



Designation: F959/F959M – 17

Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, Inch and Metric Series¹

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 (ϵ) 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 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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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 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

A325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength (Withdrawn 2016)³

A325M Specification for Structural Bolts, Steel, Heat Treated 830 MPa Minimum Tensile Strength (Metric) (Withdrawn 2016)³

A490 Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength (Withdrawn 2016)³

A490M Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints (Metric) (Withdrawn 2016)³

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

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.

³ The last approved version of this historical standard is referenced on www.astm.org.

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

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)³

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Off” Type Tension Control Structural Bolt/Nut/Washer Assemblies, Steel, Heat Treated, 150 ksi Minimum Tensile Strength (Withdrawn 2016)³

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*.⁴
Specification for Structural Joints Using High-Strength Bolts

2.3 *ASME Standard*.⁵

ASME B18.2.6 Fasteners for Use in Structural Applications

ASME B18.2.6M Fasteners for Use in Structural Applications

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.

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**.

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.

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;

⁴ Available from Research Council on Structural Connections at www.boltcouncil.org.

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

TABLE 1 Chemical Composition Requirements

Element	Composition, %			
	Heat Analysis		Product Analysis	
	Type 1 Series	Type 3 Series ⁴	Type 1 Series	Type 3 Series ⁴
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

⁴ Type 3 DTIs are also permitted to be manufactured from any of the Type 3 steels in the chemical composition sections of Specification **F3125**.

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:

9.2.1 All DTIs shall be processed in accordance with a lot identification control–quality assurance plan. The manufacturer shall identify and maintain the integrity of each production lot of DTIs 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.

9.2.2 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**.

9.3 *Number of Tests After Alterations*—If DTIs are heat treated, coated, or otherwise altered by a subcontractor or manufacturer subsequent to testing, they shall be tested in accordance with **9.2** prior to shipment to the purchaser after all alterations have been completed.

9.4 When Type 3 products are furnished to a Corrosion Resistance Index, the CRI number shall be calculated for each lot.

10. Test Methods

10.1 Compression load tests shall be conducted in accordance with Test Methods **F606/F606M**.

10.1.1 All test specimens shall conform to the values given in **Table 2**, regardless of surface coating (lubricants included).

10.2 DTIs for tests shall be tested full size “as received” without any special preparation.

10.3 Results from routine hardness tests performed during production of heat-treated DTIs satisfy the requirement for verification that product hardness does not exceed HRC37.

10.4 The Corrosion Resistance Index shall be calculated for the Heat Analysis in accordance with Guide **G101** Predictive Method based on the data of Larabee and Coburn.

TABLE 2 Acceptable Range of Compression Loads

DTI Size (Nominal Diameter, in.)	Compression Load Range in Thousands of Pounds, (kips)	
	Types 325 and 325-3	Types 490 and 490-3
1/2	12–14	15–18
5/8	19–23	24–29
3/4	28–34	35–42
7/8	39–47	49–59
1	51–61	64–77
1 1/8	56–67	80–96
1 1/4	71–85	102–122
1 3/8	85–102	121–145
1 1/2	103–124	148–178
DTI Size (Nominal Diameter, mm)	Compression Load Range for Metric Series in Kilonewtons, (kN)	
	Types 8.8-1 and 8.8-3	Types 10.9-1 and 10.9-3
M16	91–109	114–131
M20	142–170	179–206
M22	176–211	221–254
M24	205–246	257–296
M27	267–320	334–384
M30	326–391	408–469
M36	475–570	595–684

11. Inspection

11.1 If the inspection described in 11.2 is required by the purchaser, it shall be specified in the inquiry and contract or order.

11.2 The purchaser's quality assurance representative shall have free entry to all parts of the manufacturer's works that concern the manufacture of the DTIs ordered. The manufacturer shall afford the quality assurance representative all reasonable facilities to satisfy him that the DTIs 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.

12. Rejection

12.1 DTIs that fail to conform to the requirements of this specification shall be rejected. 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.

13. Test Reports

13.1 When specified on the order, the manufacturer shall furnish a test report as described in 13.2.

13.2 The manufacturers shall furnish a test report for each production lot from which DTIs 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), compression test loads, a statement indicating that product hardness is less than HRC38, Corrosion Resistance Index Number when applicable, measured thickness of protective coatings, gap, nominal size, production lot identification number, ASTM designation, type and issue date, and purchase order number.

13.3 When Type 3 products are furnished to a Corrosion Resistance Index, the CRI number shall be furnished for each lot.

14. Responsibility

14.1 The party responsible for the DTI shall be the organization that supplies the DTI to the purchaser.

15. Product Marking

15.1 Each DTI shall be marked to identify the lot number, manufacturer or private label distributor, as appropriate, and type (see 1.2). Additional markings, at the option of the manufacturer, are permissible.

15.2 All markings shall be depressed on the same face of the DTI as the protrusions. Raised markings are prohibited.

15.3 All DTIs shall have circumferential indentations, or other markings, that correspond to and are in alignment with feeler gage entry spaces to indicate where feeler gages are to be inserted. Such indentations or markings shall be equally spaced around the DTI and shall be clearly visible but no so large as to interfere with the function of the DTI.

16. Packaging and Package Marking

16.1 Packaging:

16.1.1 Unless otherwise specified on the inquiry and order, packaging shall be in accordance with the supplier's normal practice.

16.2 Package Marking:

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

ASTM designation and type,

Size,

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

Number of pieces,

Name of product,

Lot identification number,

Finish, and

Country of origin.

17. Storage

17.1 The DTIs shall be stored in an environment that preserves the surface condition supplied by the manufacturer.

18. Keywords

18.1 compressible-washer-type; direct tension indicators; DTI; indicators

APPENDIX

(Nonmandatory Information)

X1. FIELD TESTING OF DIRECT TENSION INDICATORS FOR BOLT TENSION

DTIs may be field tested in a bolt tension calibrator with bolts, nuts, and flat washers, according to the provisions of the Research Council of Structural Connections Specification for Structural Joints Using High-Strength Bolts to determine a job inspection gap. The job inspection gap shall be a gap less than the measured DTI test gap at 1.05× the minimum required bolt tension.

Because bolt tension calibrators are “soft” devices, unlike hard steel connections, care should be taken to tension the bolts with a non-impacting wrench so the tension readings can be recorded exactly.

SUMMARY OF CHANGES

Committee F16 has identified the location of selected changes to this standard since the last issue (F959–15) that may impact the use of this standard. (April 15, 2017.)

- (1) Corrected title and standard number for consistency with a dual inch/metric standard.
- (2) Updated Scope section to point to **F3125**.
- (3) Eliminated Certificates of Compliance.
- (4) Added a maximum hardness.

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