TEST METHODS FOR MECHANICAL TESTING OF STEEL PRODUCTS—METRIC

SA-1058 (**23**)

(Identical with ASTM Specification A1058-19.)

Test Methods for Mechanical Testing of Steel Products—Metric

1. Scope

1.1 These test methods cover mechanical tests described in ASTM, EN, ISO, and JIS standards that utilize the SI system of units. The test methods in each system are not exact equivalents. Each standards system (ASTM, EN, ISO, and JIS) shall be used independently of the other. Combining requirements from any two or more systems may result in nonconformance with the purchase order.

1.2 These test methods cover procedures for the mechanical testing of steels, stainless steels, and related alloys. The various mechanical tests herein described are used to determine properties required in the product specifications. Variations in testing methods are to be avoided, and standard methods of testing are to be followed to obtain reproducible and comparable results. In those cases in which the testing requirements for certain products are unique or at variance with these general procedures, the product specification testing requirements shall control.

1.3 Only one of the testing procedure tracks shall be followed: ASTM, EN, ISO, or JIS. When a test method or practice is not available in one of the tracks then an appropriate test method or practice from an alternative track shall be used. The respective tests are listed in the column shown in Table 1.

NOTE 1—The test methods in each system are not exact equivalents.

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

1.5 Attention is directed to Practice ISO 17025 when there may be a need for information on criteria for evaluation of testing laboratories.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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:*

A833 Test Method for Indentation Hardness of Metallic Materials by Comparison Hardness Testers

A956/A956M Test Method for Leeb Hardness Testing of Steel Products

A1038 Test Method for Portable Hardness Testing by the Ultrasonic Contact Impedance Method

E8/E8M Test Methods for Tension Testing of Metallic Materials

E10 Test Method for Brinell Hardness of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

E23 Test Methods for Notched Bar Impact Testing of Metallic Materials

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E110 Test Method for Rockwell and Brinell Hardness of Metallic Materials by Portable Hardness Testers

E190 Test Method for Guided Bend Test for Ductility of Welds

TABLE 1 Tests and Applicable Standards

Test	Sections	ASTM	EN	ISO	JIS
Tension	5 to 12	E8/E8M	10002-1	6892-1	Z 2241
Bend	13	E190 E290	7438[A]	7438	Z 2248
Bend (tube)	13	...	10232	8491	...
Hardness	14				
Brinell	15	E10	6506-1[A]	6506-1	Z 2243
Rockwell	16	E18	6508-1[A]	6508-1	Z 2245
Portable	17	A833 E110 A1038	...	...	...
Impact	18 to 26	E23	148-1[A]	148-1	Z 2242
Keywords	27	...	...	...	...

[A] These standards are designated EN ISO; this identifies the adoption of ISO standards by EN. "EN ISO" is part of the designation.

E290 Test Methods for Bend Testing of Material for Ductility

2.2 *Other Documents:*

ASME Boiler and Pressure Vessel Code Section VIII, Division I

ISO 148-1 Metallic Materials—Charpy Pendulum Impact Test—Part 1: Test Method

ISO 148-2 Metallic Materials—Charpy Pendulum Impact Test—Part 2: Verification of Test Machines

ISO 2566-1 Steel—Conversion of Elongation Values—Part 1: Carbon and Low Alloy Steels

ISO 2566-2 Steel—Conversion of Elongation Values—Part 2: Austenitic Steels

ISO 6506-1 Metallic Materials—Brinell Hardness Test—Part 1: Test Method[7]

ISO 6508-1 Metallic Materials—Rockwell Hardness Test—Part 1: Test Method (Scales A, B, C, D, E, F, G, H, K, N, T)

ISO 6892-1 Metallic Materials—Tensile Testing at Ambient Temperature

ISO 7438 Metallic Materials—Bend Test

ISO 8491 Metallic Materials—Tube (in Full Section)—Bend Test

ISO 17025 General Requirements for the Competence of Testing and Calibration Laboratories

JIS B 7722 Charpy Pendulum Impact Test—Verification of Testing Machines

JIS Z 2201 Test Pieces for Tensile Test for Metallic Materials

JIS Z 2241 Method of Tensile Test for Metallic Materials

JIS Z 2242 Method of Charpy Pendulum Impact Test for Metallic Materials

JIS Z 2243 Brinell Hardness Test—Test Method

JIS Z 2245 Rockwell Hardness Test—Test Method

JIS Z 2248 Method of Bend Test for Metallic Materials

3. General Precautions

3.1 The ASTM track is the default track; if other than the ASTM track is used that track shall be reported.

3.2 Certain methods of fabrication, such as bending, forming, and welding, or operations involving heating, may affect the properties of the material under test. Therefore, the product specifications cover the stage of manufacture at which mechanical testing is to be performed. The properties shown by testing prior to fabrication may not necessarily be representative of the product after it has been completely fabricated.

3.3 Improper machining or preparation of test specimens may give erroneous results. Care should be exercised to assure good workmanship in machining. Improperly machined specimens should be discarded and other specimens substituted.

3.4 Flaws in the specimen may also affect results. If any test specimen develops flaws, the retest provision of the applicable product specification shall govern.

3.5 If any test specimen fails because of mechanical reasons such as failure of testing equipment or improper specimen preparation, it may be discarded and another specimen taken.

