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 \(\frac{3}{8}\) 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. 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. 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.

2. Referenced Documents

2.1 ASTM Standards:

- 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))

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* 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.


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.

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* 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.

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

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TABLE 1 Acceptable Range of Compression Load

<table>
<thead>
<tr>
<th>DTI Nominal Diameter (in.)</th>
<th>Mean Compression Load Range in Pounds (lbs)</th>
<th>Grade 8</th>
<th>Grade 55</th>
<th>Grade 105</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>⅛</td>
<td>2200 to 2450</td>
<td>3100 to 3450</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>⅜</td>
<td>3500 to 3850</td>
<td>4950 to 5500</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>⅜</td>
<td>5300 to 5850</td>
<td>7500 to 8300</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>⅜</td>
<td>7200 to 7900</td>
<td>10 100 to 11 200</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>½</td>
<td>9700 to 10 700</td>
<td>13 700 to 15 340</td>
<td>4450 to 4900</td>
<td>8500 to 9400</td>
</tr>
<tr>
<td>⅞</td>
<td>12 350 to 13 600</td>
<td>17 400 to 19 200</td>
<td>5700 to 6300</td>
<td>10 900 to 12 050</td>
</tr>
<tr>
<td>⅞</td>
<td>15 550 to 17 200</td>
<td>21 850 to 24 200</td>
<td>7050 to 7800</td>
<td>13 500 to 15 000</td>
</tr>
<tr>
<td>⅛</td>
<td>22 600 to 25 000</td>
<td>31 900 to 35 300</td>
<td>10 500 to 11 600</td>
<td>20 000 to 22 150</td>
</tr>
<tr>
<td>⅛</td>
<td>30 850 to 34 100</td>
<td>43 550 to 48 100</td>
<td>14 500 to 16 600</td>
<td>27 650 to 30 550</td>
</tr>
<tr>
<td>⅛</td>
<td>40 200 to 44 400</td>
<td>56 700 to 62 700</td>
<td>19 000 to 21 000</td>
<td>36 250 to 40 100</td>
</tr>
<tr>
<td>⅛</td>
<td>45 100 to 49 850</td>
<td>73 150 to 80 900</td>
<td>23 950 to 26 450</td>
<td>47 300 to 52 300</td>
</tr>
<tr>
<td>⅛</td>
<td>56 550 to 62 550</td>
<td>91 750 to 101 450</td>
<td>30 400 to 33 600</td>
<td>59 850 to 66 150</td>
</tr>
<tr>
<td>⅛</td>
<td>69 350 to 79 750</td>
<td>112 450 to 124 250</td>
<td>38 550 to 42 600</td>
<td>73 800 to 81 600</td>
</tr>
<tr>
<td>⅛</td>
<td>83 350 to 92 150</td>
<td>135 150 to 149 400</td>
<td>44 050 to 48 700</td>
<td>89 300 to 98 700</td>
</tr>
<tr>
<td>⅛</td>
<td>121 850 to 134 650</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>⅛</td>
<td>121 850 to 134 650</td>
<td>177 850 to 196 500</td>
<td>59 550 to 65 850</td>
<td>124 600 to 137 750</td>
</tr>
<tr>
<td>⅛</td>
<td>154 550 to 170 800</td>
<td>206 050 to 227 750</td>
<td>75 550 to 83 500</td>
<td>144 500 to 159 700</td>
</tr>
<tr>
<td>⅛</td>
<td>160 050 to 177 200</td>
<td>236 850 to 261 750</td>
<td>78 650 to 86 950</td>
<td>165 800 to 183 300</td>
</tr>
<tr>
<td>⅛</td>
<td>208 400 to 230 350</td>
<td>277 900 to 307 100</td>
<td>102 050 to 112 750</td>
<td>212 900 to 235 350</td>
</tr>
<tr>
<td>⅛</td>
<td>256 500 to 283 500</td>
<td>379 600 to 419 600</td>
<td>125 400 to 138 600</td>
<td>240 550 to 265 850</td>
</tr>
</tbody>
</table>

*4 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.

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

B 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:

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:

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;

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.

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.
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.

### Table 2 Chemical Composition Requirements

<table>
<thead>
<tr>
<th>Element</th>
<th>Heat Analysis</th>
<th>Product Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>0.30 to 0.50</td>
<td>0.27 to 0.53</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.50 to 0.90</td>
<td>0.47 to 0.93</td>
</tr>
<tr>
<td>Phosphorus, max</td>
<td>0.035</td>
<td>0.043</td>
</tr>
<tr>
<td>Sulfur, max</td>
<td>0.040</td>
<td>0.048</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.15 to 0.35</td>
<td>0.13 to 0.37</td>
</tr>
</tbody>
</table>

5 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.

