



Designation: F 1554 – 04<sup>ε1</sup>

## Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength<sup>1</sup>

This standard is issued under the fixed designation F 1554; 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 approval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

<sup>ε1</sup> NOTE—Section S1.5.1 was editorially corrected in March 2007.

### 1. Scope\*

1.1 This specification covers straight and bent, headed and headless, carbon, carbon boron, alloy, or high-strength low-alloy steel anchor bolts (also known as anchor rods). The anchor bolts are furnished in three strength grades, two thread classes, and in the sizes specified in Section 4.

1.2 The anchor bolts are intended for anchoring structural supports to concrete foundations. Such structural supports include building columns, column supports for highway signs, street lighting and traffic signals, steel bearing plates, and similar applications.

1.3 Supplementary requirements are included to provide for Grade 55 weldable steel, permanent manufacturers and grade identification, and impact properties for Grades 55 and 105.

1.4 Zinc coating requirements are included in Section 7 for applications requiring corrosion protection.

1.5 The recommended grade and style of nut and washer are included in 6.6 and 6.7 for each grade.

1.6 This specification does not cover the requirements for mechanical expansion anchors, powder-activated nails or studs, or anchor bolts fabricated from deformed bar.

1.7 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

### 2. Referenced Documents

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

**A 153/A 153M** Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

**A 194/A 194M** Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both

**A 370** Test Methods and Definitions for Mechanical Testing of Steel Products

**A 563** Specification for Carbon and Alloy Steel Nuts

**A 673/A 673M** Specification for Sampling Procedure for Impact Testing of Structural Steel

**A 751** Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products

**B 695** Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel

**D 3951** Practice for Commercial Packaging

**F 436** Specification for Hardened Steel Washers

**F 606** Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets

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

Specification for Structural Joints Using ASTM A325 or A490 Bolts

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

**B 1.1** Unified Screw Threads

**B 1.3** Screw Thread Gaging Systems for Dimensional Acceptability

**B 18.2.2** Square and Hex Nuts

**B 18.18.2M** Inspection and Quality Assurance for High Volume Machine Assembly Fasteners

### 3. Terminology

3.1 *Definitions of Terms Specific to This Standard*:

3.1.1 *anchor bolt*—steel rod or bar, one end of which is intended to be cast in concrete, while the opposite end is threaded and projects from the concrete, for anchoring other material to the concrete. The end cast in concrete may be either straight or provided with an anchor such as a bent hook, forged head, or a tapped or welded attachment to resist forces imposed on the anchor bolt, as required.

3.1.2 *manufacturer*—manufacturer of the anchor bolt; the party that performs the cutting, bending, and threading operations.

3.1.3 *producer*—manufacturer of the steel rods or bars.

<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.

<sup>3</sup> Available from Research Council on Structural Connections, c/o Industrial Fasteners Institute, 1717 East 9th Street, Cleveland, OH 44114.

<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.

3.1.4 *purchaser*—purchaser of the finished anchor bolt, or his designated agent.

3.1.5 *responsible party*—see Section 18; this may be the manufacturer or supplier.

3.1.6 *supplier*—agent who furnishes the finished anchor bolt and nuts to the purchaser; this may be the manufacturer.

#### 4. Classification

4.1 The anchor bolts are furnished in three grades denoting minimum yield strength and two classes denoting thread class as follows:

| Grade           | Tensile Strength, ksi (MPa)        | Description<br>Yield Strength, min, ksi (MPa) | Size Range, in. (mm) |
|-----------------|------------------------------------|---|----------------------|
| 36 <sup>A</sup> | 58–80 (400–558)                    | 36 (248)                                      | ¼–4 (6.4–102)        |
| 55              | 75–95 (517–655)                    | 55 (380)                                      | ¼–4 (6.4–102)        |
| 105             | 125–150 (862–1034)                 | 105 (724)                                     | ¼–3 (6.4–76)         |
| Class           |                                    |   |                      |
| 1A              | anchor bolts with Class 1A threads |   |                      |
| 2A              | anchor bolts with Class 2A threads |   |                      |

<sup>A</sup> When Grade 36 is specified, a weldable Grade 55 may be furnished at the supplier's option.

