



Standard Specification for Load-Indicating Externally Threaded Fasteners¹

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 $\frac{1}{4}$ 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 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

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.

[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.

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

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

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 manufacturer's 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 $\leq 2\%$ 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 $\pm 5\%$ 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.

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 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**.

14. Certification

14.1 Calibration Accuracy Test Report

14.1.1 When a Calibration Accuracy Test Report is required and specified on the Purchase Order, the manufacturers shall furnish a test report for each calibration of accuracy lot from which load-indicating fasteners are supplied to fill a shipment. The report shall show the heat number (to ensure that the chemical composition is on record and could be furnished upon request), calibration loads, nominal size, calibration of accuracy lot identification number, ASTM designation, type or grade, and issue date, and purchase order number.

14.2 Chemical and Mechanical Tests, Certificate of Compliance

14.2.1 When a Certificate of Compliance for chemical and mechanical tests is required and specified on the purchase order the manufacturer shall furnish a certificate certifying that the fasteners used for the load indicators have been manufactured and tested to conform to the required specification in accordance with **Table 1** at the time of order.

14.3 Chemical and Mechanical Tests, Test Report

14.3.1 When a Test Report for chemical and mechanical test is required and specified on the Purchase Order, the manufacturer shall furnish a Test(s) Report showing the following:

- (1) Heat analysis, heat number,
- (2) Results of hardness, tensile, and proof load tests,
- (3) Plating and coating weight/thickness for coated fasteners,
- (4) Lot number and purchase order number,
- (5) Complete mailing address of responsible party, and
- (6) Title and signature of the individual assigned certification responsibility by the company officers.

15. Responsibility

15.1 The party responsible for the load-indicating fasteners shall be the organization that supplies the fastener to the purchaser and certifies that the load-indicating fasteners have been manufactured, sampled, tested and inspected in accordance with this specification and meets all of its requirements.

16. Product Marking

16.1 *Manufacturer's Identification*— All fasteners listed in **Table 1** shall be marked by the manufacturer with a unique identifier to identify the manufacturer.

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

16.2 Specification and grade identification marking shall be present and in accordance with **Table 1** (for example, F XXXX 325-1).

16.3 *Marking Location and Methods*—All markings shall be located on the top of the bolt head and may be either raised or depressed at the manufacturer's option. Markings can also be placed on the flats of the fastener head if space is limited.

16.4 *Acceptance Criteria*—Bolts which are not marked in accordance with these provisions shall be considered nonconforming and subject to rejection.

17. Packaging and Package Marking

17.1 Packaging:

17.1.1 Unless otherwise specified, packaging shall be in accordance with the practice of the manufacturer.

17.1.2 When special packaging requirements are required, they shall be defined at the time of the inquiry and order

17.2 Package Marking:

17.2.1 Each shipping unit shall include or be marked plainly with the following information:

17.2.1.1 Load-indicating fastener, ASTM designation F XXXX-XX, including type and grade;

17.2.1.2 Size, including nom. diameter, length, and thread pitch;

17.2.1.3 Name and brand or trademark of the manufacturer or private label distributor;

17.2.1.4 Number of pieces;

17.2.1.5 Purchase order number;

17.2.1.6 Name of product;

17.2.1.7 Lot identification number;

17.2.1.8 Finish; and

17.2.1.9 Country of origin.

18. Keywords

18.1 alloy steel; alternate design fasteners; bolts; cap screw; carbon steel; fasteners; load-indicating fastener; load indicators; structural; stud; tension control bolt; tension indicators; weathering steel

APPENDIX

(Nonmandatory Information)

X1. FIELD TESTING

X1.1 Field testing at the job site by the purchaser to verify compliance with the calibration accuracy requirements of **Section 8** shall be conducted in accordance with the following:

X1.1.1 A representative sample of not less than two bolts of each diameter, length, type, and grade shall be checked at the job site in a device capable of indicating bolt tension such as a calibrated load cell.

X1.1.2 Parts shall be tightened to 50 % of the proof load of the fastener. Compare the load reading with the certification provided by the manufacturer.

X1.2 If one or more of the parts tested fail to meet the ± 5 % tension accuracy, the parts shall be tested by a third party accredited laboratory.

X1.2.1 Parts shall be placed in a calibrated tensile tester and pulled to 50 % of the proof load of the fastener.

X1.2.1.1 If all parts tested meet the acceptable limits, the lot shall be acceptable. If one or more of the parts tested fail, the lot shall be considered non-conforming and subject to rejection.

SUMMARY OF CHANGES

Committee F16 has identified the location of selected changes to this standard since the last issue (F2482-05) that may impact the use of this standard.

(1) Clarified **Section 14**, Requirements.

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