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## Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, Inch and Metric Series<sup>1</sup>

This standard is issued under the fixed designation F959/F959M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope\*

1.1 This specification covers the requirements for compressible-washer-type direct tension indicators, (DTIs) capable of indicating the achievement of a specified minimum tension in a structural bolting assembly.

1.2 Eight types of DTIs in nominal diameter sizes  $\frac{1}{2}$  through  $1\frac{1}{2}$  in. as well as M16 through M36 are covered:

1.2.1 *Type 325-1*—DTIs for use with Specification **F3125** Grade **A325** Type 1 bolts or Grade **F1852** assemblies.

1.2.2 *Type 325-3*—DTIs for use with Specification **F3125** Grade **A325** Type 3 bolts or Grade **F1852** Type 3 assemblies.

1.2.3 *Type 490-1*—DTIs for use with Specification **F3125** Grade **A490** Type 1 bolts or Grade **F2280** assemblies.

1.2.4 *Type 490-3*—DTIs for use with Specification **F3125** Grade **A490** Type 3 bolts Grade **F2280** Type 3 assemblies.

1.2.5 *Type 8.8-1*—DTIs for use with Specification **F3125** Grade **A325M** Type 1 bolts.

1.2.6 *Type 8.8-3*—DTIs for use with Specification **F3125** Grade **A325M** Type 3 bolts.

1.2.7 *Type 10.9-1*—DTIs for use with Specification **F3125** Grade **A490M** Type 1 bolts.

1.2.8 *Type 10.9-3*—DTIs for use with Specification **F3125** Grade **A490M** Type 3 bolts.

1.3 DTIs are intended for installation with the protrusions against a hardened surface such as a bolt head, a hardened nut, or a hardened washer. (See Research Council on Structural Connections: Specification for Structural Joints Using High-Strength Bolts.)

1.4 This specification provides for furnishing Type 3 DTIs to a Chemical Composition Requirement or a Corrosion Resistance Index (CRI) at the manufacturer's discretion.

1.5 Terms used in this specification are defined in Terminology **F1789** unless otherwise specified.

1.6 The values stated in either SI units or inch-pound units are to be regarded 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 10 and Appendix X1 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, health, and environmental 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:*<sup>2</sup>

**A325** Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength (Withdrawn 2016)<sup>3</sup>

**A325M** Specification for Structural Bolts, Steel, Heat Treated 830 MPa Minimum Tensile Strength (Metric) (Withdrawn 2016)<sup>3</sup>

**A490** Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength (Withdrawn 2016)<sup>3</sup>

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

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

**A490M** Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric) (Withdrawn 2016)<sup>3</sup>

**A1059** Specification for Zinc Alloy Thermo-Diffusion Coatings (TDC) on Steel Fasteners, Hardware, and Other Products

**B695** Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

**F436/F436M** Specification for Hardened Steel Washers Inch and Metric Dimensions

**F606/F606M** 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

**F1789** Terminology for F16 Mechanical Fasteners

**F1852** Specification for “Twist Off” Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength (Withdrawn 2016)<sup>3</sup>

**F2280** Specification for “Twist Off” Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 150 ksi Minimum Tensile Strength (Withdrawn 2016)<sup>3</sup>

**F3125** Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions

**G101** Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

2.2 *Research Council on Structural Connections*:<sup>4</sup>

Specification for Structural Joints Using High-Strength Bolts

2.3 *ASME Standard*:<sup>5</sup>

**ASME B18.2.6** Fasteners for Use in Structural Applications

**ASME B18.2.6M** Fasteners for Use in Structural Applications

### 3. Ordering Information

3.1 Orders for DTIs under this specification shall include the following:

3.1.1 Quantity (number of pieces);

3.1.2 Name of product (DTI);

3.1.3 Size, that is, nominal diameter;

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

3.1.5 Type required, 325-1, 325-3, 490-1, 490-3, 8.8-1, 8.8-3, 10.9-1, 10.9-3 (see 1.2);

3.1.6 Coating type, if required (4.4);

3.1.7 Source inspection, if required (Section 11);

3.1.8 Test reports, if required (Section 13); and

3.1.9 Any special requirements.

### 4. Materials and Manufacture

4.1 Steel used in the manufacture of DTIs shall be produced by the basic-oxygen or electric-furnace process.

4.2 *Design*:

4.2.1 DTIs shall have a configuration produced by extrusion, punching, pressing, or similar forming, to permit a measurable decrease in thickness when placed in compression.

4.2.2 The design shall be such that the degree of plastic deformation shall indicate the tension in a tightened structural bolt. Supplementary indications of tension are permissible.