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.
10.2 Lot Method:

10.2.1 All direct tension indicators shall be processed in accordance with a lot identification control-quality assurance plan. The manufacturer shall identify and maintain the integrity of each lot of direct tension indicators from raw material selection through all processing operations and treatments to final packing and shipment. Each lot shall be assigned its own lot-identification number, each lot shall be tested, and the inspection test reports for each lot shall be retained.

10.2.2 For purposes of assigning an identification number and from which test samples shall be selected, a lot shall consist of all direct tension indicators processed essentially together through all operations to placing in the shipping container that are of the same nominal size, produced from the same mill heat of steel, heat-treated in the same heat-treatment cycle, and of the same finish.

10.2.3 The minimum number of samples to be tested to determine compression loads and coating thickness (when applicable) shall be in accordance with the requirements specified in Guide F1470.

10.3 Number of Tests After Alterations—If direct tension indicators are heat-treated, coated, or plated, or otherwise altered by a subcontractor or manufacturer subsequent to testing, they shall be re-tested in accordance with 10.2 prior to shipment to the purchaser after all alterations have been completed.

11. Specimen Preparation

11.1 Direct tension indicators selected for tests shall be tested full size “as-received” without any special preparation.

12. Test Methods

12.1 Compression load tests shall be conducted in accordance with Test Methods F606, with the specified test gap being 0.010 in. in all cases. Additional test data, when

---

**TABLE 3 Recommended Fasteners**

<table>
<thead>
<tr>
<th>DTI Size (Nominal Diameter, in.)</th>
<th>Recommended Cap Screws, Bolts, Anchors, or Studs</th>
<th>Recommended Hex Nuts</th>
<th>Recommended Flat Washers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1 Grade 55</td>
<td>Specification F1554 Grade 55</td>
<td>Specification A194/A194M 2H</td>
<td>Specification F436</td>
</tr>
<tr>
<td>Type 1 Grade 105</td>
<td>Specification A307</td>
<td>Specification A563 A, C, DH</td>
<td>Specification F436</td>
</tr>
<tr>
<td>Type 2 Grade 5</td>
<td>Specification A193/A193M B7</td>
<td>Specification A194/A194M 2H</td>
<td>Specification F436</td>
</tr>
<tr>
<td>Type 2 Grade 8</td>
<td>Specification F1544</td>
<td>Specification A563 DH</td>
<td>Specification F436</td>
</tr>
</tbody>
</table>

**TABLE 4 Dimensions of Type 1 and Type 2 Direct Tension Indicators**

<table>
<thead>
<tr>
<th>DTI Size, (ID), in.</th>
<th>Type 2: Grade 5 and Grade 8</th>
<th>Type 1: Grade 55 and Grade 105</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside Diameter (OD), in.</td>
<td>Outside Diameter (ID), in.</td>
<td>Thickness, in. (min.)</td>
</tr>
<tr>
<td>1/4</td>
<td>0.254 to 0.258</td>
<td>0.505 to 0.525</td>
</tr>
<tr>
<td>5/32</td>
<td>0.317 to 0.321</td>
<td>0.650 to 0.670</td>
</tr>
<tr>
<td>5/32</td>
<td>0.379 to 0.383</td>
<td>0.780 to 0.800</td>
</tr>
<tr>
<td>7/32</td>
<td>0.443 to 0.448</td>
<td>0.898 to 0.918</td>
</tr>
<tr>
<td>1/2</td>
<td>0.508 to 0.512</td>
<td>0.950 to 0.970</td>
</tr>
<tr>
<td>3/16</td>
<td>0.573 to 0.577</td>
<td>1.052 to 1.072</td>
</tr>
<tr>
<td>7/32</td>
<td>0.635 to 0.639</td>
<td>1.204 to 1.224</td>
</tr>
<tr>
<td>1/4</td>
<td>0.760 to 0.764</td>
<td>1.474 to 1.494</td>
</tr>
<tr>
<td>5/32</td>
<td>0.885 to 0.889</td>
<td>1.630 to 1.650</td>
</tr>
<tr>
<td>1</td>
<td>1.010 to 1.014</td>
<td>1.846 to 1.866</td>
</tr>
<tr>
<td>1/2</td>
<td>1.135 to 1.139</td>
<td>2.063 to 2.083</td>
</tr>
<tr>
<td>5/32</td>
<td>1.260 to 1.264</td>
<td>2.305 to 2.325</td>
</tr>
<tr>
<td>7/32</td>
<td>1.388 to 1.392</td>
<td>2.565 to 2.585</td>
</tr>
<tr>
<td>1/2</td>
<td>1.525 to 1.529</td>
<td>2.798 to 2.818</td>
</tr>
<tr>
<td>1/2</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>1</td>
<td>1.767 to 1.772</td>
<td>3.265 to 3.285</td>
</tr>
<tr>
<td>1/2</td>
<td>2.030 to 2.040</td>
<td>3.735 to 3.755</td>
</tr>
<tr>
<td>1/2</td>
<td>2.275 to 2.280</td>
<td>4.205 to 4.225</td>
</tr>
<tr>
<td>1/2</td>
<td>2.525 to 2.530</td>
<td>4.675 to 4.695</td>
</tr>
</tbody>
</table>

