

SPECIFICATION FOR ALLOY-STEEL BOLTING FOR SPECIAL APPLICATIONS



SA-540/SA-540M



(23)

(Identical with ASTM Specification A540/A540M-15(2021).)

Specification for Alloy-Steel Bolting for Special Applications

1. Scope

1.1 This specification covers regular and special-quality alloy steel bolting materials and bolting components that may be used for nuclear and other special applications. See Specification A962/A962M for the definition of bolting.

1.2 The following referenced common requirements are indispensable for application of this specification: Specification A962/A962M.

1.3 Supplementary requirements of an optional nature are provided for use at the option of the purchaser. These supplementary requirements only apply when specified individually by the purchaser in the purchase order or contract.

1.4 This specification is expressed in both inch-pound units and in SI units; however, unless the purchase order or contract specifies the applicable “M” specification designation (SI units), inch-pound units shall apply.

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

1.6 *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:

A962/A962M Specification for Common Requirements for Bolting Intended for Use at Any Temperature from Cryogenic to the Creep Range
E45 Test Methods for Determining the Inclusion Content of Steel

3. Ordering Information

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

- 3.1.1 Grade and Class
- 3.1.2 Condition (Section 5),
- 3.1.3 Heat treatment (Section 6),
- 3.1.4 Supplementary Requirements (S1 to S9),
- 3.1.5 Reports required (Section 16),
- 3.1.6 End use, and
- 3.1.7 Any special requirements.

3.2 The purchaser is referred to the listed supplementary requirements.

4. Common Requirements

4.1 Bolting materials and bolting components supplied to this specification shall conform to the requirements of Specification A962/A962M. These requirements include test methods, finish, thread dimensions, macro etch, 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 Bolting 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.

6. Heat Treatment

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

6.2 Bolting material 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, 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 Bolting 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 Steels used for bolting materials shall conform to the chemical requirements prescribed in Table 1.

8. Tensile Requirements

8.1 Bolting 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 Bolting 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 bolting material in the annealed condition shall not be greater than 235 HBW.

9.3 The hardness of bolting 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 bolting 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 Bolting 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 16.1).

11. Workmanship, Finish, and Appearance

11.1 Bolting material shall be uniform in quality and free of defects that would be detrimental to the intended service. If magnetic particle inspection for such defects is desired, Supplementary Requirement S6 should be specified.

11.2 *Surface Quality*—Bolting material shall be free of seams, laps, cracks, or other defects that are not removable within the machining cleanup allowance specified in Table 3.

TABLE 1 Chemical Requirements^A

Grade Symbol	B21		B22		B23		B24		B24V	
	(Cr-Mo-V)		(4142-H)		(E-4340-H)		(4340 Mod.)		(4340V Mod.)	
	Chromium-Molybdenum-Vanadium		Chromium-Molybdenum		Chromium-Nickel-Molybdenum		Chromium-Nickel-Molybdenum		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 %	Range, %	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 (Cr-Mo-V)	5	to 2, incl	120	105	15	50	241	285	Note 4
		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 (4142-H)	5	to 2, incl	120	105	15	50	248	293	Note 1
		over 2 to 4, incl	115	100	15	50	255	302	Note 4
		to 1, incl	135	120	13	45	269	341	Note 1
	4	over 1 to 4, incl	135	120	13	45	277	363	Note 4
		to 2, incl	145	130	12	40	293	363	Note 4
	3	over 2 to 4, incl	145	130	12	40	302	375	Note 4
		to 3, incl	155	140	11	40	311	401	Note 4
	1	to 1½, incl	165	150	10	35	321	401	Note 4
B23 (E-4340-H)	5	to 6, incl	120	105	15	50	248	311	Note 1
		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 (4340 Mod.)	5	to 6, incl	120	105	15	50	248	311	Note 1
		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
	3	over 8 to 9½, incl	135	120	13	45	293	363	Note 4
		to 3, incl	145	130	12	40	293	363	Note 2
		over 3 to 8, incl	145	130	12	40	302	388	Note 2
	2	over 8 to 9½, incl	145	130	12	40	311	388	Note 4
		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
		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 (4340V Mod.)	3	to 4, incl	145	130	12	40	293	363	Note 1
		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
	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	

