Designation: A 307 – 07b

Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength[1]

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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 This specification[2] covers the chemical and mechanical requirements of three grades of carbon steel bolts and studs in sizes ¼ in. through 4 in. 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 and intended for general applications,
Grade B	Bolts and studs having a tensile strength of 60 to 100 ksi and intended for flanged joints in piping systems with cast iron flanges, and
Grade C	Replaced by Specification F 1554 Gr.36

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 ¼ to 1½ in.	A, hex
A 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.

1.5 Supplementary Requirement S1 of an optional nature is provided, which describes additional restrictions to be applied when 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 Terminology F 1789 unless otherwise defined herein.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

A 563 Specification for Carbons and Alloy Steel Nuts

A 706/A 706M Specification for Low-Alloy Steel Deformed and Plain 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, Direct Tension Indicators, and Rivets

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

F 1554 Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength

F 1789 Terminology for F16 Mechanical Fasteners

F 2329 Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners

2.2 *ASME Standards:*

B 1.1 Unified Screw Threads[4]

B 18.2.1 Square and Hex Bolts and Screws[4]

B 18.24 Part Identifying Number (PIN) Code System[5]

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,

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

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

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

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

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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. 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 ASME B 18.24.

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.

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 Specification F 2329.

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 55 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 F 2329, or a mechanically deposited zinc coating in accordance with Specification B 695, Class 55. 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.

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

	Heat Analysis	Product Analysis
Carbon, max	0.29	0.33
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.

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 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.

6.6 For bolts and studs on which both hardness and tension tests are performed, acceptance based on tensile requirements

TABLE 2 Hardness Requirements for Bolts and Studs

Grade	Length, in.	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

[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.

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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]
¼	20	0.0318	1 900	1 900	3 180
5⁄16	18	0.0524	3 100	3 100	5 240
⅜	16	0.0775	4 650	4 650	7 750
7⁄16	14	0.1063	6 350	6 350	10 630
½	13	0.1419	8 500	8 500	14 190
9⁄16	12	0.182	11 000	11 000	18 200
⅝	11	0.226	13 550	13 550	22 600
¾	10	0.334	20 050	20 050	33 400
⅞	9	0.462	27 700	27 700	46 200
1	8	0.606	36 350	36 350	60 600
1⅛	7	0.763	45 800	45 800	76 300
1¼	7	0.969	58 150	58 150	96 900
1⅜	6	1.155	69 300	69 300	115 500
1½	6	1.405	84 300	84 300	140 500
1¾	5	1.90	114 000	114 000	190 000
2	4½	2.50	150 000	150 000	250 000
2¼	4½	3.25	195 000	195 000	325 000
2½	4	4.00	240 000	240 000	400 000
2¾	4	4.93	295 800	295 800	493 000
3	4	5.97	358 200	358 200	597 000
3¼	4	7.10	426 000	426 000	710 000
3½	4	8.33	499 800	499 800	833 000
3¾	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).

TABLE 4 Tensile Requirements for Machined Specimens

	Grade A	Grade B
Tensile strength, ksi	60 min	60–100
Yield point, min ksi	. . .	. . .
Elongation in 2 in., min, %	18	18

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 ASME B 1.1, 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 ASME B 18.2.1. Unless otherwise specified, Grade B bolts shall be heavy hex bolts with dimensions as given in the latest issue of ASME B 18.2.1.

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:

Diameter, in.	Oversize Limit, in. (mm)[A]
¼	0.016
5⁄16 , ⅜	0.017
7⁄16 , ½	0.018
9⁄16 to ¾ , incl	0.020
⅞	0.022
1.0 to 1¼ , incl	0.024
1⅜ , 1½	0.027
1¾ 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, gage tolerance plus) shall be used. Assembly of the gage, or the nut described above, must be possible with hand effort following application of light machine oil to prevent galling and damage to the gage. These inspections, when performed to resolve disputes, shall be performed at the frequency and quality described in Table 5.

8. Number of Tests and Retests

8.1 The requirements of this specification shall be met in continuous mass production for stock, and the manufacturer shall make sample inspections to ensure that the product conforms to the specified requirements. Additional tests of individual shipments of material are not ordinarily contemplated. Individual heats of steel are not identified in the finished product.

8.2 When specified in the order, the manufacturer shall furnish a test report certified to be the last completed set of mechanical tests for each stock size in each shipment.

8.3 When additional tests are specified on the purchase order, a lot, for purposes of selecting test samples, shall consist of all material offered for inspection at one time that has the following common characteristics:

8.3.1 One type of item,

8.3.2 One nominal size, and

8.3.3 One nominal length of bolts and studs.

8.4 From each lot, the number of tests for each requirement shall be as follows:

TABLE 5 Sample Sizes and Acceptance Numbers for Inspection of Hot-Dip or Mechanically Deposited Zinc-Coated Threads

Lot Size	Sample Size[A]	Acceptance Number
2 to 90	13	1
91 to 150	20	2
151 to 280	32	3
281 to 500	50	5
501 to 1 200	80	7
1 201 to 3 200	125	10
3 201 to 10 000	200	14
10 001 and over	315	21

[A] Inspect all bolts in the lot if the lot size is less than the sample size.

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Number of Pieces in Lot	Number of Samples
800 and under	1
801 to 8 000	2
8 001 to 22 000	3
Over 22 000	5

8.5 If any machined test specimen shows defective machining it shall be discarded and another specimen substituted.

8.6 Should any sample fail to meet the requirements of a specified test, double the number of samples from the same lot shall be tested, in which case all of the additional samples shall meet the specification.