---

*a* Dimensions are as-formed, before coatings, platings, and so forth.

*b* 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.

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specified, shall be taken at sufficient intervals to enable preparation of a load-gap curve for each lot.

13. Inspection

13.1 If the inspection described in 13.2 is required by the purchaser, it shall be specified in the inquiry and contract or order.

13.2 The purchaser’s quality assurance representative shall have free entry to all parts of the manufacturer’s works that concern the manufacture of the direct tension indicators ordered. The manufacturer shall afford the quality assurance representative all reasonable facilities to satisfy him that the direct tension indicators are being furnished in accordance with this specification. All tests and inspections required by this specification that are requested by the purchaser’s representative shall be made before shipment and shall be conducted so as not to interfere unnecessarily with the operation of the plant.

14. Rejection

14.1 Direct tension indicators that fail to conform to the requirements of this specification shall be rejected. Disposition of nonconforming lots of direct tension indicators shall be in accordance with the section on Disposition of Nonconforming Lots of Guide F1470. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

15. Certification

15.1 When specified on the order, the manufacturer shall furnish a Test Report as described in 15.2, a Certificate of Compliance, or a Certificate of Conformance as described in 15.3, whichever is required.

15.2 When test reports are required, the manufacturer shall furnish a test report for each lot from which direct tension indicators 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), the compression loads, a copy of the load-gap test curve data (when specified), measured thickness of any specified protective coatings, nominal size, type, grade, production lot identification number, ASTM designation, and issue date.

15.3 When Certificates of Compliance or Certificates of Conformance, or both, are required, the manufacturer shall furnish a Certificate of Conformance certifying that the direct tension indicators have been manufactured, tested and conform to the requirements of this specification, or a Certificate of Compliance certifying that the direct tension indicators are being supplied in compliance with all applicable requirements. Such certificates shall show the lot identification number, nominal size, type, grade, ASTM designation, issue date, and purchase order number.

16. Responsibility

16.1 The party responsible for the direct tension indicators shall be the organization that supplies the direct tension indicators to the purchaser and certifies that the direct tension indicator was manufactured, sampled, tested, and inspected in accordance with this specification and meets all of its requirements.

17. Product Marking

17.1 Each direct tension indicator shall be marked to identify the lot number, manufacturer or private label distributor, as appropriate.

17.2 Each direct tension indicator shall be marked with its appropriate grade marking:

17.2.1 Type 1 Grade 55 DTIs shall be marked with a (55), and Grade 105 with a (105);

17.2.2 Type 2 Grade 5 DTIs shall be marked with a (5), and Grade 8 with an (8).

17.3 All markings shall be depressed on the same face of the direct tension indicators as the protrusions. Raised markings are prohibited.

18. Packaging and Package Marking

18.1 Packaging:

18.1.1 Packaging shall be performed as soon as is practical following final testing.

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

18.2 Package Marking:

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

18.2.1.1 ASTM designation and type,

18.2.1.2 Size,

18.2.1.3 Name and brand or trademark of the manufacturer or private label distributor,

18.2.1.4 Number of pieces,

18.2.1.5 Name of product,

18.2.1.6 Lot identification number,

18.2.1.7 Finish, and

18.2.1.8 Country of origin.

19. Storage

19.1 The direct tension indicators shall be stored in an environment that preserves the surface condition supplied by the manufacturer.

20. Keywords

20.1 compressible-washer-type; direct tension indicators; DTI; load indicators; load indicating washers; tension indicators
SUMMARY OF CHANGES

Committee F16 has identified the location of selected changes to this standard since the last issue (F2437–07) that may impact the use of this standard. (Approved April 1, 2012)

(I) Table 1 and Table 4 were revised.

Committee F16 has identified the location of selected changes to this standard since the last issue (F2437) that may impact the use of this standard.

(I) 15.1—Deleted the word “Certified” in front of “Test Report.”

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