4. Orientation of Test Specimens

4.1 The terms "longitudinal test" and "transverse test" are used only in material specifications for wrought products and are not applicable to castings. When such reference is made to a test coupon or test specimen, the following definitions apply:

4.1.1 *Longitudinal Test,* unless specifically defined otherwise, signifies that the lengthwise axis of the specimen is parallel to the direction of the greatest extension of the steel during rolling or forging. The stress applied to a longitudinal tension test specimen is in the direction of the greatest extension, and the axis of the fold of a longitudinal bend test specimen is at right angles to the direction of greatest extension.

4.1.2 *Transverse Test,* unless specifically defined otherwise, signifies that the lengthwise axis of the specimen is at right angles to the direction of the greatest extension of the steel during rolling or forging. The stress applied to a transverse tension test specimen is at right angles to the greatest extension, and the axis of the fold of a transverse bend test specimen is parallel to the greatest extension.

4.2 The terms "radial test" and "tangential test" are used in material specifications for some wrought circular products and are not applicable to castings. When such reference is made to a test coupon or test specimen, the following definitions apply:

4.2.1 *Radial Test,* unless specifically defined otherwise, signifies that the lengthwise axis of the specimen is perpendicular to the axis of the product and coincident with one of the radii of a circle drawn with a point on the axis of the product as a center.

4.2.2 *Tangential Test,* unless specifically defined otherwise, signifies that the lengthwise axis of the specimen is perpendicular to a plane containing the axis of the product and tangent to a circle drawn with a point on the axis of the product as a center.

TENSION TEST

5. Description

5.1 The tension test related to the mechanical testing of steel products subjects a machined or full-section specimen of the material under examination to a measured load sufficient to cause rupture. The resulting properties sought are defined in Test Methods E8/E8M, ISO 6892-1, or JIS Z 2241 as applicable.

5.2 In general, the testing equipment and methods are given in Test Methods E8/E8M, ISO 6892-1, and JIS Z 2241. However, there are certain exceptions to these practices; these exceptions are covered in this standard.

6. Testing Apparatus and Operations

6.1 *Loading Systems*—There are two general types of loading systems, mechanical (screw power) and hydraulic. These differ chiefly in the variability of the rate of load application. The older screw power machines are limited to a small number of fixed free running crosshead speeds. Some modern screw power machines, and all hydraulic machines permit stepless variation throughout the range of speeds.

6.2 The tension testing machine shall be maintained in good operating condition, used only in the proper loading range, and calibrated periodically in accordance with the latest revision of the appropriate practices.

NOTE 2—Many machines are equipped with stress-strain recorders for autographic plotting of stress-strain curves. It should be noted that some recorders have a load measuring component entirely separate from the load indicator of the testing machine. Such recorders are calibrated separately.

6.3 *Loading*—It is the function of the gripping or holding device of the testing machine to transmit the load from the heads of the machine to the specimen under test. The essential requirement is that the load shall be transmitted axially. This implies that the centers of the action of the grips shall be in alignment, insofar as practicable, with the axis of the specimen at the beginning and during the test and that bending and twisting be held to a minimum.

6.4 *Speed of Testing*—The speed of testing shall not be greater than that at which load and strain readings can be made accurately. In production testing, speed of testing is commonly expressed *(1)* in terms of free running crosshead speed (rate of movement of the crosshead of the testing machine when not under load), or *(2)* in terms of rate of separation of the two heads of the testing machine under load, or *(3)* in terms of rate of stressing the specimen, or *(4)* in terms of rate of straining the specimen. The following limitations on the speed of testing are recommended as adequate for most steel products:

NOTE 3—Tension tests using closed-loop machines (with feedback control of rate) should not be performed using load control, as this mode of testing will result in acceleration of the crosshead upon yielding and elevation of the measured yield strength.

6.4.1 Any convenient speed of testing may be used up to one half the specified yield point or yield strength. When this point is reached, the free-running rate of separation of the crossheads shall be adjusted so as not to exceed 0.025 mm per second per 25 mm of reduced section, or the distance between the grips for test specimens not having reduced sections. This speed shall be maintained through the yield point or yield strength. In determining the tensile strength, the free-running rate of separation of the heads shall not exceed 13 mm per min per 25 mm of reduced section, or the distance between the grips for test specimens not having reduced sections. In any event, the minimum speed of testing shall not be less than 1/10 the specified maximum rates for determining yield point or yield strength and tensile strength.

6.4.2 It shall be permissible to set the speed of the testing machine by adjusting the free running crosshead speed to the above specified values, inasmuch as the rate of separation of heads under load at these machine settings is less than the specified values of free running crosshead speed.

6.4.3 As an alternative, if the machine is equipped with a device to indicate the rate of loading, the speed of the machine from half the specified yield point or yield strength through the yield point or yield strength may be adjusted so that the rate of stressing does not exceed 11 MPa per second. However, the minimum rate of stressing shall not be less than 1 MPa per second.

7. Test Specimen Parameters

7.1 *Selection*—Test coupons shall be selected in accordance with the applicable product specifications.

7.2 *Size and Tolerances*—Test specimen dimensions and tolerances shall comply with the requirements of the relevant standards.

7.3 *Procurement of Test Specimens*—Specimens shall be prepared from portions of the material. They are usually machined so as to have a reduced cross section at mid-length in order to obtain uniform distribution of the stress over the cross section and to localize the zone of fracture. Care shall be taken to remove by machining all distorted, cold-worked, or heat-affected areas from the edges of the section used in evaluating the test.