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	
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
		to 25, incl	930	825	13	45	269	341	Note 1
	4	over 25 to 100, incl	930	825	13	45	277	363	Note 4
		to 50, incl	1000	895	12	40	293	363	Note 4
	3	over 50 to 100, incl	1000	895	12	40	302	375	Note 4
		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
	3	over 150 to 240, incl	930	825	13	45	285	363	Note 4
		to 75, incl	1000	895	12	40	293	363	Note 2
	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
	1	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
	B24 (4340 Mod.)	5	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
4		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
3		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	
2	over 200 to 240, incl	930	825	13	45	293	363	Note 4	
	to 75, incl	1000	895	12	40	293	363	Note 2	
1	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	
B24V (4340V Mod.)	3	to 180, incl	1070	965	11	40	311	401	Note 2
		over 180 to 240, incl	1070	965	11	40	321	415	Note 4
		to 150, incl	1140	1035	10	35	321	415	Note 3
	2	over 150 to 200, incl	1140	1035	10	35	331	429	Note 4
		to 100, incl	1000	895	12	40	293	363	Note 1
	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
B24V (4340V Mod.)	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
	1	over 200 to 280, incl	1070	965	11	40	321	415	Note 4
		to 100, incl	1140	1035	10	35	321	415	Note 3
	1	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	

12. Surface Condition

12.1 Bolting material shall be cleaned and furnished in the scale-free condition.

13. Number of Tests

13.1 Mechanical Tests on Quenched and Tempered Bolting Material:

TABLE 3 Rolled Bars^A—Permissible Grinding Depth for Removal of Surface Defects

Diameter, in. [mm]	Minimum Stock Removal Per Side	
	in.	mm
1 to 1 $\frac{1}{8}$ [25 to 29], incl	0.025	0.64
Over 1 $\frac{1}{8}$ to 1 $\frac{1}{4}$ [29 to 32], incl	0.028	0.71
Over 1 $\frac{1}{4}$ to 1 $\frac{3}{8}$ [32 to 35], incl	0.030	0.76
Over 1 $\frac{3}{8}$ to 1 $\frac{1}{2}$ [35 to 38], incl	0.033	0.84
Over 1 $\frac{1}{2}$ to 2 [38 to 50], incl	0.042	1.07
Over 2 to 2 $\frac{1}{2}$ [50 to 65], incl	0.052	1.32
Over 2 $\frac{1}{2}$ to 3 $\frac{1}{2}$ [65 to 90], incl	0.072	1.83
Over 3 $\frac{1}{2}$ to 4 $\frac{1}{2}$ [90 to 115], incl	0.090	2.29
Over 4 $\frac{1}{2}$ to 5 $\frac{1}{2}$ [115 to 140], incl	0.110	2.79
Over 5 $\frac{1}{2}$ to 6 $\frac{1}{2}$ [140 to 165], incl	0.125	3.18
Over 6 $\frac{1}{2}$ to 8 $\frac{1}{4}$ [165 to 210], incl	0.155	3.94
Over 8 $\frac{1}{4}$ to 9 $\frac{1}{2}$ [210 to 240], incl	0.203	5.16

^A Consult the manufacturer on forged bars, cold-finished bars, bored bars, seamless tubes, and forged hollows.

13.1.1 One test coupon shall be removed from each end of one bar, one seamless tube, or one bored bar or from each of two forged hollows from each size of each heat in each tempering charge, or each 10 000 lb [4540 kg], whichever is less. One tension test and one impact test consisting of three Charpy V-notch specimens shall be taken from each test coupon. For testing in accordance with 15.1.1, two tests shall be obtained from two representative production pieces from each size of each heat in each tempering charge or each 10 000 lb [4540 kg], whichever is less.

13.1.2 Hardness Test:

13.1.2.1 Bars 2 in. [50 mm] and over and all seamless tubes or bored bars shall be tested near each end of each mill-treated length. Each forged hollow with thickness 2 in. [50 mm] or over shall be tested on the surface.

13.1.2.2 Bars under 2 in. [50 mm] shall be tested near each end of not less than 10 % of the bars. Forged hollows less than 2 in. [50 mm] thick shall be tested on the surface of not less than 10 % of the forgings.

