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Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength¹

This standard is issued under the fixed designation A 307; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification² covers the chemical and mechanical requirements of three grades of carbon steel bolts and studs in sizes ¼ in. (6.35 mm) through 4 in. (104 mm). The fasteners are designated by “Grade” denoting tensile strength and intended use, as follows:

Grade	Description
Grade A	Bolts and studs having a minimum tensile strength of 60 ksi (414 MPa) and intended for general applications,
Grade B	Bolts and studs having a tensile strength of 60 to 100 ksi (414 to 690 MPa) and intended for flanged joints in piping systems with cast iron flanges, and
Grade C	Nonheaded anchor bolts, either bent or straight, having properties conforming to Specification A 36 (tensile strength of 58 to 80 ksi (400 to 550 MPa)) and intended for structural anchorage purposes.
Grade C	<u>Nonheaded anchor bolts, either bent or straight, having properties conforming to Specification A 36/A 36M (tensile strength of 58 to 80 ksi (400 to 550 MPa)) and intended for structural anchorage purposes.</u>

1.1.1 The term *studs* includes stud stock, sometimes referred to as *threaded rod*.

1.2 This specification does not cover requirements for machine screws, thread cutting/forming screws, mechanical expansion anchors or similar externally threaded fasteners.

1.3 Suitable nuts are covered in Specification A 563. Unless otherwise specified, the grade and style of nut for each grade of fastener, of all surface finishes, shall be as follows:

Fastener Grade and Size	Nut Grade and Style ^A
A, C, ¼ to 1½ in.	A, hex
A, C, over 1½ to 4 in.	A, heavy hex
B, ¼ to 4 in.	A, heavy hex

^A Nuts of other grades and styles having specified proof load stresses (Specification A 563, Table 3) greater than the specified grade and style of nut are also suitable.

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

1.5 Supplementary Requirement S1 of an optional nature is provided, which describes additional restrictions to be applied when

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² For ASME Boiler and Pressure Vessel Code applications see related Specification SA-307 in Section II of that Code.

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

bolts are to be welded. It shall apply only when specified in the inquiry, order, and contract.

1.6 Terms used in this specification are defined in Specification Terminology F 1789 unless otherwise defined herein.

2. Referenced Documents

2.1 *ASTM Standards:*³

A 36/A 36M Specification for Carbon Structural Steel

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

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

A 563 Specification for Carbon and Alloy Steel Nuts

A 706/A 706M Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement

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 606 Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets

F 1470 Guide for Fastener Sampling for Specified Mechanical Properties and Performance Inspection

F 1789 Terminology for F16 Mechanical Fasteners

2.2 *ANSI/ASME Standards:*

B 1.1 Unified Screw Threads⁴

B 18.2.1 Square and Hex Bolts and Screws⁴

B 18.24.1 Part Identifying Number (PIN) Code System⁵

2.3 *Military Standard:*

MIL-STD 105 Single Sampling Plan for Normal Inspection⁶

3. Ordering Information

3.1 Orders for externally threaded fasteners (including nuts and accessories) under this specification shall include the following:

3.1.1 ASTM designation and year of issue,

3.1.2 Name of product, bolts or studs; and bolt head style, that is, hex or heavy hex,

3.1.3 Grade, that is, A, or B, or C. If no grade is specified, Grade A is furnished.

3.1.4 Quantities (number of pieces by size including nuts),

3.1.5 Fastener size and length,

3.1.6 *Washers*—Quantity and size (separate from bolts),

3.1.7 *Zinc Coating*—Specify the zinc-coating process required, for example, hot-dip, mechanically deposited, or no preference (see 4.5).

3.1.8 *Other Finishes*—Specify other protective finish, if required.

3.1.9 Specify if inspection at point of manufacture is required,

3.1.10 Specify if certified test report is required (see 8.2), and

3.1.11 Specify additional testing (8.3) or special requirements.

3.1.12 For establishment of a part identifying system, see ANSI/ASME B18.24.1.

4. Materials and Manufacture

4.1 Steel for bolts and studs shall be made by the open-hearth, basic-oxygen, or electric-furnace process.

4.2 Bolts shall be produced by hot or cold forging of the heads or machining from bar stock.

4.3 *Heat Treatment:*

4.3.1 Cold headed fasteners with head configurations other than hex shall be stress relief annealed.

4.3.2 Stress relieving of hex head fasteners shall be at the manufacturer's option.

4.4 Bolt and stud threads shall be rolled or cut.

4.5 *Zinc Coatings, Hot-Dip and Mechanically Deposited:*

4.5.1 When zinc-coated fasteners are required, the purchaser shall specify the zinc-coating process, for example hot dip, mechanically deposited, or no preference.

³ Annual Book of ASTM Standards, Vol 01.04.

³ 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.

⁴ Annual Book of ASTM Standards, Vol 01.06.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

⁵ Annual Book of ASTM Standards, Vol 01.03.

⁵ Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

⁶ Annual Book of ASTM Standards, Vol 01.08.

⁶ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

4.5.2 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.

4.5.3 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.

4.5.4 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.

5. Chemical Composition

5.1 Grade A and B bolts and studs shall have a heat analysis conforming to the requirements specified in Table 1 based on the steel producer's heat analysis.

5.2 The purchaser shall have the option of conducting product analyses on finished bolts in each lot, which shall conform to the product analysis specified in Table 1.

5.3 In case of conflict or for referee purposes, the product analysis shall take precedence.

5.4 Bolts and studs are customarily furnished from stock, in which case individual heats of steel cannot be identified.

5.5 Application of heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted for Grade B bolts and studs.

5.6 Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology A 751.