7.4 *Aging of Test Specimens*—Unless otherwise specified, it shall be permissible to age tension test specimens. The time-temperature cycle employed must be such that the effects of previous processing will not be materially changed. It may be accomplished by aging at room temperature 24 to 48 h, or in shorter time at moderately elevated temperatures by boiling in water, heating in oil or in an oven.

7.5 *Measurement of Dimensions of Test Specimens*—Test specimens shall be measured in accordance with the requirements of 7.5.1 and 7.5.2 for ASTM or the appropriate paragraphs of ISO 6892-1 or JIS Z 2241, as applicable.

7.5.1 *Rectangular Tension Test*—These forms of specimens are shown in Test Methods E8/E8M. To determine the cross-sectional area, the center width dimension shall be measured to the nearest 0.15 mm for the 200-mm gauge length specimen and 0.025 mm for the 50-mm gauge length specimen. The center thickness dimension shall be measured to the nearest 0.025 mm for both specimens.

7.5.2 *Round Tension Test Specimens*—These forms of specimens are shown in Test Methods E8/E8M. To determine the

cross-sectional area, the diameter shall be measured at the center of the gauge length to the nearest 0.025 mm.

7.6 *General*—Test specimens shall be either substantially full size or machined, as prescribed in the product specifications for the material being tested.

7.6.1 It is desirable to have the cross-sectional area of the specimen smallest at the center of the gauge length to ensure fracture within the gauge length. This is provided for by the taper in the gauge length permitted for each of the specimens described in the following sections.

7.6.2 For low ductility materials it is desirable to have fillets of large radius at the ends of the gauge length.

8. Plate-Type Specimen

8.1 The standard plate-type test specimen is shown in Test Methods E8/E8M, ISO 6892-1, or JIS Z 2241. This specimen is used for testing metallic materials in the form of plate, structural and bar-size shapes, and flat material having a nominal thickness of 5 mm or over. When product specifications so permit, other types of specimens may be used.

9. Sheet-Type Specimen

9.1 The standard sheet-type test specimen is shown in Test Methods E8/E8M, ISO 6892-1, or JIS Z 2241. This specimen is used for testing metallic materials in the form of sheet, plate, flat wire, strip, band, and hoop ranging in nominal thickness from 0.13 to 19 mm. When product specifications so permit, other types of specimens may be used, as specified in Test Methods E8/E8M.

10. Round Specimens

10.1 The standard diameter round test specimen as shown in Test Methods E8/E8M, ISO 6892-1, or JIS Z 2241 is frequently used for testing metallic materials.

10.2 Small size specimens proportional to standard specimens may be used when it is necessary to test material from which the standard specimens cannot be prepared. When small size specimens are used, the gauge length for measurement of elongation shall be five times the diameter of the specimen.

10.3 The type of specimen ends outside of the gauge length shall accommodate the shape of the product tested, and shall properly fit the holders or grips of the testing machine so that axial loads are applied with a minimum of load eccentricity and slippage.

11. Gauge Marks

11.1 Test specimens shall be marked in accordance with the requirements of the relevant standards.

12. Determination of Tensile Properties

12.1 The determination and description of the tensile properties shall be in accordance with the requirements of the relevant standards.

12.2 Elongation values may be converted from (*i*) 4d gauge length to a 5d gauge length, or (*ii*) 5d gage length to a 4d gage length by use of the multiplication factors shown in Table 2. If this conversion is used, the supplier must show the calculation on the certification.

TABLE 2 Conversion Factors for 4d and 5d Gauge Lengths (ISO 2566-1 and ISO 2566-2)

Conversion from	4d to 5d	5d to 4d
Carbon and low alloy steels	0.916	1.093
Austenitic steels	0.972	1.029

12.2.1 *Example 1*—Conversion of Carbon and low alloy steel elongation derived from 4d gauge length to a 5d gauge length elongation value:

$$23\ \% \times 0.916 = 21\ \%$$

12.2.2 *Example 2*—Conversion of Austenitic steel elongation derived from 5d gauge length to a 4d gauge length elongation value:

$$23\ \% \times 1.029 = 24\ \%$$

12.3 *Reduction of Area*—Fit the ends of the fractured specimen together and measure the mean diameter or the width and thickness at the smallest cross section to the same accuracy as the original dimensions. The difference between the area thus found and the area of the original cross section expressed as a percentage of the original area is the reduction of area.

BEND TEST

13. Description

13.1 The bend test is one method for evaluating ductility, but it cannot be considered as a quantitative means of predicting service performance in all bending operations. The severity of the bend test is primarily a function of the angle of bend and inside diameter to which the specimen is bent, and of the cross section of the specimen. These conditions are varied according to location and orientation of the test specimen and the chemical composition, tensile properties, hardness, type, and quality of the steel specified. Test Method E190, Test Methods E290, EN ISO 7438, EN 10232 (tube), ISO 7438, or ISO 8491 (tube) and JIS Z 2248 may be consulted for methods of performing the test.

13.2 Unless otherwise specified, it shall be permissible to age bend test specimens. The time-temperature cycle employed must be such that the effects of previous processing will not be materially changed. It may be accomplished by aging at room temperature 24 to 48 h, or in shorter time at moderately elevated temperatures by boiling in water or by heating in oil or in an oven.

13.3 Bend the test specimen at room temperature to an inside diameter, as designated by the applicable product specifications, to the extent specified. The speed of bending is ordinarily not an important factor.

HARDNESS TEST

14. General

14.1 A hardness test is a means of determining resistance to penetration and is occasionally employed to obtain a quick approximation of tensile strength. Table 3, Table 4, Table 5, and Table 6 are for the conversion of hardness measurements from one scale to another or to approximate tensile strength.

