fe/Zn, 5C Coating. Calibration Accuracy 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 Reduced Loadability—Where applicable, if due to geometric modification, the fasteners no longer conform to the specified material standard's stated tensile load (klbf, kN) but do conform (see 6.1) to the stated material strengths (psi, MPa), a reduced loadability designation shall be used to mark the product.

6.1.1.1 For inch product, an asterisk, *, may be used to designate the reduced loadability.

6.1.1.2 For metric product, a leading "0" in front of the class marking is acceptable per ISO 898-1.

6.1.1.3 The material test records for the modified product shall reflect the magnitude of reduced loadability.

6.1.1.4 Other marking methods that adequately convey the reduced loadability designation to the end user will be acceptable.

6.1.1.5 Refer to ISO 898-1 for a more complete definition of reduced loadability.

6.2 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). Load-indicating fasteners are capable of displaying load up to their full-scale specifications. Common full-scale load specifications are Design Load, Proof Load, 7) and Yield Load.

(1) Design Load is defined as a tensile load value set as a percentage of the fastener's proof or yield strength.

(2) Proof Load is the tensile load value equal to the fastener's proof strength.

(3) Yield Load is the tensile load value equal to the fastener's yield strength.

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

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

6.2.3 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-proof strength~~ of the fastener.

6.2.4 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 up to the yield strength of the fastener.~~ (See Practice E1685).)

6.2.5 Type OT load-indicating fasteners shall incorporate an optical sensor capable of signaling fastener tension visually and/or be capable of connecting to a fiber optic coupling device that measures the fastener load up to the yield strength of the fastener.

6.2.6 Type EW load indicating fasteners shall incorporate an electronic measuring device capable of measuring, converting, and wirelessly transmitting fastener tension up to the yield strength to a receiving device.

7. Chemical and Mechanical Properties

7.1 The chemical and mechanical properties shall be dictated by the associated ASTM or other governing engineering specification to which the load-indicating features are being added. See [Table 1.2](#) for additional information.

8. Performance Requirements

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

8.2 *Load Tolerance*—The load-indicating fastener can be specified to conform with multiple load tolerances.

LT1: ± 5 % of full-scale load

LT2: ± 10 % of full-scale load

LT3: ± 20 % of full-scale load

8.2.1 All load-indicating fastener types may be specified to the load tolerance that meets or exceeds the needs of the application.

8.3 *Field Tests*—The ~~purchase~~user shall have the option of specifying calibration accuracy test reports from the manufacturer or performing field tests to verify calibration accuracy. When exercised, the load-indicating fasteners and all lots shall demonstrate an accuracy of ~~±5 % when tested~~ compliant with the specified load tolerance 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.~~ fasteners, such as ASME B18.2.1. Head height may be increased by 1.0 in. (25.4 mm) 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 21](#).

TABLE 21 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

10.1.2 When calibrating in accordance with the required sampling plan, a lot shall either be rejected or processed by 100 % sort if any of the test specimens fail to meet the calibration requirements (see 13.1).

11. Test Methods

11.1 For mechanical and chemical requirements, refer to parent specification in (see Table 15.1.5).

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~~ tensile force at 25 % increments up to the proof load or other full-scale load requirement of the parent specification. For cases where full-scale load testing may be destructive to the fastener, a reading not less than 85 % of full-scale load may be used. The load-indicating fastener must exhibit accuracy to ± 5 % of specified accuracy when compared against 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.

12.2 The inspector representing the purchaser shall have free entry to all parts of the manufacturer's works or supplier's place of business that concern the manufacture or supply of the load-indicating fasteners ordered. The manufacturer or supplier shall afford the inspector all reasonable facilities to satisfy ~~him~~ the inspector that the material is being furnished in accordance with this specification. All tests and inspections required by the specification that are requested by the purchaser's representative shall be made before shipment, and shall be conducted so as not to unnecessarily interfere with the operation of the manufacturer's works or supplier's place of business.

13. Rejection and Rehearing

13.1 Disposition of nonconforming load-indicating fasteners shall be in accordance with the section on Disposition of Nonconforming Lots of Guide F1470.