6. Mechanical Properties

6.1 Grades A and B bolts and studs shall conform to the hardness specified in Table 2.

6.2 Grade A and B bolts and studs 1½ in. in diameter or less, other than those excepted in 6.4, shall be tested full size and shall conform to the requirements for tensile strength specified in Table 3.

6.3 Grade A and B bolts and studs larger than 1½ in. in diameter, other than those excepted in 6.4, shall preferably be tested full size and when equipment of sufficient capacity is available and shall conform to the requirements for tensile strength specified in Table 3. When equipment of sufficient capacity for full-size bolt testing is not available, or when the length of the bolt makes full-size testing impractical, machined specimens shall be tested and shall conform to the requirements specified in Table 4.

6.4 Grades A and B bolts and studs less than three diameters in length or bolts with drilled or undersize heads are not subject to tensile tests.

6.5 Grade C nonheaded anchor bolts shall be tested using machined specimens and shall conform to the tensile properties specified for bars in Specification A 36/A 36M. Properties are shown in Table 4 for information. In the event of conflict Specification A 36/A 36M shall control.

6.6 In the event that bolts are tested by both full size and by machine test specimen methods, the full-size test shall govern if a controversy between the two methods exists.

6.7 For bolts and studs on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence in the event that there is controversy over low readings of hardness tests.

7. Dimensions

7.1 Unless otherwise specified, threads shall be the Coarse Thread Series as specified in the latest issue of ANSI/ASME B1.1, and shall have a Class 2A tolerance.

7.2 Unless otherwise specified, Grade A bolts shall be hex bolts with dimensions as given in the latest issue of ANSI/ASME B18.2.1. Unless otherwise specified, Grade B bolts shall be heavy hex bolts with dimensions as given in the latest issue of ANSI/ASME B18.2.1.

7.3 Unless otherwise specified, bolts and studs to be used with nuts or tapped holes which have been tapped oversize, in accordance with Specification A 563, shall have Class 2A threads before hot-dip or mechanically deposited zinc coating. After zinc coating the maximum limit of pitch and major diameter shall not exceed the Class 2A maximum limit by more than the following amounts:

TABLE 1 Chemical Requirements for Grades A and B Bolts and Studs

	Heat Analysis	Product Analysis
Carbon, max	0.29	0.33
Manganese, max	0.90	0.99
Manganese, max	1.20	1.25
Phosphorus, max	0.04	0.041
Sulfur, max		
Grade A	0.15	^A
Grade B	0.05	0.051

^A Resulfurized steel is not subject to rejection based on product analysis for sulfur.

TABLE 2 Hardness Requirements for Bolts and Studs

Grade	Length, in. 0	Hardness ^A			
		Brinell		Rockwell B	
		min	max	min	max
A	Less than 3 × dia ^B	121	241	69	100
	3 × dia and longer	...	241	...	100
B	Less than 3 × dia ^B	121	212	69	95
	3 × dia and longer	...	212	...	95
C	All	No hardness required			

^A As measured anywhere on the surface or through the cross section.

^B Also bolts with drilled or undersize heads. These sizes and bolts with modified heads shall meet the minimum and maximum hardness as hardness is the only requirement.

TABLE 3 Tensile Requirements for Full-Size Bolts and Studs

Bolt Size, in.	Threads per inch	Stress Area, ^A in. ²	Tensile Strength, lbf ^B		
			Grade A, min ^C	Grade B	
				min ^D	max ^D
1/4	20	0.0318	1 900	1 900	3 180
5/16	18	0.0524	3 100	3 100	5 240
3/8	16	0.0775	4 650	4 650	7 750
7/16	14	0.1063	6 350	6 350	10 630
1/2	13	0.1419	8 500	8 500	14 190
9/16	12	0.182	11 000	11 000	18 200
5/8	11	0.226	13 550	13 550	22 600
3/4	10	0.334	20 050	20 050	33 400
7/8	9	0.462	27 700	27 700	46 200
1	8	0.606	36 350	36 350	60 600
1 1/8	7	0.763	45 800	45 800	76 300
1 1/4	7	0.969	58 150	58 150	96 900
1 3/8	6	1.155	69 300	69 300	115 500
1 1/2	6	1.405	84 300	84 300	140 500
1 3/4	5	1.90	114 000	114 000	190 000
2	4 1/2	2.50	150 000	150 000	250 000
2 1/4	4 1/2	3.25	195 000	195 000	325 000
2 1/2	4	4.00	240 000	240 000	400 000
2 3/4	4	4.93	295 800	295 800	493 000
3	4	5.97	358 200	358 200	597 000
3 1/4	4	7.10	426 000	426 000	710 000
3 1/2	4	8.33	499 800	499 800	833 000
3 3/4	4	9.66	579 600	579 600	966 000
4	4	11.08	664 800	664 800	1 108 000

^A Area calculated from the equation:

$$A_s = 0.7854 [D - (0.9743/n)]^2$$

where:

 A_s = stress area,
 D = nominal diameter of bolt, and
 n = threads per inch.

^B 1 lbf = 4.448 N.

^C Based on 60 ksi (414 MPa).

^D Based on 60–100 ksi (414–690 MPa).

Diameter, in.	Oversize Limit, in. (mm) ^A
1/4	0.016
5/16, 3/8	0.017
7/16, 1/2	0.018
5/8 to 3/4, incl	0.020
7/8	0.022
1.0 to 1 1/4, incl	0.024
1 1/8, 1 1/2	0.027
1 3/4 to 4.0, incl	0.050

^A These values are the same as the overtapping required for zinc-coated nuts in Specification A 563.

7.4 The gaging limit for bolts and studs shall be verified during manufacture or use by assembly of a nut tapped as nearly as practical to the amount oversize shown above. In case of dispute, a calibrated thread ring gage of that same size (Class X tolerance,