TABLE 3 Approximate Hardness Conversion Numbers for Nonaustenitic Steels[A] (Rockwell C to Other Hardness Numbers)

Rockwell C Scale, 150-kgf Load, Diamond Penetrator	Vickers Hardness Number	Brinell Hardness, 3000-kgf Load, 10-mm Ball	Knoop Hardness, 500-gf Load and Over	Rockwell A Scale, 60-kgf Load, Diamond Penetrator	Rockwell Superficial Hardness			
					15N Scale, 15-kgf Load, Diamond Penetrator	30N Scale 30-kgf Load, Diamond Penetrator	45N Scale, 45-kgf Load, Diamond Penetrator	Approximate Tensile Strength, ksi (MPa)
68	940	. . .	920	85.6	93.2	84.4	75.4	. . .
67	900	. . .	895	85.0	92.9	83.6	74.2	. . .
66	865	. . .	870	84.5	92.5	82.8	73.3	. . .
65	832	739	846	83.9	92.2	81.9	72.0	. . .
64	800	722	822	83.4	91.8	81.1	71.0	. . .
63	772	706	799	82.8	91.4	80.1	69.9	. . .
62	746	688	776	82.3	91.1	79.3	68.8	. . .
61	720	670	754	81.8	90.7	78.4	67.7	. . .
60	697	654	732	81.2	90.2	77.5	66.6	. . .
59	674	634	710	80.7	89.8	76.6	65.5	351 (2420)
58	653	615	690	80.1	89.3	75.7	64.3	338 (2330)
57	633	595	670	79.6	88.9	74.8	63.2	325 (2240)
56	613	577	650	79.0	88.3	73.9	62.0	313 (2160)
55	595	560	630	78.5	87.9	73.0	60.9	301 (2070)
54	577	543	612	78.0	87.4	72.0	59.8	292 (2010)
53	560	525	594	77.4	86.9	71.2	58.6	283 (1950)
52	544	512	576	76.8	86.4	70.2	57.4	273 (1880)
51	528	496	558	76.3	85.9	69.4	56.1	264 (1820)
50	513	482	542	75.9	85.5	68.5	55.0	255 (1760)
49	498	468	526	75.2	85.0	67.6	53.8	246 (1700)
48	484	455	510	74.7	84.5	66.7	52.5	238 (1640)
47	471	442	495	74.1	83.9	65.8	51.4	229 (1580)
46	458	432	480	73.6	83.5	64.8	50.3	221 (1520)
45	446	421	466	73.1	83.0	64.0	49.0	215 (1480)
44	434	409	452	72.5	82.5	63.1	47.8	208 (1430)
43	423	400	438	72.0	82.0	62.2	46.7	201 (1390)
42	412	390	426	71.5	81.5	61.3	45.5	194 (1340)
41	402	381	414	70.9	80.9	60.4	44.3	188 (1300)
40	392	371	402	70.4	80.4	59.5	43.1	182 (1250)
39	382	362	391	69.9	79.9	58.6	41.9	177 (1220)
38	372	353	380	69.4	79.4	57.7	40.8	171 (1180)
37	363	344	370	68.9	78.8	56.8	39.6	166 (1140)
36	354	336	360	68.4	78.3	55.9	38.4	161 (1110)
35	345	327	351	67.9	77.7	55.0	37.2	156 (1080)
34	336	319	342	67.4	77.2	54.2	36.1	152 (1050)
33	327	311	334	66.8	76.6	53.3	34.9	149 (1030)
32	318	301	326	66.3	76.1	52.1	33.7	146 (1010)
31	310	294	318	65.8	75.6	51.3	32.5	141 (970)
30	302	286	311	65.3	75.0	50.4	31.3	138 (950)
29	294	279	304	64.6	74.5	49.5	30.1	135 (930)
28	286	271	297	64.3	73.9	48.6	28.9	131 (900)
27	279	264	290	63.8	73.3	47.7	27.8	128 (880)
26	272	258	284	63.3	72.8	46.8	26.7	125 (860)
25	266	253	278	62.8	72.2	45.9	25.5	123 (850)
24	260	247	272	62.4	71.6	45.0	24.3	119 (820)
23	254	243	266	62.0	71.0	44.0	23.1	117 (810)
22	248	237	261	61.5	70.5	43.2	22.0	115 (790)
21	243	231	256	61.0	69.9	42.3	20.7	112 (770)
20	238	226	251	60.5	69.4	41.5	19.6	110 (760)

[A] This table gives the approximate interrelationships of hardness values and approximate tensile strength of steels. It is possible that steels of various compositions and processing histories will deviate in hardness-tensile strength relationship from the data presented in this table. The data in this table should not be used for austenitic stainless steels, but have been shown to be applicable for ferritic and martensitic stainless steels. The data in this table should not be used to establish a relationship between hardness values and tensile strength of hard drawn wire. Where more precise conversions are required, they should be developed specially for each steel composition, heat treatment, and part.

