



Designation: **F959 – 13 F959 – 15**

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

This standard is issued under the fixed designation F959; 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~~ indicators, (DTIs) capable of indicating the achievement of a specified minimum bolt tension in a structural bolt.

1.2 ~~Four~~Eight types of ~~direct tension indicators~~ 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~~325-1 ~~direct tension indicators~~ DTIs for use with Specification A325 Type 1 bolts or F or F1852 assemblies.

1.2.2 ~~Type 325-3~~ direct tension indicators DTIs for use with Specification A325 Type 3 bolts or F1852 Type 3 assemblies.

1.2.3 ~~Type 490~~490-1 ~~direct tension indicators~~ DTIs for use with Specification A490 Type 1 bolts or F2280 assemblies.

1.2.4 ~~Type 490-3~~ direct tension indicators DTIs for use with Specification A490 Type 3 F2280 Type 3 assemblies.

1.2.5 ~~Type 8.8-1~~ DTIs for use with Specification A325M Type 1 bolts.

1.2.6 ~~Type 8.8-3~~ DTIs for use with Specification A325M Type 3 bolts.

1.2.7 ~~Type 10.9-1~~ DTIs for use with Specification A490M Type 1 bolts.

1.2.8 ~~Type 10.9-3~~ DTIs for use with Specification A490M Type 3 bolts.

1.3 ~~Direct tension indicators~~ DTIs are intended for installation under either a bolt head or a hardened washer. (See Research Council on Structural Connections: Specification for Structural Joints Using ASTM High-Strength A325 or A490 Bolts.)

1.4 This specification provides for furnishing ~~Types 325-3 and 490-3~~ Type 3 DTIs to a Chemical Composition Requirement or a Corrosion Resistance Index (CRI) at the ~~suppliers option~~ manufacturer's discretion.

1.5 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in ~~this~~ Terms used in this specification are defined in Terminology F1789 ~~standard~~; unless otherwise specified.

1.6 The following precautionary statement pertains only to the test method portions, Section ~~1210~~ 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 and health practices and determine the applicability of regulatory limitations prior to use.*

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

A325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

A325M Specification for Structural Bolts, Steel, Heat Treated 830 MPa Minimum Tensile Strength (Metric)

A490 Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength

A490M Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric)

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

~~D3951 Practice for Commercial Packaging~~

F436 Specification for Hardened Steel Washers

F436M Specification for Hardened Steel Washers (Metric)

<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, 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

~~F606~~F606/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

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

F2280 Specification for “Twist Off” Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 150 ksi Minimum Tensile Strength

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

2.2 *Research Council on Structural Connections:*<sup>3</sup>

Specification for Structural Joints Using ASTM High-Strength A325 or A490 Bolts

2.3 *ASME Standard:*<sup>4</sup>

ASME B18.2.6 Fasteners for Use in Structural Applications

ASME B18.2.6M Fasteners for Use in Structural Applications

### 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 ~~compressible washer-type direct tension indicator, n~~—washer-type element inserted under the bolt head or hardened washer, having the capability of indicating the achievement of a required minimum bolt tension by the degree of direct tension indicator plastic deformation. Hereafter referred to as *direct tension indicator*.

### 3. Ordering Information

3.1 Orders for ~~direct tension indicators~~ DTIs under this specification shall include the following:

3.1.1 Quantity (number of pieces);

3.1.2 Name of product (~~direct tension indicator~~); (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, 325-3, 490, 490-3~~ 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 (~~5.44.4~~);

3.1.7 Source inspection, if required (Section ~~1311~~);

3.1.8 Certificates of compliance or test reports, if required (Section ~~1513~~); and

3.1.9 Any special requirements.

### 4. Materials and Manufacture

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

4.2 *Design:*

4.2.1 ~~Direct tension indicators~~ 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.

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 heating to a suitable temperature.

4.4 *Protective Coatings:*

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

4.4.2 When “~~zinc coated~~” zinc coated is specified, the ~~direct tension indicators~~ DTIs shall be zinc coated by the mechanical deposition process in accordance with the requirements of Class 55 of Specification B695.

~~5.4.3 When “baked epoxy” is specified, the epoxy shall be 0.001 to 0.002 in. thick applied over the zinc coating specified in 5.4.2. The epoxy shall not flake off exposed surfaces during installation.~~

4.4.3 Other coatings are to be used only when approved by the ~~direct tension indicator~~ DTI manufacturer.

<sup>3</sup> Available from Research Council on Structural Connections at [www.boltcouncil.org](http://www.boltcouncil.org).

<sup>4</sup> Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

## 5. Chemical Composition

5.1 Direct tension indicators furnished to Chemical Composition Requirements 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 In addition to the compositions in [Table 1](#), weathering steels type 325-3 and Type 490-3 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 Predictive Method based on the data of Larabee and Coburn](#) shall be considered acceptable. See [Note 1](#).

NOTE 1—The user is cautioned that the Guide [G101](#) predictive equation ([Predictive Method Based on the Data of Larabee and Coburn](#)) 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.

6.3 For all types furnished to the chemical compositions in [Table 1](#), 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 1](#), Product Analysis.

6.4 Product Analyses are not applicable to Type 325-3 and Type 490-3 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 weathering 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 compressed to the gap specified in [Table 2](#), 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 32](#).

## 7. Dimensions

7.1 The direct tension indicators 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 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](#) washer

## 8. Workmanship, Finish, and Appearance

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

**TABLE 1 Chemical Composition Requirements**

Element	Composition, %			
	Heat Analysis		Product Analysis	
	Type 325 and 1 Series Type 490	Type 325-3 and 3 Series Type 490-3 <sup>A</sup>	Type 325 and 1 Series Type 490	Type 325-3 and 3 Series Type 490-3 <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	0.045	0.050	0.053	0.055
Silicon	0.15–0.35	0.15–0.35	0.13–0.37	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> Weathering steel Type 3 DTIs are also permitted to be manufactured from any of the Type 3 steels in the chemical composition sections of Specifications [A325](#) and [F436](#) or [A325M](#) and [F436M](#).