13.2 Hardness Tests of Annealed Bolting Material:

13.2.1 Hardness tests shall be made on the annealed bars to assure compliance with 10.2.

13.3 Bolting Components:

13.3.1 The number of bolting components tested shall be as specified in Specification A962/A962M.

14. Retests

14.1 If the results of the mechanical tests of any test lot do not conform to the specified requirements, the manufacturer shall reject the lot or the manufacturer may re-heat treat such a lot no more than twice. After the lot is re-heat treated, all of the tests specified in Section 13 shall be repeated, and all shall conform to the specified requirements.

15. Test Specimens and Methods of Testing

15.1 A discard equivalent to the diameter of the bar when heat treated as a solid or a discard equivalent to the wall

thickness when heat treated as a seamless tube, bored bar, or hollow forging shall be taken prior to removal of test coupons.

15.1.1 When production pieces are not of sufficient length to permit removal of test coupons in accordance with 15.1, the mid-length of the specimens shall be at the mid-length of the production pieces selected for destruction to provide test coupons of the bolting material. The production pieces selected for test shall be identical with respect to the quenched contour and size except for length which shall equal or exceed the length of the represented production pieces.

15.2 Tension and impact specimens from bolting components with cross sections of 1 $\frac{1}{2}$ in. [38 mm] or less shall be taken so that their longitudinal axis is on a line representing the center of the diameter or thickness.

15.3 Tension test specimens from bolting components with cross sections exceeding 1 $\frac{1}{2}$ in. [38 mm] shall be taken so that their longitudinal axis is midway between mid-thickness and surface.

15.4 Impact specimens from bolting components with cross sections exceeding 1 $\frac{1}{2}$ in. [38 mm] shall be taken so that their longitudinal axis is midway between mid-thickness and surface or 1 in. [25 mm] below the surface plus the machining allowance per side, whichever is less.

16. Certification

16.1 When requested in the purchaser's order, a test report shall be furnished to the purchaser. In addition to the requirements of Specification A962/A962M the report shall include any other tests which may be specified in writing by the purchaser.

17. Product Marking

17.1 Bars under 2 in. [50 mm] in diameter shall be bundled and tagged with the specification, grade symbol, and mill heat number. The specification number marked on the tag need not include specification year date and revision number.

17.2 Bars 2 in. [50 mm] and over in diameter and all seamless tubes and bored bars shall be die-stamped with the mill heat number and grade symbol on one surface.

17.3 Each hollow forging shall be die-stamped with the heat number or heat symbol code and grade symbol.

17.4 See Specification A962/A962M for marking bolting components. Use the grade symbol shown in Table 1.

18. Keywords

18.1 bolts—steel; chromium-molybdenum alloy steel; chromium-molybdenum-vanadium alloy steel; chromium-nickel-molybdenum-vanadium alloy steel; bolting components—steel; nickel-chromium-molybdenum alloy steel; nuclear applications; nuts—steel; steel bars—alloy; steel bolting material

SUPPLEMENTARY REQUIREMENTS

These requirements shall not apply unless specified in the order, in which event the tests shall be made at the mill at the purchaser's expense unless otherwise agreed upon.

S1. Product Analysis

S1.1 Product analysis shall be made on each bar, seamless tube, bored bar, or the parent bar from which forged hollows are made. Individual pieces failing to conform to Table 1 shall be rejected.

S2. Macroetch Test

S2.1 The material shall be macroetch tested and shall meet the quality and cleanliness requirements as specified by the purchaser. The macroetch examination may be made on representative billets from which the material will be produced or it may be made on samples cut from the ends of the bars, seamless tubes, bored bars, or forged hollows. The samples shall be prepared in accordance with the procedure described in Method E381.

NOTE S2.1—The quality and cleanliness may be specified by the purchaser as equal to or better than that indicated by a designated letter and plate number of Military Standard—430 (latest revision).

S3. Ultrasonic Test

S3.1 Each length shall be ultrasonically inspected in a manner agreeable to the purchaser and supplier.

S4. Demonstration of Capability

S4.1 When annealed bolting material is ordered to 6.1, a sample piece in length at least $3 \times$ diameter D of a representative bar shall be heat treated in accordance with 6.2 and 6.3. Mechanical test samples taken as required by Section 15 shall meet the requirements of 8.2 and 10.2.