TABLE 4 Approximate Hardness Conversion Numbers for Nonaustenitic Steels[A] (Rockwell B to Other Hardness Numbers)

Rockwell B Scale, 100-kgf Load 1/16-in. (1.588-mm) Ball	Vickers Hardness Number	Brinell Hardness, 3000-kgf Load, 10-mm Ball	Knoop Hardness, 500-gf Load and Over	Rockwell A Scale, 60-kgf Load, Diamond Penetrator	Rockwell F Scale, 60-kgf Load, 1/16-in. (1.588-mm) Ball	Rockwell Superficial Hardness			Approximate Tensile Strength ksi (MPa)
						15T Scale, 15-kgf Load, 1/16-in. (1.588-mm) Ball	30T Scale, 30-kgf Load, 1/16-in. (1.588-mm) Ball	45T Scale, 45-kgf Load, 1/16-in. (1.588-mm) Ball	
100	240	240	251	61.5	. . .	93.1	83.1	72.9	116 (800)
99	234	234	246	60.9	. . .	92.8	82.5	71.9	114 (785)
98	228	228	241	60.2	. . .	92.5	81.8	70.9	109 (750)
97	222	222	236	59.5	. . .	92.1	81.1	69.9	104 (715)
96	216	216	231	58.9	. . .	91.8	80.4	68.9	102 (705)
95	210	210	226	58.3	. . .	91.5	79.8	67.9	100 (690)
94	205	205	221	57.6	. . .	91.2	79.1	66.9	98 (675)
93	200	200	216	57.0	. . .	90.8	78.4	65.9	94 (650)
92	195	195	211	56.4	. . .	90.5	77.8	64.8	92 (635)
91	190	190	206	55.8	. . .	90.2	77.1	63.8	90 (620)
90	185	185	201	55.2	. . .	89.9	76.4	62.8	89 (615)
89	180	180	196	54.6	. . .	89.5	75.8	61.8	88 (605)
88	176	176	192	54.0	. . .	89.2	75.1	60.8	86 (590)
87	172	172	188	53.4	. . .	88.9	74.4	59.8	84 (580)
86	169	169	184	52.8	. . .	88.6	73.8	58.8	83 (570)
85	165	165	180	52.3	. . .	88.2	73.1	57.8	82 (565)
84	162	162	176	51.7	. . .	87.9	72.4	56.8	81 (560)
83	159	159	173	51.1	. . .	87.6	71.8	55.8	80 (550)
82	156	156	170	50.6	. . .	87.3	71.1	54.8	77 (530)
81	153	153	167	50.0	. . .	86.9	70.4	53.8	73 (505)
80	150	150	164	49.5	. . .	86.6	69.7	52.8	72 (495)
79	147	147	161	48.9	. . .	86.3	69.1	51.8	70 (485)
78	144	144	158	48.4	. . .	86.0	68.4	50.8	69 (475)
77	141	141	155	47.9	. . .	85.6	67.7	49.8	68 (470)
76	139	139	152	47.3	. . .	85.3	67.1	48.8	67 (460)
75	137	137	150	46.8	99.6	85.0	66.4	47.8	66 (455)
74	135	135	147	46.3	99.1	84.7	65.7	46.8	65 (450)
73	132	132	145	45.8	98.5	84.3	65.1	45.8	64 (440)
72	130	130	143	45.3	98.0	84.0	64.4	44.8	63 (435)
71	127	127	141	44.8	97.4	83.7	63.7	43.8	62 (425)
70	125	125	139	44.3	96.8	83.4	63.1	42.8	61 (420)
69	123	123	137	43.8	96.2	83.0	62.4	41.8	60 (415)
68	121	121	135	43.3	95.6	82.7	61.7	40.8	59 (405)
67	119	119	133	42.8	95.1	82.4	61.0	39.8	58 (400)
66	117	117	131	42.3	94.5	82.1	60.4	38.7	57 (395)
65	116	116	129	41.8	93.9	81.8	59.7	37.7	56 (385)
64	114	114	127	41.4	93.4	81.4	59.0	36.7	. . .
63	112	112	125	40.9	92.8	81.1	58.4	35.7	. . .
62	110	110	124	40.4	92.2	80.8	57.7	34.7	. . .
61	108	108	122	40.0	91.7	80.5	57.0	33.7	. . .
60	107	107	120	39.5	91.1	80.1	56.4	32.7	. . .
59	106	106	118	39.0	90.5	79.8	55.7	31.7	. . .
58	104	104	117	38.6	90.0	79.5	55.0	30.7	. . .
57	103	103	115	38.1	89.4	79.2	54.4	29.7	. . .
56	101	101	114	37.7	88.8	78.8	53.7	28.7	. . .
55	100	100	112	37.2	88.2	78.5	53.0	27.7	. . .
54	. . .	. . .	111	36.8	87.7	78.2	52.4	26.7	. . .
53	. . .	. . .	110	36.3	87.1	77.9	51.7	25.7	. . .
52	. . .	. . .	109	35.9	86.5	77.5	51.0	24.7	. . .
51	. . .	. . .	108	35.5	86.0	77.2	50.3	23.7	. . .
50	. . .	. . .	107	35.0	85.4	76.9	49.7	22.7	. . .
49	. . .	. . .	106	34.6	84.8	76.6	49.0	21.7	. . .
48	. . .	. . .	105	34.1	84.3	76.2	48.3	20.7	. . .
47	. . .	. . .	104	33.7	83.7	75.9	47.7	19.7	. . .
46	. . .	. . .	103	33.3	83.1	75.6	47.0	18.7	. . .
45	. . .	. . .	102	32.9	82.6	75.3	46.3	17.7	. . .
44	. . .	. . .	101	32.4	82.0	74.9	45.7	16.7	. . .
43	. . .	. . .	100	32.0	81.4	74.6	45.0	15.7	. . .
42	. . .	. . .	99	31.6	80.8	74.3	44.3	14.7	. . .
41	. . .	. . .	98	31.2	80.3	74.0	43.7	13.6	. . .
40	. . .	. . .	97	30.7	79.7	73.6	43.0	12.6	. . .
39	. . .	. . .	96	30.3	79.1	73.3	42.3	11.6	. . .
38	. . .	. . .	95	29.9	78.6	73.0	41.6	10.6	. . .
37	. . .	. . .	94	29.5	78.0	72.7	41.0	9.6	. . .
36	. . .	. . .	93	29.1	77.4	72.3	40.3	8.6	. . .
35	. . .	. . .	92	28.7	76.9	72.0	39.6	7.6	. . .
34	. . .	. . .	91	28.2	76.3	71.7	39.0	6.6	. . .
33	. . .	. . .	90	27.8	75.7	71.4	38.3	5.6	. . .