4.2 Weldable steel for Grade 55 is provided for in Supplementary Requirement SI.

#### 5. Ordering Information

5.1 Orders for anchor bolts should include the following information:

5.1.1 *Quantity (Number of Pieces)*—If the purchaser intends to perform destructive tests on finished anchor bolts, the manufacturer should be advised so that an adequate number are produced, especially for the sizes and types not readily available from stock.

5.1.2 Name of product (steel anchor bolt).

5.1.3 ASTM designation and year of issue.

5.1.4 Grade and class, that is, Grade 36, 55, or 105 and Class 1A or 2A. Weldable Grade 55 may be furnished when Grade 36 is ordered (see 4.1).

5.1.5 Copper, if copper bearing steel is required.

5.1.6 *Size and Dimensions*—Include the diameter and threads (based on nominal thread diameter), bolt length, thread length, and length of hook if a hook is required, or provide a drawing showing the required information.

5.1.7 Zinc coatings in accordance with 7.1. When zinc coatings in accordance with 7.1 are required, specify the zinc coating process to be used, that is, hot dip, mechanically deposited, or no preference (see 7.1). Also, specify the length to be coated as measured from the exposed end.

5.1.8 *Other Coatings*—Specify other protective coatings, if required (see 7.2).

5.1.9 Number of nuts, either the total number or number per bolt.

5.1.10 Number of washers, either the total number or number per bolt, and dimensions if other than standard.

5.1.11 Inspection at place of manufacture, if required (see 15.1).

5.1.12 Color coding, if different from the standard in 19.1.

5.1.13 Test reports, if required (see 17.1).

5.1.14 Supplementary requirements, if required.

5.1.15 Special requirements, if required.

NOTE 1—An example of a typical order follows: 5000 pieces; steel anchor bolts; ASTM designations including issue date; Grade 55; Class 2A; Supplementary Requirement S 1; 1.0-8-in. thread size by 15-in. long, 3.0-in. thread length, 4.0-in. hook; zinc coated by hot dipping 5.0 in. from exposed end; each with one zinc-coated nut and washer; test report required.

#### 6. Materials and Manufacture

6.1 *Process*—Steel for anchor bolts shall be made by the open-hearth, basic-oxygen, or electric-furnace process.

6.2 *Threading*—Threads shall be rolled, cut, or ground at the option of the manufacturer, unless otherwise specified.

6.3 *Heat Treatment*:

6.3.1 When required, the anchor bolts may be heat treated to develop the specified properties. Heat treatment shall be at the option of the manufacturer.

6.3.2 Heat treatment may be performed prior to or after bending or threading.

6.3.3 When heat treatment is required, the anchor bolts shall be heat treated by quenching in a liquid medium from above the transformation temperature and then tempering by reheating to a temperature not less than 800°F (425°C) for Grade 55 and 1100°F (593°C) for Grade 105.

6.4 *Bending*:

6.4.1 When required, hooks, shall be made by cold bending or hot bending. The bent portion shall be free from cracks when examined at 10× magnification after bending.

6.4.2 Hot bending performed on bar stock without heat treatment shall not have the temperature exceed 1300°F (705°C) at any location during hot bending and shall be allowed to air cool after bending.

6.4.3 Hot bending performed on heat-treated bar stock shall not have the temperature come within 100°F (56°C) of the tempering (stress relieve) temperature of the heat-treat process at any location during hot bending and shall be allowed to air cool after bending.

6.4.4 The bending shall not reduce the cross-sectional area below that required in 10.3.

6.5 *Secondary Processing*—If a subcontractor, or party other than the manufacturer or producer, performs heat treatment, coating, welding, machining, or other process affecting the properties or performance of the anchor bolts, the anchor bolts shall be inspected and tested after such processing by the party responsible for supplying the anchor bolts to the purchaser.

