Designation: A540/A540M – 06

Standard Specification for Alloy-Steel Bolting Materials for Special Applications[1]

This standard is issued under the fixed designation A540/A540M; 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[2] covers regular and special-quality alloy steel bolting materials which may be used for nuclear and other special applications. Bolting materials as used in this specification cover rolled or forged bars, rotary pierced or extruded seamless tubes, bored bars, or forged hollows from forged or rolled bar segments to be manufactured into bolts, studs, washers, and nuts.

1.2 Several grades of steel are covered. The grade and class shall be specified by the purchaser.

1.3 Supplementary requirements of an optional nature are provided for use when special quality is desired. These supplementary requirements call for additional tests to be made and when desired shall be so stated in the order, together with the acceptance limits required.

1.4 This specification is expressed in both inch-pound units and in SI units. However, unless the order specifies the applicable" M" specification designation (SI units), the material shall be furnished to inch-pound units.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

A962/A962M Specification for Common Requirements for Steel Fasteners or Fastener Materials, or Both, Intended for Use at Any Temperature from Cryogenic to the Creep Range

E45 Test Methods for Determining the Inclusion Content of Steel

2.2 *AIAG Standard:*

AIAG B-5 02.00 Primary Metals Identification Tag Application Standard[4]

2.3 *ANSI Standards:*[5]

B 1.1 Unified Screw Threads

B 18.2.1 Square and Hex Bolts and Screws Including Hex Cap Screws and Lag Bolts

B 18.2.2 Square and Hex Nuts

B 18.3 Hexagon Socket and Spline Socket Screws

3. Ordering Information

3.1 The inquiry and orders for material under this specification shall include the following, as required, to describe the desired material adequately:

3.1.1 Condition (Section 5),

3.1.2 Heat treatment (Section 6),

3.1.3 Supplementary Requirements (S1 to S9),

3.1.4 Reports required (Section 17),

3.1.5 End use, and

3.1.6 Any special requirements.

3.2 The purchaser is referred to the listed supplementary requirements.

4. Common Requirements

4.1 Material and fasteners supplied to this specification shall conform to the requirements of Specification A962/A962M. These requirements include test methods, finish, thread dimensions, marking, certification, optional supplementary requirements, and others. Failure to comply with the requirements of Specification A962/A962M constitutes nonconformance with this specification. In case of conflict between this specification and Specification A962/A962M, this specification shall prevail.

5. Manufacture

5.1 The material shall be supplied hot-rolled or hot-forged or cold-finished at the option of the producer. However, if desired by the purchaser, cold finishing may be specified.

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel, and Related Alloys, and is the direct responsibility of Subcommittee A01.22 on Steel Forgings and Wrought Fittings for Piping Applications and Bolting Materials for Piping and Special Purpose Applications.

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[2] For ASME Boiler and Pressure Vessel Code Applications see related Specification SA-540 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 Automotive Industry Action Group, 26200 Lahser, Suite 200, Southfield, MI 48034.

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

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

6. Heat Treatment

6.1 Material which is ordered in the annealed condition shall have a structure suitable for machining. Such annealed bolting material is not intended to be used without subsequent quenching and tempering as specified in 6.2

6.2 Material which is ordered in the liquid-quenched and tempered condition shall be uniformly reheated from a temperature below the cooling transformation range to the proper austenitizing temperature. It shall be quenched in a liquid medium under substantially uniform conditions and then uniformly reheated for tempering. The minimum tempering temperature shall be 850 °F [455 °C].

6.3 Material that has been straightened after quenching and tempering shall be stress relieved by reheating to a temperature not lower than 100 °F [55 °C] under the tempering temperature.

7. Chemical Composition

7.1 The steel shall conform to the chemical requirements prescribed in Table 1.

8. Tensile Requirements

8.1 Material furnished in the annealed condition shall be capable of meeting the specified tensile properties for the class as specified in Table 2 when heat treated in accordance with 6.2 and 6.3 (see Supplementary Requirement S4).

8.2 Material in the quenched and tempered or quenched, tempered and stress-relieved condition shall conform to properties shown in Table 2 for the specified class.

9. Hardness Requirements

9.1 The hardness shall be determined on the surface of the material after removal of decarburization.

9.2 The hardness of material in the annealed condition shall not be greater than 235 HB.

9.3 The hardness of material in the quenched and tempered or quenched, tempered and stress-relieved condition shall be within the limits in Table 2 for the specified class.

