



Designation: F2437 – 12

Standard Specification for Carbon and Alloy Steel Compressible-Washer-Type Direct Tension Indicators for Use with Cap Screws, Bolts, Anchors, and Studs¹

This standard is issued under the fixed designation F2437; 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 the requirements for carbon and alloy steel compressible-washer-type direct tension indicators capable of indicating a specified bolt tension in cap screws, bolts, anchors, and studs.

1.2 Direct tension indicators in nominal diameter sizes $\frac{1}{4}$ through $2\frac{1}{2}$ in. are covered.

1.3 There are two Types of DTIs covered by this specification, Type 1 and Type 2.

1.3.1 Type 1 DTIs are suitable for comparatively large bearing surfaces.² Type 1 DTIs are available in Grades 55 and 105, which differ in the amount of tension they indicate at a prescribed gap (see Table 1).

1.3.2 Type 2 DTIs are suitable for comparatively smaller bearing surfaces.³ Type 2 DTIs are available in Grades 5 and 8, which differ in the amount of tension they indicate at a prescribed gap (see Table 1).

1.4 Direct tension indicators are intended for installation under a bolt or cap screw head, a hex nut, or against a hardened washer or other flat hardened surface.

1.5 *The following precautionary statement pertains only to the test method portions, Section 12 and Appendix XI of this 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.*

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 Examples of a comparatively large bearing surface would include heavy hex bolts, heavy hex nuts, and so forth.

³ Examples of a comparatively small bearing surface would include a hex cap screw, hex nut, and so forth.

2. Referenced Documents

2.1 ASTM Standards:⁴

- A193/A193M Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
- A194/A194M Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
- A307 Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
- 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
- A563 Specification for Carbon and Alloy Steel Nuts
- B633 Specification for Electrodeposited Coatings of Zinc on Iron and Steel
- B695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
- F436 Specification for Hardened Steel Washers
- F606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
- F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
- F1554 Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
- F1941 Specification for Electrodeposited Coatings on Threaded Fasteners (Unified Inch Screw Threads (UN/UNR))

⁴ 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 Acceptable Range of Compression Load^A

DTI Nominal Diameter (in.)	Mean Compression Load ^B Range in Pounds (lbs)		Mean Compression Load ^C Range in Pounds (lbs)	
	Grade 5	Grade 8	Grade 55	Grade 105
1/4	2200 to 2450	3100 to 3450	...	...
5/16	3500 to 3850	4950 to 5500	...	...
3/8	5300 to 5850	7500 to 8300	...	...
7/16	7200 to 7900	10 100 to 11 200	...	...
1/2	9700 to 10 700	13 700 to 15 340	4450 to 4900	8500 to 9400
9/16	12 350 to 13 600	17 400 to 19 200	5700 to 6300	10 900 to 12 050
5/8	15 550 to 17 200	21 850 to 24 200	7050 to 7800	13 500 to 15 000
3/4	22 600 to 25 000	31 900 to 35 300	10 500 to 11 600	20 000 to 22 150
7/8	30 850 to 34 100	43 550 to 48 100	14 500 to 16 000	27 650 to 30 550
1	40 200 to 44 400	56 700 to 62 700	19 000 to 21 000	36 250 to 40 100
1 1/8	45, 100 to 49 850	73 150 to 80 900	23 950 to 26 450	47 300 to 52 300
1 1/4	56 550 to 62 550	91 750 to 101 450	30 400 to 33 600	59 850 to 66 150
1 3/8	69 350 to 79 750	112 450 to 124 250	38 550 to 42 600	73 800 to 81 600
1 1/2	83 350 to 92 150	135 150 to 149 400	44 050 to 48 700	89 300 to 98 700
1 5/8	...	...	55 800 to 61 700	106 200 to 117 400
1 3/4	121 850 to 134 650	177 850 to 196 500	59 550 to 65 850	124 600 to 137 750
1 7/8	154 550 to 170 800	206 050 to 227 750	75 550 to 83 500	144 500 to 159 700
2	160 050 to 177 200	236 850 to 261 750	78 650 to 86 950	165 800 to 183 300
2 1/4	208 400 to 230 350	277 900 to 307 100	102 050 to 112 750	212 900 to 235 550
2 1/2	256 500 to 283 500	379 600 to 419 600	125 400 to 138 600	240 550 to 265 850