6.6 *Recommended Nuts*:

6.6.1 Unless otherwise specified, all nuts used on these anchor bolts shall conform to the requirements of Specifications A 194/A 194M or A 563 and shall be of the grade, surface finish, and style for each grade and size of anchor bolt as follows:

| Anchor Bolt Grade and Size, in. (mm)               | Specification A 563 Recommended Nut |  |       |         |  |
|--|-------------------------------------|--|-------|---------|--|
|  | Plain                               | Hot-Dip or Mechanical Zinc Coated in accordance with 7.1 |       |         |  |
| Grade    Size, in. (mm)                            | Grade                               | Style  | Grade | Style   |  |
| 36<br>¼ – 1½ (6.4–38)<br>over 1½ – 4.0<br>(38–102) | A                                   | Hex  | A     | Hex     |  |
|  | A                                   | Heavy Hex  | A     | Hvy Hex |  |
| 55<br>¼ – 1½ (6.4–38)<br>over 1½ – 4.0<br>(38–102) | A                                   | Hex  | A     | Hvy Hex |  |
|  | A                                   | Heavy Hex  | A     | Hvy Hex |  |
| 105<br>¼ – 1½ (6.4–38)<br>over 1½ – 3.0<br>(38–76) | D                                   | Hex  | DH    | Hvy Hex |  |
|  | DH                                  | Heavy Hex  | DH    | Hvy Hex |  |

6.6.2 The requirements for the recommended grade and style of nut may be fulfilled by furnishing a nut of one of the grades or styles listed in Specifications A 194/A 194M or A 563 having a proof load stress equal to or higher than the minimum tensile strength specified for the anchor bolt.

6.7 Recommended Washers:

6.7.1 The washer material and dimensions shall be specified in the inquiry and the order (see Note 2).

6.7.2 Unless the requirement of 6.7.1 is met, washers conforming to the requirements of Specification F 436, Type 1 shall be furnished.

6.7.3 When anchor bolts are specified to be zinc coated, the washers shall be zinc coated as specified in 7.1, except that the coating process for the washers need not be the same as that for the anchor bolts and nuts.

NOTE 2—Washers used on anchor bolts, installed in holes with dimensions greater than oversize or short slot as defined by the Research Council on Structural Connections, require design consideration. (For guidance refer to Specification for Structural Joints Using ASTM A 325 or A 490 Bolts.)

7. Protective Coatings

7.1 Zinc, Hot Dip or Mechanically Deposited—Specification A 153/A 153M, Class C, and mechanically deposited, Specification B 695, Class 50.

7.1.1 When zinc-coated anchor bolts with the coating specified in 7.1 are required, the purchaser shall specify the zinc coating process, for example, hot dip, mechanically deposited, or no preference.

7.1.2 When hot-dip is specified, the fasteners shall be zinc coated by the hot-dip process in accordance with the requirements of Class C of Specification A 153/A 153M.

7.1.3 When mechanically deposited is specified, the fasteners shall be zinc coated by the mechanical deposition process in accordance with the requirements of Class 50 of Specification B 695.

7.1.4 When no preference is specified, the supplier may furnish either a hot-dip zinc coating in accordance with Specification A 153/A 153M, Class C, or a mechanically deposited zinc coating in accordance with Specification B 695, Class 50. Threaded components (bolts and nuts) shall be coated by the same zinc-coating process, and the supplier’s option is limited to one process per item, with no mixed processes in a lot.

7.2 Other Coatings:

7.2.1 Coatings other than the zinc coatings specified in 7.1 shall be as specified by the purchaser on the purchase order.

7.2.2 The complete specification shall be included as part of the purchase order when other coatings are specified.

8. Chemical Composition

8.1 Anchor bolts shall have a chemical composition conforming to the requirements listed in Table 1 for Grade 36 and Table 2 for Grades 55 and 105.

8.2 Grade 55 ordered as weldable shall conform to the requirements specified in Supplementary Requirement S1.

8.3 Anchor bolts made from low-carbon martensitic steel shall not be permitted.

8.4 The application of heats of steel to which bismuth, selenium, tellurium, or lead has been added intentionally shall not be permitted.

8.5 Product analyses may be made by the purchaser from finished anchor bolts representing each heat. The chemical composition thus determined shall conform to the requirements specified in 8.1 through 8.4.

9. Mechanical Properties

9.1 Bars—The bars or rods from which the anchor bolts are made shall conform to the tensile properties listed in Table 3, except when heat treated after bending or threading.

9.2 Anchor Bolts—The finished anchor bolts shall conform to the tensile properties listed in Table 3 for tests on machined specimens and Table 4 for axial tests on full-size threaded anchor bolts.