10. Impact Requirements

10.1 Annealed material after proper heat treatment shall be capable of meeting the impact requirements in Table 2 or of Supplementary Requirement S8, if so specified (see Supplementary Requirement S4).

10.2 Material in the quenched and tempered or quenched, tempered, and stress-relieved condition shall conform to the impact requirements in Table 2, or of Supplementary Requirement S8 if so specified.

10.3 The percent of shear (ductility or fibrous) fracture shall be computed. The computed value shall be recorded for all impact specimens.

10.4 The amount of lateral expansion shall be measured. The measured value shall be recorded for all impact specimens.

10.5 The percent shear and the amount of lateral expansion shall be reported for information purposes (see 17.1).

TABLE 1 Chemical Requirements[A]

Identification Symbol Grade	B21 (Cr-Mo-V) Chromium-Molybdenum-Vanadium		B22 (4142-H) Chromium-Molybdenum		B23 (E-4340-H) Chromium-Nickel-Molybdenum		B24 (4340 Mod.) Chromium-Nickel-Molybdenum		B24V (4340V Mod.) Chromium-Nickel-Molybdenum-Vanadium	
	Range, %	Product Variation, Over or Under,[B] %	Range, %	Product Variation, Over or Under,[B] %	Range, %	Product Variation, Over or Under,[B] %	Range, %	Product Variation, Over or Under,[B] %		Product Variation, Over or Under,[B] %
Carbon	0.36–0.44	0.02	0.39–0.46	0.02	0.37–0.44	0.02	0.37–0.44	0.02	0.37–0.44	0.02
Manganese	0.45–0.70	0.03	0.65–1.10	0.04	0.60–0.95	0.04	0.70–0.90	0.04	0.60–0.95	0.04
Phosphorus, max	0.025[C]	0.005	0.025[C]	0.005	0.025[C]	0.005	0.025[C]	0.005	0.025[C]	0.005
Sulfur, max	0.025[C]	0.005	0.025[C]	0.005	0.025[C]	0.005	0.025[C]	0.005	0.025[C]	0.005
Silicon	0.15–0.35	0.02	0.15–0.35	0.02	0.15–0.35	0.02	0.15–0.35	0.02	0.15–0.35[D]	0.02
Chromium	0.80–1.15	0.05	0.75–1.20	0.05	0.65–0.95	0.05	0.70–0.95	0.05	0.60–0.95	0.05
Nickel	. . .	. . .	. . .	. . .	1.55–2.00	0.05	1.65–2.00	0.05	1.55–2.00	0.05
Molybdenum	0.50–0.65	0.03	0.15–0.25	0.02	0.20–0.30	0.02	0.30–0.40	0.02	0.40–0.60	0.03
Vanadium	0.25–0.35	0.03	. . .	. . .	. . .	. . .	. . .	. . .	0.04–0.10	0.01

[A] The intentional addition of Bi, Se, Te, and Pb is not permitted.
[B] Unless otherwise specified, separate determinations may vary from the specified ranges, except that elements in any heat must not vary both above and below the specified range.
[C] Phosphorus and sulfur content is 0.04 % max when open-hearth steel is specified.
[D] Silicon content is 0.35 % max if vacuum-carbon deoxidized.

TABLE 2 Mechanical Property Requirements

NOTE 1—The minimum average of 3 specimens shall not be less than 35 ft·lbf [47 J]. One specimen from a set of 3 may be less than 35 ft·lbf [47 J] but not less than 30 ft·lbf [41 J].

NOTE 2— The minimum average of 3 specimens shall not be less than 30 ft·lbf [41 J]. One specimen from a set of 3 may be less than 30 ft·lbf [41 J] but not less than 25 ft·lbf [34 J].

NOTE 3—The minimum average of 3 specimens shall not be less than 25 ft·lbf [34 J]. One specimen from a set of 3 may be less than 25 ft·lbf [34 J] but not less than 20 ft·lbf [27 J].

NOTE 4—No minimum values established. Tests shall be run for information only.

