



Designation: A307-21

Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength¹

This standard is issued under the fixed designation A307; 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 U.S. Department of Defense.

1. Scope*

1.1 This specification² covers the chemical and mechanical requirements of two grades of carbon steel bolts and studs in sizes 1/4 in. through 4 in. The fasteners are designated by "Grade" denoting tensile strength and intended use, as follows:

Grade	Description
Grade A	Bolts, studs, and threaded rod having a minimum tensile strength of 60 ksi and intended for general applications.
Grade B	Bolts, studs, and threaded rod 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 F1554 Gr.36

A Threaded rod is not usually produced to Grade B, but can be when specified by the purchaser.

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 A563. 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 1/4 to 1 in.	A, hex
A over 1 1/2 to 4 in.	A, heavy hex
B, V to 4 in.	A, heavy hex

A Nuts of other grades and styles having specified proof load stresses (Specification A563, Table 3) greater than the specified grade and style of nut are also suitable.

¹This 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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²For ASME Boiler and Pressure Vessel Code applications see related Specification SA-307 in Section II of that Code.

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

1.5 Supplementary Requirement SI 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 F1789 unless otherwise defined herein.

1.7 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:³

- A563 Specification for Carbon and Alloy Steel Nuts
- A706/A706M Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
- A751 Test Methods and Practices for Chemical Analysis of Steel Products
- B695 Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
- F606/F606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
- F788 Specification for Surface Discontinuities of Bolts, Screws, Studs, and Rivets, Inch and Metric Series
- F1470 Practice for Fastener Sampling for Specified Mechanical Properties and Performance Inspection
- F1554 Specification for Anchor Bolts, Steel, 3/8, 5/8, and 1 1/2-in. Yield Strength
- F1789 Terminology for F16 Mechanical Fasteners

³For 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.

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



F2329/F2329M 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:⁴

B1.1 Unified Screw Threads

B18.2.1 Square and Hex Bolts and Screws

B18.24 Part Identifying Number (PIN) Code System

B 18.5 Round Head Bolts (Inch Series)

B18.31.3 Threaded Rods (Inch Series)

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, or threaded rod,

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 9.2), and

3.1.11 Specify additional testing (9.3) or special requirements.

3.1.12 For establishment of a part identifying system, see ASME B18.24.

4. Materials and Manufacture

4.1 Steel for bolts, studs, and threaded rod 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 having a specified minimum head height less than or equal to 0.5 D (D is nominal diameter) shall be stress relief annealed at a minimum temperature of 875 °F. This would include cold headed Round Head and Round Head Square Neck Bolts in accordance with ASME B18.5. When specified by the purchaser, cold headed hex head bolts and screws shall be stress relieved at 875 °F minimum.

4.3.2 Stress relieving of hex head fasteners and those with minimum head heights greater than 0.5 D shall be at the manufacturer's option.

⁴Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, <http://www.asme.org>.

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 F2329/F2329M.

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 B695.

4.5.4 When no preference is specified, the supplier may furnish either a hot-dip zinc coating in accordance with Specification F2329/F2329M, or a mechanically deposited zinc coating in accordance with Specification B695, 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, studs, and threaded rod 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 A751.

6. Mechanical Properties

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

6.2 Grade A and B bolts, studs, and threaded rod 1/8 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. Threaded rod is permitted to be

TABLE 1 Chemical Requirements for Grades A and B Bolts, Studs, and Threaded Rod

	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

¹Resulfurized steel is not subject to rejection based on product analysis for sulfur.

TABLE 2 Hardness Requirements for Bolts, Studs, and Threaded Rod

Grade	Nominal Length, in.	Hardness			
		Brinell		Rockwell B	
		min	max	min	max
A	Less than 3×dia and longer	121	241	69	100
B	Less than 3×dia and longer	121	212	69	95

AAs measured anywhere on the surface or through the cross section.
 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, Studs, and Threaded Rod

Bolt Size, per inch in.	Threads per inch	Stress Area, in.	Tensile Strength, lbf		
			Grade A, min ^c	Grade B min ^o	Grade B max ^o
%4	20	0.0318	1900	1900	3180
e	18	0.0524	3100	3100	5240
%	16	0.0775	4650	4650	7750
h6	14	0.1063	6350	6350	10630
	13	0.1419	8500	8500	14190
%6	12	0.182	11000	11000	18200
%	11	0.226	13550	13550	22600
%	10	0.334	20050	20050	33400
%	9	0.462	27700	27700	46200
1	8	0.606	36350	36350	60600
1%		0.763	45 800	45800	76300
1%4	7	0.969	58 150	58150	96900
1%	6	1.155	69300	69300	115500
1%	6	1.405	84300	84300	140500
1%	5	1.90	114000	114000	190000
2	4%	2.50	150000	150000	250000
2V4	4	3.25	195000	195000	325000
2%	4	4.00	240000	240000	400000
2%4	4	4.93	295 800	295800	493000
3	4	5.97	358 200	358200	597000
34	4	7.10	426000	426000	710000
3	4	8.33	499800	499800	833000
3%	4	9.66	579600	579600	966000
4	4	11.08	664800	664800	1108000

A Area calculated from the equation:

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

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)

cut to a length suitable for tensile testing and shall be treated using the same method specified for studs.

