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Standard Specification for Carbon and Alloy Steel Compressible-Washer-Type Direct Tension Indicators for Use with Cap Screws, Bolts, Anchors, and Studs[1]

This standard is issued under the fixed designation ~~F2437;~~F2437/F2437M; 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 (DTIs) capable of indicating a specified bolt tension in cap screws, bolts, anchors, and studs.

1.2 Direct tension indicators in ~~nominal diameter~~ inch sizes ¼ through 2½ in. and metric sizes M6 and M72 are covered.

1.3 ~~There are two Types of DTIs covered by this specification, Type 1~~ Direct tension indicators have two styles and four grades for inch fasteners, Grades 5, 8, 55, and 105, and two property classes for metric fasteners, property classes 8.8 and 10.9 each of which differ in their compressive load requirements at a given gap (see Table 1 and Table 2~~Type 2.~~).

1.3.1 ~~Type~~Style 1 DTIs are suitable for comparatively ~~large~~smaller bearing surfaces. ~~Type~~Style 1 DTIs are available in Grades ~~5~~55 and ~~105,~~8, which differ in the amount of tension they indicate at a prescribed gap (see Table 1 and Table 3).

~~NOTE 1—Examples of a comparatively large bearing surface would include heavy hex bolts, heavy hex nuts, and so forth.~~

1.3.2 ~~Type~~Style 2 DTIs are suitable for comparatively ~~smaller~~large bearing ~~surfaces.Type~~ surfaces. Style 2 DTIs are available in Grades ~~5~~55 and ~~8,~~105, which differ in the amount of tension they indicate at a prescribed gap (see Table 1 and Table 3).

~~NOTE 2—Examples of a comparatively small bearing surface would include a hex cap screw, hex nut, and so forth.~~

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 *Recommended Fasteners*—Fasteners meeting the requirements of the standards referenced in Table 3 are considered compatible with the DTI grade or class listed.

1.6 The values stated for Inch DTIs are expressed in inch-pound units ~~are~~ and for Metric DTIs values are expressed in SI units.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~~ separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.7 *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.*

1.8 *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**

TABLE 1 Acceptable Range of Compression Load[A] for Inch DTIs

DTI Nominal Diameter (in.)	Mean Compression Load[B] Range in Pounds (lbs) Style 1		Mean Compression Load[C] Range in Pounds (lbs) Style 2	
	Grade 5	Grade 8	Grade 55	Grade 105
¼	2200 to 2450	3100 to 3450	. . .	. . .
5⁄16	3500 to 3850	4950 to 5500	. . .	. . .
⅜	5300 to 5850	7500 to 8300	. . .	. . .
7⁄16	7200 to 7900	10 100 to 11 200	. . .	. . .
½	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
⅝	15 550 to 17 200	21 850 to 24 200	7050 to 7800	13 500 to 15 000
¾	22 600 to 25 000	31 900 to 35 300	10 500 to 11 600	20 000 to 22 150
⅞	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
1⅛	40 250 to 44 450	73 150 to 80 900	23 950 to 26 450	47 300 to 52 300
1¼	51 100 to 56 450	91 750 to 101 450	30 400 to 33 600	59 850 to 66 150
1⅜	61 150 to 67 600	112 450 to 124 250	38 550 to 42 600	73 800 to 81 600
1½	74 350 to 82 150	135 150 to 149 400	44 050 to 48 700	89 300 to 98 700
1⅝	. . .	. . .	55 800 to 61 700	106 200 to 117 400
1¾	74 450 to 82 300	177 850 to 196 500	59 550 to 65 850	124 600 to 137 750
1⅞	...	206 050 to 227 750	75 550 to 83 500	144 500 to 159 700
2	98 000 to 108 300	236 850 to 261 750	78 650 to 86 950	165 800 to 183 300
2¼	127 400 to 140 800	277 900 to 307 100	102 050 to 112 750	212 900 to 235 350
2½	156 750 to 173 250	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] The Mean compression load values for Grades 5 and 8 in nominal sizes up through 1-½ in are based upon 75% of the proof load for SAE J429 cap screws. For Grade 5 in nominal sizes over 1-½ in and up to 2-½ in inclusive, the mean compression load values are based on 75% of the proof load for ASTM A449. For grade 8 in nominal sizes over 1-½ in and up to 2-½ in inclusive, mean compression load values are based upon 75 % of the proof load for ASTM A354BD.
[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.

TABLE 2 Acceptable Range of Compression Load[A] for Metric DTIs

Nominal Diameter (M)	Mean Compression Load Range in kN	
	Property Class 8.8	Property Class 10.9
M6	8 to 9	12 to 13
M8	15 to 17	22 to 24
M10	24 to 27	35 to 38
M12	35 to 39	50 to 55
M14	48 to 53	68 to 75
M16	65 to 72	93 to 103
M18	82 to 91	114 to 125
M20	105 to 116	145 to 160
M22	130 to 143	179 to 198
M24	151 to 167	209 to 231
M27	196 to 217	271 to 300
M30	240 to 265	332 to 367
M33	297 to 328	410 to 454
M36	349 to 386	483 to 534
M39	417 to 461	577 to 638
M42	479 to 529	662 to 732
M45	560 to 619	775 to 856
M48	628 to 695	869 to 961
M52	752 to 832	1041 to 1150
M56	868 to 959	1200 to 1327
M60	1009 to 1115	1396 to 1543
M64	1146 to 1266	1585 to 1752
M68	1308 to 1446	1810 to 2000
M72	1479 to 1635	2046 to 2262

[A] The Mean compression load values for property classes 8.8 and 10.9 are based upon 75% of the proof load for ISO 898-1 Bolts/Stud/Screws.