4.3 *Heat Treatment*:

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

4.3.2 If 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 reheating to not less than 800°F/427°C: 800 °F/427 °C.

4.4 *Protective Coatings*:

4.4.1 Unless otherwise specified, the DTIs shall be furnished “plain” with the “as fabricated” surface finish without protective coatings.

4.4.2 When “zinc coated” or “galvanized” is specified, the DTIs shall be zinc coated by the mechanical deposition process in accordance with the requirements of Class 55 of Specification **B695**, or the DTIs shall be zinc coated by the thermal diffusion process in accordance with the requirements of Class 25 of Specification **A1059**.

<sup>4</sup> Available from Research Council on Structural Connections at [www.boltcouncil.org](http://www.boltcouncil.org).

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

4.4.3 Other coatings are to be used only when approved by the DTI manufacturer.

**5. Chemical Composition**

5.1 DTIs shall conform to the full Heat Analysis specified in **Table 1** or the requirements of **5.2**.

5.1.1 For all types furnished to the chemical compositions in **Table 1**, Product Analysis may be made by the purchaser from finished DTIs representing each lot. The chemical composition shall conform to the requirements given in **Table 1**, Product Analysis.

5.2 Type 3 products having Copper, Phosphorus, and Sulfur conforming to **Table 1** and a Corrosion Resistance Index of 6 or higher calculated on the basis of the Heat Analysis as described in Guide **G101** shall be considered acceptable. See **Note 1**.

*NOTE 1*—The user is cautioned that the Guide **G101** predictive equation for calculation of an atmospheric corrosion index has been verified only for the composition limits stated in that guide.

5.2.1 Product Analyses are not applicable to Type 3 indicators furnished to a CRI of 6 or higher. Acceptance shall be based on the CRI of 6 or higher calculated from the Heat Analysis. Other specified Type 3 Steels with Copper, Phosphorus, and Sulfur conforming to the specified limits and a Corrosion Resistance of 6 or higher, are acceptable in lieu of compliance with the full specified Chemical Compositions.

**6. Performance Requirements**

6.1 *Compression Loads*—When the gap of inch series DTIs are compressed to 0.015 in. or metric series DTIs to 0.4 mm, the compression load shall conform to the requirements specified in **Table 2**.

6.2 *Hardness*—When DTIs are heat-treated in accordance with **4.3.2**, the maximum hardness shall be HRC37.

**7. Dimensions**

7.1 Except as permitted by **7.1.1** and **7.1.2** the DTIs shall conform to the dimensional and related requirements of ASME B18.2.6 for inch series and ASME B18.2.6M for metric series products.

7.1.1 At the manufacture’s discretion, the number of protrusions may be altered provided there are no fewer than four protrusions and the performance requirements of Section **6** are maintained.

7.1.2 The minimum outside diameter of the DTIs may alternatively match the minimum outside diameter requirements of the matching nominal size ASTM **F436/F436M** washer.

**8. Workmanship, Finish, and Appearance**

8.1 The DTIs shall be commercially smooth and free of injurious material or manufacturing defects that would affect their performance.

**9. Number of Tests and Retests**

9.1 *Responsibility:*

9.1.1 The DTI manufacturer shall inspect each lot of DTIs prior to shipment in accordance with the quality assurance procedures described in **9.2**.

9.1.2 The purchaser is required to maintain the identification and integrity of each lot following delivery until the product is installed in its service application.

9.2 *Production Lot Method:*

**TABLE 1 Chemical Composition Requirements**

Element	Composition, %			
	Heat Analysis		Product Analysis	
	Type 1 Series	Type 3 Series <sup>A</sup>	Type 1 Series	Type 3 Series <sup>A</sup>
Carbon	0.30–0.55	...	0.27–0.58	...
Manganese	0.50–0.90	...	0.47–0.93	...
Phosphorus, Max	0.04	0.040	0.048	0.045
Sulfur, Max	<del>0.045</del>	<del>0.050</del>	<del>0.053</del>	<del>0.055</del>
Sulfur, Max	0.05	0.050	0.053	0.055
Silicon	<del>0.15–0.35</del>	<del>0.15–0.35</del>	<del>0.13–0.37</del>	<del>0.13–0.37</del>
Silicon	...	0.15–0.35	...	0.13–0.37
Chromium	...	0.45–0.65	...	0.42–0.68
Nickel	...	0.25–0.45	...	0.22–0.48
Copper	...	0.25–0.45	...	0.22–0.48

<sup>A</sup> Type 3 DTIs are also permitted to be manufactured from any of the Type 3 steels in the chemical composition sections of Specification **F3125**. Unless otherwise specified, the manufacturer may use Type 3 steel to produce Type 1 product.