^A Compression load requirements establish the capability of the direct tension indicators to satisfy typical tension requirements for these grades. The user is not obliged to install fasteners and DTIs to these tensions, and is free to specify installation to lower tension values. When so specified, the DTI supplier shall provide a load-gap curve in accordance with 15.2 to enable the user to select the appropriate gap criteria for the intended target tension of the application.

^B Mean compression load values for Grades 5 and 8 are based upon 75 % of the proof load for SAE J429 cap screws.

^C Mean compression load values for Grades 55 and 105 are based upon 60 % of the yield strength for the matching fasteners on which they are used.

2.2 ASME Standards:⁵

ASME B18.2.1 Square and Hex Bolts and Screws, Inch Series

ASME B18.2.8 Clearance Holes for Bolts Screws, and Studs

2.3 SAE Standard:⁶

SAE J429 Mechanical and Material Requirements for Externally Threaded Fasteners

SAE J995 Mechanical and Material Requirements for Steel Nuts

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *compressible-washer-type direct tension indicator, n*—a washer-type element inserted under the cap screw or bolt head, hex nut, or hardened washer, having the capability of indicating the achievement of a required bolt tension by the degree of direct tension indicator plastic deformation. Hereafter referred to as *direct tension indicator or DTI*. Alternatively, DTIs are commonly referred to as load-indicating washers or tension-indicating washers.

4. Ordering Information

4.1 Orders for direct tension indicators under this specification shall include the following:

- 4.1.1 Quantity (number of pieces);
- 4.1.2 Name of product (direct tension indicator);
- 4.1.3 Size, that is, nominal diameter;

⁵ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

⁶ Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

4.1.4 ASTM designation and year of issue (if not specified, current issue shall be used);

4.1.5 Type and Grade:

4.1.5.1 *Type 1*—Either Grade 55 or Grade 105,

4.1.5.2 *Type 2*—Either Grade 5 or Grade 8;

4.1.6 Finish or coating type, if required (5.4);

4.1.7 Source inspection, if required (Section 13);

4.1.8 Certificates of Compliance, Certificates of Conformance, or Certified Test Reports, if required (Section 15); and

4.1.9 Any special requirements, including those for load-gap curves or other special test data, as well as intended bolt, anchor, or stud tension, if known.

4.2 *Recommended Fasteners*—Fasteners meeting the requirements of the Standards referenced in Table 1 are considered compatible with the DTI type(s) listed.⁷

5. Materials and Manufacture

5.1 Direct tension indicators shall have a configuration produced by extrusion, punching, pressing, or similar forming to permit a measurable decrease in thickness when placed in compression.

5.2 The design shall be such that the degree of plastic deformation of the protrusions shall indicate the tension in a tightened cap screw, bolt, anchor, or stud.

5.3 *Heat Treatment*—The process used for heat treatment of DTIs, if required, shall be through-hardening by heating to a temperature above the upper transformation temperature,

⁷ Coating or plating of previously tested DTIs requires retesting. See 10.3.

quenching in oil, and then tempering by reheating to a suitable temperature to attain desired mechanical/performance properties.