TABLE 4 *Continued*

Rockwell B Scale, 100-kgf Load 1/16-in. (1.588-mm) Ball	Vickers Hardness Number	Brinell Hardness, 3000-kgf Load, 10-mm Ball	Knoop Hardness, 500-gf Load and Over	Rockwell A Scale, 60-kgf Load, Diamond Penetrator	Rockwell F Scale, 60-kgf Load, 1/16-in. (1.588-mm) Ball	Rockwell Superficial Hardness			Approximate Tensile Strength ksi (MPa)
						15T Scale, 15-kgf Load, 1/16-in. (1.588-mm) Ball	30T Scale, 30-kgf Load, 1/16-in. (1.588-mm) Ball	45T Scale, 45-kgf Load, 1/16-in. (1.588-mm) Ball	
32	. . .	. . .	89	27.4	75.2	71.0	37.6	4.6	. . .
31	. . .	. . .	88	27.0	74.6	70.7	37.0	3.6	. . .
30	. . .	. . .	87	26.6	74.0	70.4	36.3	2.6	. . .

[A] This table gives the approximate interrelationships of hardness values and approximate tensile strength of steels. It is possible that steels of various compositions and processing histories will deviate in hardness-tensile strength relationship from the data presented in this table. The data in this table should not be used for austenitic stainless steels, but have been shown to be applicable for ferritic and martensitic stainless steels. The data in this table should not be used to establish a relationship between hardness values and tensile strength of hard drawn wire. Where more precise conversions are required, they should be developed specially for each steel composition, heat treatment, and part.

TABLE 5 Approximate Hardness Conversion Numbers for Austenitic Steels (Rockwell C to other Hardness Numbers)

Rockwell C Scale, 150-kgf Load, Diamond Penetrator	Rockwell A Scale, 60-kgf Load, Diamond Penetrator	Rockwell Superficial Hardness		
		15N Scale, 15-kgf Load, Diamond Penetrator	30N Scale, 30-kgf Load, Diamond Penetrator	45N Scale, 45-kgf Load, Diamond Penetrator
48	74.4	84.1	66.2	52.1
47	73.9	83.6	65.3	50.9
46	73.4	83.1	64.5	49.8
45	72.9	82.6	63.6	48.7
44	72.4	82.1	62.7	47.5
43	71.9	81.6	61.8	46.4
42	71.4	81.0	61.0	45.2
41	70.9	80.5	60.1	44.1
40	70.4	80.0	59.2	43.0
39	69.9	79.5	58.4	41.8
38	69.3	79.0	57.5	40.7
37	68.8	78.5	56.6	39.6
36	68.3	78.0	55.7	38.4
35	67.8	77.5	54.9	37.3
34	67.3	77.0	54.0	36.1
33	66.8	76.5	53.1	35.0
32	66.3	75.9	52.3	33.9
31	65.8	75.4	51.4	32.7
30	65.3	74.9	50.5	31.6
29	64.8	74.4	49.6	30.4
28	64.3	73.9	48.8	29.3
27	63.8	73.4	47.9	28.2
26	63.3	72.9	47.0	27.0
25	62.8	72.4	46.2	25.9
24	62.3	71.9	45.3	24.8
23	61.8	71.3	44.4	23.6
22	61.3	70.8	43.5	22.5
21	60.8	70.3	42.7	21.3
20	60.3	69.8	41.8	20.2

These conversion values have been obtained from computer-generated curves and are presented to the nearest 0.1 point to permit accurate reproduction of those curves. Since all converted hardness values must be considered approximate, however, all converted Rockwell hardness numbers shall be rounded to the nearest whole number.

14.2 *Hardness Testing:*

14.2.1 If the product specification permits alternative hardness testing to determine conformance to a specified hardness requirement, the conversions listed in Table 3, Table 4, Table 5, and Table 6 shall be used.

14.2.2 When recording converted hardness numbers, the measured hardness and test scale shall be indicated in parentheses, for example: 353 HBW (38 HRC). This means that a hardness value of 38 was obtained using the Rockwell C scale and converted to a Brinell hardness of 353.

15. Brinell Test

15.1 The Brinell Test shall be carried out in accordance with the requirements of Test Method E10, ISO 6506-1, or JIS Z 2243.

