



# 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 (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 capable of indicating the achievement of a specified minimum bolt tension in a structural bolt.

1.2 Four types of direct tension indicators in nominal diameter sizes ½ through 1½ in. are covered:

1.2.1 *Type 325*—direct tension indicators for use with Specification **A325** Type 1 bolts or **F** or **F1852** assemblies.

1.2.2 *Type 325–3*—direct tension indicators for use with Specification **A325** Type 3 or **F1852** Type 3 assemblies.

1.2.3 *Type 490*—direct tension indicators for use with Specification **A490** Type 1 bolts or **F2280** assemblies.

1.2.4 *Type 490–3*—direct tension indicators for use with Specification **A490** Type 3 **F2280** Type 3 assemblies.

1.3 Direct tension indicators 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 **A325** or **A490** Bolts.)

1.4 This specification provides for furnishing Types 325–3 and 490–3 to a Chemical Composition Requirement or a Corrosion Resistance Index (CRI) at the suppliers option.

1.5 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 The following precautionary statement pertains only to the test method portions, Section 12 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.*

<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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## 2. Referenced Documents

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

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

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

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

**D3951** Practice for Commercial Packaging

**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

**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 **A325** or **A490** Bolts

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

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

## 3. Terminology

### 3.1 Definitions of Terms Specific to This Standard:

<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> 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>.

\*A Summary of Changes section appears at the end of 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*.

#### 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 required, 325, 325-3, 490, 490-3 (see 1.2);
- 4.1.6 Coating type, if required (5.4);
- 4.1.7 Source inspection, if required (Section 13);
- 4.1.8 Certificates of compliance or test reports, if required (Section 15); and
- 4.1.9 Any special requirements.

#### 5. Materials and Manufacture

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

##### 5.2 Design:

5.2.1 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.

5.2.2 The design shall be such that the degree of plastic deformation shall indicate the tension in a tightened structural bolt.

##### 5.3 Heat Treatment:

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 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.

#### 5.4 Protective Coatings:

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 “zinc coated” is specified, the direct tension indicators 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.

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

#### 6. Chemical Composition

6.1 Direct tension indicators furnished to Chemical Composition Requirements shall conform to the full Heat Analysis specified in Table 1.

6.2 In addition to the compositions in Table 1, weathering steels type 325–3 and Type 490–3 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.

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.

**TABLE 1 Chemical Composition Requirements**

| Element         | Composition, %        |                                        |                       |                                        |
|-----------------|-----------------------|----------------------------------------|-----------------------|----------------------------------------|
|                 | Heat Analysis         |                                        | Product Analysis      |                                        |
|                 | Type 325 and Type 490 | Type 325-3 and Type 490-3 <sup>A</sup> | Type 325 and Type 490 | Type 325-3 and 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 DTIs are also permitted to be manufactured from any of the Type 3 steels in the chemical composition sections of Specifications A325 and F436.

## 7. Performance Requirements

7.1 *Compression Loads*—When compressed to the gap specified in Table 2, the compression load shall conform to the requirements specified in Table 3.

## 8. Dimensions

8.1 The direct tension indicators shall conform to the dimensional and related requirements of ASME B18.2.6.

## 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 Production 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 production 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 production 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, and heat treated in the same heat treatment cycle.

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.

**TABLE 2 Direct Tension Indicator Gap for Compression Load Testing**

| Direct Tension Indicator Finish                       | Gap, in.              |                       |
|-------------------------------------------------------|-----------------------|-----------------------|
|                                                       | Specification<br>A325 | Specification<br>A490 |
| Plain finish                                          | 0.015                 | 0.015                 |
| Mechanically galvanized                               | 0.015                 | ...                   |
| Baked epoxy coating on<br>mechanically deposited zinc | 0.015                 | ...                   |

**TABLE 3 Acceptable Range of Compression Loads**

| Direct Tension Indicator Size<br>(bolt diameter, (in.)) | Compression Load Range in Thousands<br>of Pounds, (kips) |                        |
|---------------------------------------------------------|----------------------------------------------------------|------------------------|
|                                                         | Types 325 and<br>325-3                                   | Types 490 and<br>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                |

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

10.4 When weathering steels are furnished to a Corrosion Resistance Index, the CRI number shall be calculated for each heat.

## 11. Specimen Preparation

11.1 Indicators 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.

12.2 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.

## 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. 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 or a certificate of compliance as described in 15.4, whichever is required.

15.2 When test reports are required, the manufacturers shall furnish a test report for each production 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), compression test loads, 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.

15.3 When weathering steels Ttypes 325–3 and 490–3 are furnished under the Corrosion Resistance Index option, the calculated CRI number shall be furnished for each heat.

15.4 When certificates of compliance are required, the manufacturer shall furnish a certificate certifying that the indicators have been manufactured and tested and conform to the requirements of this specification. The certificate shall show the production lot identification number, nominal size, ASTM designation, type and issue date, and purchase order number.

## 16. Responsibility

16.1 The party responsible for the direct tension indicator shall be the organization that supplies the direct tension indicator to the purchaser.

## 17. Product Marking

17.1 Each direct tension indicator shall be marked to identify the lot number, manufacturer or private label distribution, as appropriate, and type (see 1.2).

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

17.3 All direct tension indicators shall have a 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 direct tension indicator and shall be clearly visible but no so large as to interfere with the function of the direct tension indicator.

## 18. Packaging and Package Marking

### 18.1 Packaging:

18.1.1 Unless otherwise specified, packaging shall be in accordance with Practice D3951.

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

18.1.3 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 Purchase order number,

18.2.1.6 Name of product,

18.2.1.7 Lot identification number,

18.2.1.8 Finish, and

18.2.1.9 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; 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 A325 or A490 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 (F959–09) that may impact the use of this standard. (Approved March 1, 2013)

(1) Revised Heat Treatment requirements to clarify that through hardening is optional and at the Manufactures' discretion.

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