5.4 Protective Coatings or Platings:

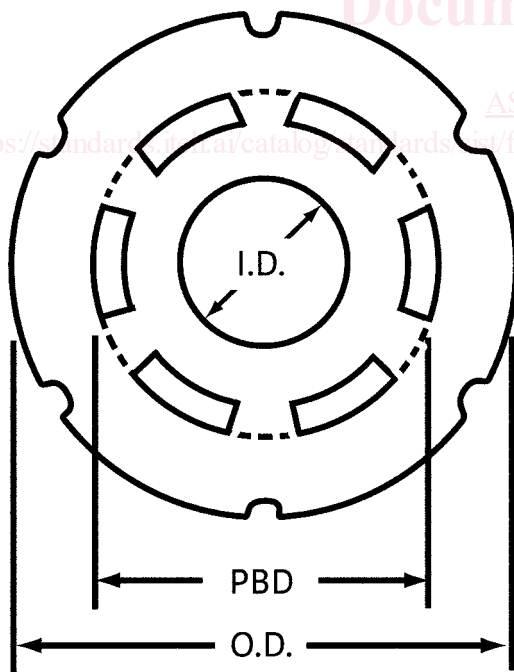
5.4.1 Unless otherwise specified, the direct tension indicators shall be furnished “plain” with the “as-fabricated” surface finish without protective coatings.

5.4.2 When “plated” is specified, the direct tension indicators shall be processed in accordance with the requirements of Specifications B633, B695, or F1941 for the class and type of finish specified.

5.4.3 Direct tension indicator manufacturers are free to offer other coatings, platings, or finishes when specified. However, application of any such coating, plating, or finish shall not be undertaken without the approval of the direct tension indicator manufacturer.

5.5 All direct tension indicators shall have circumferential indentations spaced equally around the outside circumference, corresponding to and in alignment with each space between the protrusions. Indentations shall be clearly visible but not so large as to interfere with the function of the direct tension indicator (see Fig. 1).

5.5.1 The circumferential indentations indicate where feeler gages, if used, are to be inserted during installation inspections, and further make it visually obvious that a direct tension indicator (rather than a flat washer) has been used in the assembly.



DIRECT TENSION INDICATOR

NOTE 1—Contour of protrusions will vary from manufacturer to manufacturer. The example shown is illustrative.

FIG. 1 Direct Tension Indicator Inside Diameter (I.D.) Outside Diameter (O.D.) and Protrusion Bearing Diameter (PBD)

TABLE 2 Chemical Composition Requirements^{A,B}

Element	Composition, %	
	Heat Analysis	Product Analysis
Carbon	0.30 to 0.50	0.27 to 0.53
Manganese	0.50 to 0.90	0.47 to 0.93
Phosphorus, max	0.035	0.043
Sulfur, max	0.040	0.048
Silicon	0.15 to 0.35	0.13 to 0.37

^A Steel is considered to be alloy by the American Iron and Steel Institute when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: manganese, 1.65 %; silicone, 0.60 %; copper, 0.60 %; or in which a definite range or definite maximum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, chromium up to 3.99 %, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying elements added to obtain a desired alloying effect.

^B Suitable materials for weathering steel DTIs include the chemistries for Type 3 products listed in Specifications A325 and F436.

6. Chemical Composition

6.1 The direct tension indicators shall conform in chemical composition to the limits given in Table 2.

6.2 Product analysis may be made by the purchaser from finished direct tension indicators representing each lot. The chemical composition shall conform to the requirements given in Table 3.

7. Performance Requirements

7.1 Compression Load—When compressed to the specified gap, the compression load shall conform to the requirements specified in Table 1.

7.2 Hardness:

7.2.1 Type 1 DTIs shall have a hardness not less than HRB70 nor more than HRC22.

7.2.2 Type 2 DTIs shall have a hardness not less than HRB80 nor more than HRC35.

8. Dimensions

8.1 Type 1 (Grades 55 and 105) and Type 2 (Grades 5 and 8) direct tension indicators shall conform to the dimensions specified in Table 4.

9. Workmanship, Finish, and Appearance

9.1 The direct tension indicators shall be commercially smooth and free of injurious material or manufacturing defects that would affect their performance.

10. Number of Tests and Retests

10.1 Responsibility:

10.1.1 The direct tension indicator manufacturer shall inspect each lot of direct tension indicators prior to shipment in accordance with the quality assurance procedures described in 10.2.

10.1.2 The purpose of a lot inspection testing program is to ensure that each lot conforms to the requirements of this specification. For such a plan to be fully effective, it is essential that the purchaser continue to maintain the identification and integrity of each lot following delivery until the product is installed in its service application.