TABLE 6 Approximate Hardness Conversion Numbers for Austenitic Steels (Rockwell B to other Hardness Numbers)

Rockwell B Scale, 100-kgf Load, 1/16-in. (1.588-mm) Ball	Brinell Indentation Diameter, mm	Brinell Hardness, 3000-kgf Load, 10-mm Ball	Rockwell A Scale, 60-kgf Load, Diamond Penetrator	Rockwell Superficial Hardness		
				15T Scale, 15-kgf Load, 1/16-in. (1.588-mm) Ball	30T Scale, 30-kgf Load, 1/16-in. (1.588-mm) Ball	45T Scale, 45-kgf Load, 1/16-in. (1.588-mm) Ball
100	3.79	256	61.5	91.5	80.4	70.2
99	3.85	248	60.9	91.2	79.7	69.2
98	3.91	240	60.3	90.8	79.0	68.2
97	3.96	233	59.7	90.4	78.3	67.2
96	4.02	226	59.1	90.1	77.7	66.1
95	4.08	219	58.5	89.7	77.0	65.1
94	4.14	213	58.0	89.3	76.3	64.1
93	4.20	207	57.4	88.9	75.6	63.1
92	4.24	202	56.8	88.6	74.9	62.1
91	4.30	197	56.2	88.2	74.2	61.1
90	4.35	192	55.6	87.8	73.5	60.1
89	4.40	187	55.0	87.5	72.8	59.0
88	4.45	183	54.5	87.1	72.1	58.0
87	4.51	178	53.9	86.7	71.4	57.0
86	4.55	174	53.3	86.4	70.7	56.0
85	4.60	170	52.7	86.0	70.0	55.0
84	4.65	167	52.1	85.6	69.3	54.0
83	4.70	163	51.5	85.2	68.6	52.9
82	4.74	160	50.9	84.9	67.9	51.9
81	4.79	156	50.4	84.5	67.2	50.9
80	4.84	153	49.8	84.1	66.5	49.9

15.1.1 A range of hardness can properly be specified only for quenched and tempered or normalized and tempered material. For annealed material a maximum figure only should be specified. For normalized material a minimum or a maximum hardness may be specified by agreement. In general, no hardness requirements should be applied to untreated material.

15.1.2 Brinell hardness may be required when tensile properties are not specified.

15.2 *Test Specimen*—Brinell hardness tests are made on prepared areas and sufficient metal must be removed from the surface to eliminate decarburized metal and other surface irregularities. The thickness of the piece tested must be such that no bulge or other marking showing the effect of the load appears on the side of the piece opposite the indentation.

15.3 *Procedure:*

15.3.1 It is essential that the applicable product specifications state clearly the position at which Brinell hardness indentations are to be made and the number of such indentations required. The distance of the center of the indentation from the edge of the specimen or edge of another indentation must be at least two and one-half times the diameter of the indentation.

15.3.2 Measure two diameters of the indentation at right angles to the nearest 0.1 mm, estimate to the nearest 0.05 mm, and average to the nearest 0.05 mm. If the two diameters differ by more than 0.1 mm, discard the readings and make a new indentation.

16. Rockwell Test

16.1 The Rockwell Test shall be carried out in accordance with the requirements of Test Methods E18, ISO 6508-1, or JIS Z 2245.

17. Portable Hardness Test

17.1 Although this standard generally prefers the use of fixed-location Brinell or Rockwell hardness test methods, it is not always possible to perform the hardness test using such equipment due to the part size, location, or other logistical reasons. In this event, hardness testing using portable equipment as described in Test Methods A956/A956M, A1038, and E110 shall be used with strict compliance for reporting the test results in accordance with the selected standard (see examples below). Standard Practice A833 may be used, although it might not always be suitable as a criterion for acceptance or rejection since Practice A833 does not contain a precision and bias statement.

17.1.1 *Practice A833*—The measured hardness number shall be reported in accordance with the standard methods and given the HBC designation followed by the comparative test bar hardness to indicate that it was determined by a portable comparative hardness tester, as in the following example:

17.1.1.1 *232 HBC/240* where 232 is the hardness test result using the portable comparative test method (HBC) and 240 is the Brinell hardness of the comparative test bar.

17.1.2 *Practice A956/A956M:*

17.1.2.1 The measured hardness number shall be reported in accordance with the standard methods and appended with a Leeb impact device in parenthesis to indicate that it was determined by a portable hardness tester, as in the following example:

(1) 350 HLD where 350 is the hardness test result using the portable Leeb hardness test method with the HLD impact device.

17.1.2.2 When hardness values converted from the Leeb number are reported, the portable instrument used shall be reported in parentheses, for example:

(1) 350 HB (HLD) where the original hardness test was performed using the portable Leeb hardness test method with the HLD impact device and converted to the Brinell hardness value (HB).

17.1.3 *Test Method A1038*—The measured hardness number shall be reported in accordance with the standard methods and appended with UCI in parenthesis to indicate that it was determined by a portable hardness tester, as in the following example:

17.1.3.1 *446 HV (UCI) 10* where 446 is the hardness test result using the portable UCI test method under a force of 10 kgf.

17.1.4 *Test Method E110:* The measured hardness number shall be reported in accordance with the standard methods and appended with a /P to indicate that it was determined by a portable hardness tester, as follows:

17.1.4.1 *Rockwell Hardness Examples:*

(1) 40 HRC/P where 40 is the hardness test result using the Rockwell C portable test method.

(2) 72 HRBW/P where 72 is the hardness test result using the Rockwell B portable test method using a tungsten carbide ball indenter.

17.1.4.2 *Brinell Hardness Examples:*

(1) 220 HBW/P 10/3000 where 220 is the hardness test result using the Brinell portable test method with a ball of 10 mm diameter and with a test force of 3000 kgf (29.42 kN) applied for 10 s to 15 s.