Grade	Class	Diameter	Tensile Strength, min	Yield Strength, 0.2 % offset, min	Elongation, min, %	Reduction of Area, min, %	Surface Brinell Hardness		Charpy V-Notch +10 °F [–12.2 °C]
							min	max	
			Inch-Pound Units						
		in.	ksi	ksi	In 2 in.				
B21	5	to 2, incl	120	105	15	50	241	285	Note 4
(Cr-Mo-V)		over 2 to 6, incl	115	100	15	50	248	302	Note 4
		over 6 to 8, incl	115	100	15	50	255	311	Note 4
	4	to 3, incl	135	120	13	45	269	331	Note 4
		over 3 to 6, incl	135	120	13	45	277	352	Note 4
	3	to 3, incl	145	130	12	40	293	352	Note 4
		over 3 to 6, incl	145	130	12	40	302	375	Note 4
	2	to 4, incl	155	140	11	40	311	401	Note 4
	1	to 4, incl	165	150	10	35	321	429	Note 4
B22	5	to 2, incl	120	105	15	50	248	293	Note 1
(4142-H)		over 2 to 4, incl	115	100	15	50	255	302	Note 4
	4	to 1, incl	135	120	13	45	269	341	Note 1
		over 1 to 4, incl	135	120	13	45	277	363	Note 4
	3	to 2, incl	145	130	12	40	293	363	Note 4
		over 2 to 4, incl	145	130	12	40	302	375	Note 4
	2	to 3, incl	155	140	11	40	311	401	Note 4
	1	to 1½ , incl	165	150	10	35	321	401	Note 4
B23	5	to 6, incl	120	105	15	50	248	311	Note 1
(E-4340-H)		over 6 to 8, incl	115	100	15	50	255	321	Note 1
		over 8 to 9½ , incl	115	100	15	50	262	321	Note 4
	4	to 3, incl	135	120	13	45	269	341	Note 1
		over 3 to 6, incl	135	120	13	45	277	352	Note 1
		over 6 to 9½ , incl	135	120	13	45	285	363	Note 4
	3	to 3, incl	145	130	12	40	293	363	Note 2
		over 3 to 6, incl	145	130	12	40	302	375	Note 2
		over 6 to 9½ , incl	145	130	12	40	311	388	Note 4
	2	to 3, incl	155	140	11	40	311	388	Note 4
		over 3 to 6, incl	155	140	11	40	311	401	Note 4
		over 6 to 9½ , incl	155	140	11	40	321	415	Note 4
	1	to 3, incl	165	150	10	35	321	415	Note 4
		over 3 to 6, incl	165	150	10	35	331	429	Note 4
		over 6 to 8, incl	165	150	10	35	341	444	Note 4
B24	5	to 6, incl	120	105	15	50	248	311	Note 1
(4340 Mod.)		over 6 to 8, incl	115	100	15	50	255	321	Note 1
		over 8 to 9½ , incl	115	100	15	50	262	321	Note 1
	4	to 3, incl	135	120	13	45	269	341	Note 1
		over 3 to 6, incl	135	120	13	45	277	352	Note 1
		over 6 to 8, incl	135	120	13	45	285	363	Note 1
		over 8 to 9½ , incl	135	120	13	45	293	363	Note 4
	3	to 3, incl	145	130	12	40	293	363	Note 2
		over 3 to 8, incl	145	130	12	40	302	388	Note 2
		over 8 to 9½ , incl	145	130	12	40	311	388	Note 4
	2	to 7, incl	155	140	11	40	311	401	Note 2
		over 7 to 9½ , incl	155	140	11	40	321	415	Note 4
	1	to 6, incl	165	150	10	35	321	415	Note 3
		over 6 to 8, incl	165	150	10	35	331	429	Note 4
B24V	3	to 4, incl	145	130	12	40	293	363	Note 1
(4340V Mod.)		over 4 to 8, incl	145	130	12	40	302	375	Note 2
		over 8 to 11, incl	145	130	12	40	311	388	Note 3
	2	to 4, incl	155	140	11	40	311	388	Note 2
		over 4 to 8, incl	155	140	11	40	311	401	Note 3
		over 8 to 11, incl	155	140	11	40	321	415	Note 4