10. Anchor Bolt Dimensions

10.1 Nominal Size—The nominal anchor bolt diameter shall be the same as the nominal thread diameter.

10.2 Body Diameter:

10.2.1 When threads are rolled, the body diameter shall not be less than the minimum pitch diameter for the thread class, 1A or 2A, designated by the purchaser and specified in ANSI/ASME B 1.1. Class 2A shall be furnished when the thread class is not specified.

10.2.2 The body diameter shall not be less than the minimum major diameter when threads are cut.

TABLE 1 Chemical Requirements for Grade 36

| Element                         | Diameter, in. (mm) |                                  |                                      |
|---------------------------------|--------------------|----------------------------------|--------------------------------------|
|                                 | To ¾ (20),<br>incl | Over ¾ to 1½<br>(20 to 40), incl | Over 1½ to<br>4 (40 to<br>100), incl |
| Carbon, max, %                  |                    |                                  |                                      |
| Heat                            | 0.26               | 0.27                             | 0.28                                 |
| Product                         | 0.29               | 0.30                             | 0.31                                 |
| Manganese, %                    |                    |                                  |                                      |
| Heat                            | A                  | 0.60–0.90                        | 0.60–0.90                            |
| Product                         | A                  | 0.54–0.98                        | 0.54–0.98                            |
| Phosphorus, max, %              |                    |                                  |                                      |
| Heat                            | 0.04               | 0.04                             | 0.04                                 |
| Product                         | 0.05               | 0.05                             | 0.05                                 |
| Sulfur, max, %                  |                    |                                  |                                      |
| Heat                            | 0.05               | 0.05                             | 0.05                                 |
| Product                         | 0.06               | 0.06                             | 0.06                                 |
| Copper, min, % (when specified) |                    |                                  |                                      |
| Heat                            | 0.20               | 0.20                             | 0.20                                 |
| Product                         | 0.18               | 0.18                             | 0.18                                 |

<sup>A</sup> Optional with the manufacturer but shall be compatible with weldable steel.

**TABLE 2 Chemical Requirements for Grades 55 and 105**

| Element                            | Composition, % |                  |
|------------------------------------|----------------|------------------|
|                                    | Heat Analysis  | Product Analysis |
| Phosphorous, max                   | 0.040          | 0.048            |
| Sulfur, max                        | 0.050          | 0.058            |
| Copper, min (when Cu is specified) | 0.20           | 0.18             |

**TABLE 3 Tensile Properties for Bars and Machined Specimens**

|   | Grade     |           |            |
|---|-----------|-----------|------------|
|   | 36        | 55        | 105        |
| Tensile strength, ksi                             | 58–80     | 75–95     | 125–150    |
| Tensile strength, MPa                             | (400–552) | (517–655) | (862–1034) |
| Yield strength, min, ksi (0.2 % offset)           | 36        | 55        | 105        |
| Yield strength, min, MPa (0.2 % offset)           | 248       | 380       | 724        |
| Elongation in 8 in. (200 mm), min, % <sup>A</sup> | 20        | 18        | 12         |
| Elongation in 2 in. (50 mm), min, % <sup>A</sup>  | 23        | 21        | 15         |
| Reduction of Area, min, %                         |           |           |            |
| ¼ to 2 in. (6.4 to 50 mm), incl                   | 40        | 30        | 45         |
| over 2 to 2½ in. (50 to 63 mm), incl              | 40        | 22        | –45        |
| over 2½ to 3 in. (63 to 76), incl                 | 40        | 20        | 45         |
| over 3 to 4 in. (76 to 102 mm), incl              | 40        | 18        | ...        |

<sup>A</sup> Elongation in 8 in. (200 mm) applies to bars. Elongation in 2 in. (50 mm) applies to tests on machined specimens.

10.2.3 The minimum body diameters are listed in **Table 5** based on the requirements specified in 10.2.1 and 10.2.2.

10.3 *Bend Section*—The bend section of bent anchor bolts shall have a cross-sectional area not less than 90 % of the area of straight portions. The area in the bend shall be calculated by the following formula:  $A_b = 0.25\pi D \cdot d$

where

$A_b$  = cross-sectional area in the bend,

$d$  = minor (or minimum) diameter at any point, generally in the plane of the bend, and

$D$  = major diameter, at the same cross section as, and at 90 degrees to, the minor diameter.