A194/A194M Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
A307 Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
~~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
A563 Specification for Carbon and Alloy Steel Nuts

TABLE 3 Recommended Fasteners[A]

Type/Grade		Recommended Cap Screws, Bolts, Anchors, or Studs	Recommended Hex[B] Nuts	Recommended Flat Washers[C]
Type 1 Grade 55	Specification F1554 Grade 55 Specification A307	Specification A194/A194M 2H Specification A563 A, C, DH	Specification F436	
Type 1 Grade 105	Specification A193/A193M B7 Specification F1554 Grade 105	Specification A194/A194M 2H Specification A563 DH	Specification F436	
Type 2 Grade 5	Specification A449, Specification A354 BC SAE J429 Grade 5	SAE J995 Grade 5 Specification A563 B, C, D, DH	Specification F436	
Type 2 Grade 8	Specification A354 BD SAE J429 Grade 8	SAE J995 Grade 8 Specification A563 D, DH	Specification F436	

TABLE 3 Recommended Fasteners

Series/Grade or Property Class		Recommended Cap Screws, Bolts, Anchors, or Studs[A]	Recommended Nuts[B]	Recommended Flat Washers
Inch Fasteners	Style 2 Grade 55	Specification F1554 Grade 55 Specification A307	Specification A194/A194M 2H Specification A563 A, C, DH	Specification F436/F436M
	Style 2 Grade 105	Specification A193/A193M B7 Specification F1554 Grade 105	Specification A194/A194M 2H Specification A563 DH	Specification F436/F436M
	Style 1 Grade 5	Specification A449, Specification A354 BC SAE J429 Grade 5	SAE J995 Grade 5 Specification A563 B, C, D, DH	Specification F436/F436M
	Style 1 Grade 8	Specification A354 BD SAE J429 Grade 8	SAE J995 Grade 8 Specification A563 D, DH	Specification F436/F436M
Metric Fasteners	Property Class 8.8	Specification ISO 898-1 Class 8.8	Specification ISO 898-2 Class 10	Specification ISO 887 (300 HV) DIN 125 Part 2
	Property Class 10.9	Specification ISO 898-1 Class 10.9	Specification ISO 898-2 Class 10	Specification ISO 887 (300 HV) ISO 7089

[A] For use of fasteners manufactured to other standards, see A Inch bolt and cap screw dimensions are designated 5.5.1. in ASME B18.2.1 and metric bolt dimensions are designated in ISO 4014.

[B] When DTIs are placed directly against the nut, heavy hex nuts are recommended for Type 1 DTIs. Inch nuts dimensions are designated in ASME B18.2.2 and metric nut dimensions are designated in ISO 4032.

[C] Flat washers of comparable hardness and thicknesses with inside diameters conforming to ASME B18.2.8 for close tolerance holes are suitable alternatives. Flat washers with larger outside diameters are permissible with the approval of the DTI manufacturer.

B633 Specification for Electrodeposited Coatings of Zinc on Iron and Steel
B695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
F436F436/F436M Specification for Hardened Steel Washers (Metric) F0436_F0436M Inch and Metric Dimensions
F606F606/F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets (Metric) F0606_F0606M 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
F1789 Terminology for F16 Mechanical Fasteners
F1941F1941/F1941M Specification for Electrodeposited Coatings on Threaded Fasteners (Metric) F1941_F1941M Mechanical Fasteners, Inch and Metric

2.2 *ASME Standards:*[3]

ASME B18.2.1 Square and Hex Bolts and Screws, Inch Series
ASME B18.2.2 Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)

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

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

2.3 *SAE ~~Standard:~~Standards:*[4]

SAE J429 Mechanical and Material Requirements for Externally Threaded Fasteners

SAE J995 Mechanical and Material Requirements for Steel Nuts

2.4 *ISO Standards*[5]

ISO 887 : Plain washers for metric bolts, screws and nuts for general purposes -- General plan

ISO 898-1 : Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs with specified property classes - Coarse thread and fine pitch

ISO 898-2 : Mechanical properties of fasteners made of carbon steel and alloy steel — Part 2: Nuts with specified property classes — Coarse thread and fine pitch thread

ISO 4014 : Hexagon head bolts - Product grades A and B

ISO 4032 : Hexagon regular nuts (style 1) - Product grades A and B

ISO 7089 : Plain washers — Normal series — Product grade A

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.~~

3.1 For terminology definitions refer to Terminology F1789.

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;

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

4.1.5 ~~Type and Grade:~~ Grade: Grade 5, 8, 55 or 105 for inch products or property class 8.8 or 10.9 for metric products.

4.1.5.1 ~~*Type 1*—~~*Style 2*—Either Grade 55 or Grade 105,

4.1.5.2 ~~*Type 2*—~~*Style 1*—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.

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

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

5.3.1 The heat treatment of DTIs is optional at the manufacturer's discretion, provided the DTIs meet all of the mechanical and performance requirements.

5.3.2 When heat treatment is performed, the process shall be through-hardening by heating to a temperature above the upper transformation temperature, quenching in a liquid medium, and tempering by heating to a suitable temperature.

5.4 *Protective Coatings or Platings:*

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

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.