S5. Fracture Transition Temperature

S5.1 The fracture transition temperature for a 50 % fibrous (ductile shear) fracture shall be determined. The procedure for determination of the fracture transition temperature shall be to prepare four sets (three to a set) of Charpy V-notch specimens in accordance with Section 15. One set of three specimens shall be tested at approximately 70 °F [20 °C]. The absorbed energy in foot-pounds shall be recorded and the percent of fibrous fracture determined from Table S5.1 and Fig. S5.1. The other three sets shall be tested at successively lower or higher temperatures to bracket the temperature where the bolting material will exhibit a 50 % fibrous fracture. The results of all test data are to be reported to the purchaser.

S6. Magnetic Particle Inspection

S6.1 Bolting material may be supplied to cleanliness requirements by agreement between the purchaser and supplier. The cleanliness shall be determined by the magnetic particle method described in the latest issue of Practice E45.

NOTE S6.1—The bolting material shall have the minimum stock removal specified in Table S6.1 prior to magnetic particle inspection.

S7. Elevated Temperature Test

S7.1 Three Charpy V-notch specimens shall be tested at 212 °F [100 °C] to determine the “upper shelf” fracture energy of the material. No specimen thus tested shall break at an energy less than 30 ft-lbf [41 J].

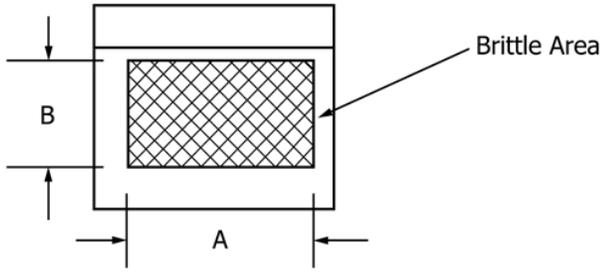
S8. Alternative Fracture Toughness Requirement

S8.1 The fracture toughness requirements (Charpy impact test) for bolting material of the ASME Boiler and Pressure Vessel Code, Section III, Subarticle NB 2300, shall be used instead of the Charpy impact test requirement specified in

TABLE S5.1 Percent Fibrous Fracture^A
Dimension A Width, mm

Dimension B Height, mm	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10
1.0	98	98	97	96	96	95	94	94	93	93	92	91	91	90	89	89	88	87
1.5	97	96	95	94	93	93	92	91	90	89	88	87	86	85	85	83	82	81
2.0	96	95	94	93	91	90	89	88	86	85	84	82	81	80	79	78	76	75
2.5	95	94	92	91	89	87	86	84	83	81	80	79	76	75	73	72	70	69
3.0	94	93	91	90	87	85	83	81	79	78	76	74	72	70	68	66	64	63
3.5	93	91	89	87	85	83	80	78	75	74	72	69	67	65	63	61	58	56
4.0	93	90	87	85	83	80	78	75	72	70	68	65	62	60	57	55	52	50
4.5	92	89	86	83	80	78	75	72	69	66	63	61	58	55	52	49	46	43
5.0	91	88	84	81	78	75	72	69	66	63	59	56	53	50	48	44	40	38
5.5	90	86	83	79	75	72	69	66	63	59	55	52	48	45	42	38	35	31
6.0	89	85	81	78	74	70	66	63	59	55	51	47	44	40	36	33	29	25
6.5	88	84	80	76	72	68	63	59	55	51	47	43	40	35	31	27	23	19
7.0	87	82	79	74	69	65	61	56	52	47	43	39	34	30	26	21	16	12
7.5	86	81	76	72	67	62	58	53	48	44	40	34	30	25	23	16	11	6
8.0	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5	0

^A See Fig. S5.1.



Measure Dimensions *A* and *B* to the nearest 1/2 mm.

FIG. S5.1 Calculation of Percent Fibrous Area

TABLE S6.1 Rolled Bars^A—Stock Removal for Magnetic Particle Inspection

Diameter, in. [mm]	Minimum Stock Removal Per Side	
	in.	mm
1 to 1½ [25 to 38], incl	0.075	1.90
Over 1½ to 2 [38 to 50], incl	0.090	2.29
Over 2 to 2½ [50 to 65], incl	0.125	3.18
Over 2½ to 3½ [65 to 90], incl	0.156	3.96
Over 3½ to 4½ [90 to 115], incl	0.187	4.75
Over 4½ to 6 [115 to 155], incl	0.250	6.35
Over 6 to 10 [155 to 255], incl	0.312	7.92

^A Consult the manufacturer on forged bars, cold-finished bars, bored bars, seamless tubes, and forged hollows.

Table 2.