TABLE 2 *Continued*

Grade	Class	Diameter	Tensile Strength, min	Yield Strength, 0.2 % offset, min	Elongation, min, %	Reduction of Area, min, %	Surface Brinell Hardness		Charpy V-Notch +10 °F [−12.2 °C]
							min	max	
	1	to 4, incl	165	150	10	35	321	415	Note 3
		over 4 to 8, incl	165	150	10	35	331	429	Note 4
		over 8 to 11, incl	165	150	10	35	331	444	Note 4
		Metric Units							
		mm	MPa	MPa	In 50 mm				
B21 (Cr-Mo-V)	5	to 50, incl	825	725	15	50	241	285	Note 4
		over 50 to 150, incl	795	690	15	50	248	302	Note 4
		over 150 to 205, incl	795	690	15	50	255	311	Note 4
	4	to 75, incl	930	825	13	45	269	331	Note 4
		over 75 to 150, incl	930	825	13	45	277	352	Note 4
	3	to 75, incl	1000	895	12	40	293	352	Note 4
		over 75 to 150, incl	1000	895	12	40	302	375	Note 4
	2	to 100, incl	1070	965	11	40	311	401	Note 4
	1	to 100, incl	1140	1035	10	35	321	429	Note 4
B22 (4142-H)	5	to 50, incl	825	725	15	50	248	293	Note 1
		over 50 to 100, incl	795	690	15	50	255	302	Note 4
	4	to 25, incl	930	825	13	45	269	341	Note 1
		over 25 to 100, incl	930	825	13	45	277	363	Note 4
	3	to 50, incl	1000	895	12	40	293	363	Note 4
		over 50 to 100, incl	1000	895	12	40	302	375	Note 4
	2	to 75, incl	1070	965	11	40	311	401	Note 4
	1	to 38, incl	1140	1035	10	35	321	401	Note 4
B23 (E-4340-H)	5	to 150, incl	825	725	15	50	248	311	Note 1
		over 150 to 200 incl	795	690	15	50	255	321	Note 1
		over 200 to 240, incl	795	690	15	50	262	321	Note 4
	4	to 75, incl	930	825	13	45	269	341	Note 1
		over 75 to 150, incl	930	825	13	45	277	352	Note 1
		over 150 to 240, incl	930	825	13	45	285	363	Note 4
	3	to 75, incl	1000	895	12	40	293	363	Note 2
		over 75 to 150, incl	1000	895	12	40	302	375	Note 2
		over 150 to 240, incl	1000	895	12	40	311	388	Note 4
	2	to 75, incl	1070	965	11	40	311	388	Note 4
		over 75 to 150, incl	1070	965	11	40	311	401	Note 4
		over 150 to 240, incl	1070	965	11	40	321	415	Note 4
	1	to 75, incl	1140	1035	10	35	321	415	Note 4
		over 75 to 150, incl	1140	1035	10	35	331	429	Note 4
		over 150 to 200, incl	1140	1035	10	35	341	444	Note 4
B24 (4340 Mod.)	5	to 150, incl	825	725	15	50	248	311	Note 1
		over 150 to 200, incl	795	690	15	50	255	321	Note 1
		over 200 to 240, incl	795	690	15	50	262	321	Note 1
	4	to 75, incl	930	825	13	45	269	341	Note 1
		over 75 to 150, incl	930	825	13	45	277	352	Note 1
		over 150 to 200, incl	930	825	13	45	285	363	Note 1
		over 200 to 240, incl	930	825	13	45	293	363	Note 4
	3	to 75, incl	1000	895	12	40	293	363	Note 2
		over 75 to 200, incl	1000	895	12	40	302	388	Note 2
		over 200 to 240, incl	1000	895	12	40	311	388	Note 4
	2	to 180, incl	1070	965	11	40	311	401	Note 2
		over 180 to 240, incl	1070	965	11	40	321	415	Note 4
	1	to 150, incl	1140	1035	10	35	321	415	Note 3
		over 150 to 200, incl	1140	1035	10	35	331	429	Note 4
B24V (4340V Mod.)	3	to 100, incl	1000	895	12	40	293	363	Note 1
		over 100 to 200, incl	1000	895	12	40	302	375	Note 2
		over 200 to 240, incl	1000	895	12	40	311	388	Note 3
	2	to 100, incl	1070	965	11	40	311	388	Note 2
		over 100 to 200, incl	1070	965	11	40	311	401	Note 3
		over 200 to 280, incl	1070	965	11	40	321	415	Note 4
	1	to 100, incl	1140	1035	10	35	321	415	Note 3
		over 100 to 200, incl	1140	1035	10	35	331	429	Note 4
		over 200 to 280, incl	1140	1035	10	35	331	444	Note 4