#### 10.4 Length:

10.4.1 The overall length of straight anchor bolts, or length to the inside of the hook, shall be the specified length  $\pm \frac{1}{2}$  in. (13 mm) for lengths 24 in. (600 mm) or less, and  $\pm 1$  in. (25 mm) for longer bolts (see **Fig. 1**).

10.4.2 The length of hooks shall be the specified length,  $\pm 10$  % of the specified hook length, or  $\pm \frac{1}{2}$  in. (13 mm), whichever is greater.

10.5 *Bend Angle*—The bend angle of hooks shall not vary from that specified by more than  $\pm 5^\circ$ .

10.6 *Coated Length*—When only the exposed end of the anchor bolt is required to be zinc coated, the length of zinc coating shall not be less than that specified on the order.

#### 10.7 Other Dimensions:

10.7.1 Tolerances for dimensions other than those given in **10.1** through **10.6** shall be as specified by the purchaser.

10.7.2 When tolerances are not specified, they shall be in accordance with the manufacturer's documented standard practice.

## 11. Thread Dimensions

### 11.1 Uncoated Anchor Bolts:

11.1.1 Unless otherwise specified, uncoated threads shall be Unified Coarse Thread Series as specified in the latest issue of ANSI/ASME B 1.1, and they shall have Class 1A or 2A tolerances, as specified by the purchaser. Class 2A shall be furnished when the class is not specified.

11.1.2 When required, anchor bolts having a nominal diameter greater than 1.0 in. (25.5 mm) may be specified to have threads conforming to the 8-Thread Series (8 UN Series) in ANSI/ASME B 1.1, and they shall have Class 2A tolerances.

11.2 *Anchor Bolts Zinc Coated in Accordance With 7.1, Specification A 153/A 153M, Class C, and Specification B 695, Class 50:*

11.2.1 Unless otherwise specified, anchor bolts hot dip or mechanically zinc coated in accordance with **7.1.1** through **7.1.4** (requiring overtapped nuts, see **Note 3**) shall be the Unified Coarse Thread Series and shall have Class 1A or 2A threads, as specified by the purchaser, before zinc coating. After zinc coating, and due to the zinc buildup, the pitch and major diameters for hot-dip zinc-coated anchor bolts shall not exceed the dimensions listed in **Table 6**.

**NOTE 3**—Zinc-coated nuts of the grade and style recommended in **6.6.1**, when overtapped the diametral allowance for the thread series listed in the table entitled "Thread Dimensions and Overtapping Allowances for Nuts" in Specification **A 563**, will develop the bolt tensile strength required in **Table 4** of this specification.

11.2.2 Thread conformance shall be verified during manufacture. In case of dispute, a calibrated thread ring gage of the same size as the oversize limit specified in **11.2.1** (Class X tolerance, gage tolerance plus) shall be used to verify compliance. Assembly of the gage shall be possible with hand effort, following the application of light machine oil to prevent galling and damage to the gage.

11.3 *Thread Length*—The thread length shall not vary from that specified more than +1.0 in. (25.5 mm), –0.00 in. (0.00 mm).

11.4 *Thread Gaging System*—Thread acceptability shall be in accordance with System 21 or ANSI/ASME B 1.3, unless otherwise specified.

## 12. Workmanship

12.1 Anchor bolts shall be commercially smooth and free of burrs, laps, seams, cracks, and other injurious manufacturing defects that would make them unsuitable for the intended application.

## 13. Number of Tests and Retests

### 13.1 Testing Responsibility:

13.1.1 The anchor bolt manufacturer or supplier, whichever is the responsible party as defined in Section **18**, shall be responsible for conducting or ensuring that the required tests have been conducted to determine compliance with all of the requirements of this specification and the purchaser order.

13.1.2 Reports of tension tests, conducted by the steel producer on bar stock used to manufacture the anchor bolts without additional heat treatment, may be used to qualify the finished anchor bolt tensile properties.

13.1.3 The purchaser shall be permitted to perform any of the tests and inspections listed in this specification or the purchaser order.