9. Test Methods

9.1 Grades A and B bolts and studs shall be tested in accordance with Test Methods F 606.

9.2 Standard square and hex head bolts only shall be tested by the wedge tension method except as noted in 6.4. Fracture shall be in the body or threads of the bolt without any fracture at the junction of the head and body. Other headed bolts shall be tested by the axial tension method.

9.3 Speed of testing as determined with a free running crosshead shall be a maximum of 1 in./min for the tensile strength tests of bolts.

10. Inspection

10.1 If the inspection described in 10.2 is required by the purchaser it shall be specified in the inquiry, order, or contract.

10.2 The inspector representing the purchaser shall have free entry to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspections required by the specification that are requested by the purchaser's representative shall be made before shipment, and shall be conducted as not to interfere unnecessarily with the operation of the works.

11. Responsibility

11.1 The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser.

12. Rejection and Rehearing

12.1 Disposition of nonconforming lots shall be in accordance with Guide F 1470, specifically sections on disposition of nonconforming lots, suppliers option, and purchasers option.

13. Product Marking

13.1 *Grades A and B Bolts and Studs*:

13.1.1 Bolt heads and one end of studs shall be marked with a unique identifier by the manufacturer to identify the manufacturer or private label distributor, as appropriate. Additional marking required by the manufacturer for his own use shall be at the option of the manufacturer.

13.1.2 In addition to the requirements of 13.1, all bolt heads, one end of studs ⅜ in. and larger, and whenever feasible studs less than ⅜ in. shall be marked with a grade marking as follows:

Grade	Marking
A	307A
B	307B

13.1.3 All markings shall be located on the top of the bolt head or stud end and shall be raised or depressed at the option of the manufacturer.

14. Packaging and Package Marking

14.1 *Packaging*:

14.1.1 Unless otherwise specified, packaging shall be in accordance with Practice D 3951.

14.1.2 When special packaging requirements are required, they shall be defined at the time of the inquiry and order.

14.2 *Package Marking*:

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

14.2.1.1 ASTM designation and grade,

14.2.1.2 Size,

14.2.1.3 Name and brand or trademark of the manufacturer,

14.2.1.4 Number of pieces,

14.2.1.5 Purchase order number,

14.2.1.6 Country of origin.

15. Keywords

15.1 bolts; carbon steel; steel; studs

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirement shall apply only when specified in the purchase order or contract:

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S1. Bolts Suitable for Welding

S1.1 The material described in this section is intended for welding. This supplemental section, by additional chemical composition restrictions and by a carbon equivalent formula, provides assurance of weldability by chemical composition control.

S1.2 Welding technique is of fundamental importance when bolts produced to this supplementary section are welded. It is presupposed that suitable welding procedures for the steel being welded and the intended service will be selected.

S1.3 All of the requirements of this supplemental section apply in addition to all of the chemical, mechanical, and other requirements of the base specification, Specification A 307 for Grade B.

S1.4 Because of the embrittling effects of welding temperatures on cold-forged steel, this supplemental section is limited to hot-forged bolts, or, if not forged, then to bolts produced from hot-rolled bars without forging or threaded bars, bars studs, or stud bolts produced from hot-rolled bars without forging. Cold-forged bolts, or cold-drawn threaded bars, if they are given a thermal treatment by heating to a temperature of not less than 1500°F (815°C) and air-cooled are also suitable.

S1.5 *Chemical Requirements:*

S1.5.1 *Heat Chemical Analysis*—Material conforming to the following additional analysis limitations shall be used to manufacture the product described in this supplementary requirement.

Carbon	0.30 %, max
Manganese	1.00 %, max
Phosphorus	0.04 %, max
Sulfur	0.05 %, max
Silicon	0.50 %, max

S1.5.2 *Carbon Equivalent (Source—Specification A 706/A 706M)*—In addition to the heat chemical analysis requirements in S1.5.1, the heat analysis shall be such as to provide a carbon equivalent (CE) not exceeding 0.55 when calculated as follows:

$$CE = \%\ C + \frac{\%\ Mn}{6} + \frac{\%\ Cu}{40} + \frac{\%\ Ni}{20} + \frac{\%\ Cr}{10} - \frac{\%\ Mo}{50} - \frac{\%\ V}{10}$$

S1.6 *Analysis Reports*—If requested on the order or contract, the chemical composition of each heat of steel used and the calculated carbon equivalent for each heat shall be reported to the purchaser.

S1.7 *Product (Check) Verification Analysis*—Chemical analyses when made by the purchaser or a representative on bolts from each heat of steel, shall not exceed the values specified in S1.5.2 by more than the following amounts:

	%
Carbon	+0.03
Manganese	+0.06
Phosphorus	+0.008
Sulfur	+0.008
Silicon	+0.05

S2. Permanent Manufacturer's Identification

S2.1 Replaced by Specification F 1554.

S3. Permanent Grade Identification

S3.1 Replaced by Specification F 1554.

SUMMARY OF CHANGES

Committee F16 has identified the location of selected changes to this standard since the last issue (A 307–07a) that may impact the use of this standard. (Approved Dec. 1, 2007.)

(*1*) Sections 4.5.3 and 4.5.4 were revised.

Committee F16 has identified the location of selected changes to this standard since the last issue (A 307–07) that may impact the use of this standard. (Approved Aug. 1, 2007.)

(*1*) Changed the reference hot dip zinc coating specification from Specification A 153/A 153M to Gr. C to Specification F 2329.

Committee F16 has identified the location of selected changes to this standard since the last issue (A 307–04) that may impact the use of this standard. (Approved June 15, 2007.)

(*1*) Revised 1.1 Gr. C anchor bolts, and all related sections, to delete anchor bolts and replaced with reference to Specification F 1554 Gr. 36.

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