6.3 Grade A and B bolts, studs, and threaded rod larger than 1%2 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 testing is not available, or when the length of the bolt or stud 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 nominal length or bolts with drilled or undersize heads are not subject to tensile tests.

6.5 In the event that bolts, studs, and threaded rod 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, studs, and threaded rod 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 on bolts and studs shall be the Coarse Thread Series as specified in the latest issue of ASME B1.1, and shall have a Class 2A tolerance. Unless otherwise specified, threads on threaded rod shall be per the requirements of the latest issue of ASME B18.31.3.

7.2 Unless otherwise specified, Grade A bolts shall be hex bolts with dimensions as given in the latest issue of ASME B18.2.1. Unless otherwise specified, Grade B bolts shall be heavy hex bolts with dimensions as given in the latest issue of ASME B18.2.1. Unless otherwise specified, threads on threaded rod shall be per the requirements of the latest issue of ASME B18.31.3.

7.3 Unless otherwise specified, bolts, studs, and threaded rod to be used with nuts or tapped holes which have been tapped oversize, in accordance with Specification A563, shall have threads as specified in 7.1 before hot-dip or mechanically deposited zinc coating.

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

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.A
4	0.016
%c, ^o %	0.017
7/c,%2	0.018
%e to 3/4,incl	0.020
%	0.022
1.0 to 1%4,incl	0.024
1%, 1 ¹ /2	0.027
1%to 4.0,incl	0.050

A These values are the same as the overlapping required for zinc-coated nuts in Specification A563.

7.4 The gaging limit for bolts and studs,and threaded rod 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.Workmanship,Finish,and Appearance

8.1 Surface discontinuity limits,inspection and evaluation shall be in accordance with Specification F788.

9.Number of Tests and Retests

9.1 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.

9.2 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.

9.3 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:

- 9.3.1 One type of item,
- 9.3.2 One nominal size,and
- 9.3.3 One nominal length of bolts and studs.

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 1200	80	7
1201 to 3200	125	10
3201 to 10000	200	14
10001 and over	315	21

AInspect all bolts in the lot if the lot size is less than the sample size.

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

Number of Pieces in Lot	
800 and under	1
801 to 8000	2
8001 to 22000	
Over 22000	3

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

9.6 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.

10.Test Methods

10.1 Grades A and B bolts and studs shall be tested in accordance with Test Methods F606/F606M.

10.2 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.

11.Inspection

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

11.2 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.

12.Responsibility

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

13.Rejection and Rehearing

13.1 Disposition of nonconforming lots shall be in accordance with Guide F1470, specifically sections on disposition of nonconforming lots,suppliers option,and purchasers option.

14.Product Marking

14.1 Grades A and B Bolts and Studs:

14.1.1 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 shall be at the option of the manufacturer.

14.1.2 In addition to the requirements of 14.1, allbolt heads, one end of studs 3%^s in.and larger,and whenever feasible studs less than %in.shall be marked with a grade marking as follows:

Grade	Marking
A	307A
B	307B



14.1.3 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.

14.2 Grades A and B Threaded Rod:

14.2.1 Refer to ASME B18.31.3 for marking of Grade A and B threaded rod.

14.2.2 If markings are required, they shall be located on the ends of the threaded rod and shall be raised or depressed at the option of the manufacturer.

15. Packaging and Package Marking

15.1 Packaging:

15.1.1 Unless otherwise specified, packaging shall be in accordance with the manufacturer's practice to prevent damage before and during shipment.

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

15.2 Package Marking:

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

15.2.1.1 ASTM designation and grade,

15.2.1.2 Size,

15.2.1.3 Name and brand or trademark of the manufacturer,

15.2.1.4 Number of pieces,

15.2.1.5 Purchase order number (when specified in the order),

15.2.1.6 Country of origin.

16. Keywords

16.1 all thread rod; bolts; carbon steel; steel; studs; threaded rod

SUPPLEMENTARY REQUIREMENTS

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

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 A307 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 A706/A706M)—*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 **F1554**.

S3. Permanent Grade Identification

S3.1 Replaced by Specification **F1554**.

**SUMMARY OF CHANGES**

Committee F16 has identified the location of selected changes to this standard since the last issue(A307-14) that may impact the use of this standard.

(1)Added further clarification to 4.3.1 regarding the product requiring stress relief.

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