(2) 350 HBW/P 5/750 where 350 is the hardness test result using the Brinell portable test method with a ball of 5 mm diameter and with a test force of 750 kgf (7.355 kN) applied for 10 s to 15 s.

CHARPY IMPACT TESTING

18. Description

18.1 The equipment, test specimen and testing procedures shall comply with the requirements of Test Methods E23, ISO 148-1, or JIS Z 2242.

19. Testing Machines

19.1 Charpy machines used for testing steel generally have capacities in the 300 to 400 J energy range. Sometimes machines of lesser capacity are used; however, the capacity of the machine should be substantially in excess of the absorbed energy of the specimens (see Test Methods E23). The linear velocity at the point of impact should be in the range of 4.9 to 5.8 m/s or in accordance with ISO 148-1, or JIS Z 2242.

20. Sampling and Number of Specimens

20.1 *Sampling:*

20.1.1 Test location and orientation should be addressed by the product specifications. If not, for wrought products, the test location shall be the same as that for the tensile specimen and the orientation shall be longitudinal with the notch perpendicular to the major surface of the product being tested.

20.1.2 *Number of Specimens:*

20.1.2.1 All specimens used for a Charpy impact test shall be taken from a single test coupon or test location.

20.1.2.2 When the specification calls for a minimum average test result, three specimens shall be tested.

20.1.2.3 When the specification requires determination of a transition temperature, eight to twelve specimens are usually needed.

20.2 *Type and Size:*

20.2.1 A standard full size Charpy V-notch specimen as shown in Test Methods E23, ISO 148-1, or JIS Z 2242 shall be used except as provided in the following sub-paragraphs.

20.2.2 If a standard full-size specimen cannot be prepared, the largest feasible standard subsize specimen shall be prepared. The specimens shall be machined so that the specimen does not include material nearer to the surface than 0.5 mm.

20.2.3 Tolerances for standard subsize specimens are shown in Test Methods E23, ISO 148-1, or JIS Z 2242.

20.3 *Notch Preparation*—The machining of the notch is critical, as it has been demonstrated that extremely minor variations in notch radius and profile, or tool marks at the bottom of the notch may result in erratic test data.

21. Calibration

21.1 *Accuracy and Sensitivity*—Calibrate and adjust Charpy impact machines in accordance with the requirements of the test methods used Test Methods E23, ISO 148-2, or JIS B 7722.

22. Conditioning—Temperature Control

22.1 When a specific test temperature is required by the specification or purchaser, control the temperature of the heating or cooling medium within ±2 °F (1 °C).

23. Procedure

23.1 *Individual Test Values:*

23.1.1 *Impact Energy*—Record the impact energy absorbed to the nearest J.

23.1.2 *Fracture Appearance:*

23.1.2.1 Determine the percentage of shear fracture area by any of the methods described in Test Methods E23, ISO 148-1, or JIS Z 2242.

23.1.2.2 Determine the individual fracture appearance values to the nearest 5 % shear fracture and record the value.

23.1.3 *Lateral Expansion:*

23.1.3.1 Methods of measurement and precautions are described in Test Methods E23.

23.1.3.2 Measure the individual lateral expansion values to the nearest 0.025 mm and record the values.

23.1.3.3 With the exception described as follows, any specimen that does not separate into two pieces when struck by a single blow may be reported as unbroken. If the specimen can be separated by force applied by bare hands, the specimen may be considered as having been separated by the blow.

24. Interpretation of Test Result

24.1 When the acceptance criterion of any impact test is specified to be a minimum average value at a given

temperature, the test result shall be the average (arithmetic mean) of the individual test values of three specimens from one test location.

24.1.1 When a minimum average test result is specified:

24.1.1.1 The test result is acceptable when all of the below are met:

(1) The test result equals or exceeds the specified minimum average (given in the specification),

(2) The individual test value for not more than one specimen measures less than the specified minimum average, and

(3) The individual test value for any specimen measures not less than two-thirds of the specified minimum average.

24.1.1.2 If the acceptance requirements of 24.1.1.1 are not met, perform one retest of three additional specimens from the same test location. Each individual test value of the retested specimens shall be equal to or greater than the specified minimum average value.

24.2 *Test Specifying a Minimum Transition Temperature:*

24.2.1 *Definition of Transition Temperature*—For specification purposes, the transition temperature is the temperature at which the designated material test value equals or exceeds a specified minimum test value.

24.2.2 *Determination of Transition Temperature:*

24.2.2.1 Break one specimen at each of a series of temperatures above and below the anticipated transition temperature using the procedures in Section 23. Record each test temperature to the nearest 0.5 °C.

24.2.2.2 Plot the individual test results (J or percent shear) as the ordinate versus the corresponding test temperature as the abscissa and construct a best-fit curve through the plotted data points.

24.2.2.3 If transition temperature is specified as the temperature at which a test value is achieved, determine the temperature at which the plotted curve intersects the specified test value by graphical interpolation (extrapolation is not permitted). Record this transition temperature to the nearest 3 °C. If the tabulated test results clearly indicate a transition temperature lower than specified, it is not necessary to plot the data. Report the lowest test temperature for which test value exceeds the specified value.

24.2.2.4 Accept the test result if the determined transition temperature is equal to or lower than the specified value.

24.2.2.5 If the determined transition temperature is higher than the specified value, but not more than 12 °C higher than the specified value, test sufficient samples in accordance with Section 25 to plot two additional curves. Accept the test results if the temperatures determined from both additional tests are equal to or lower than the specified value.

24.3 When subsize specimens are permitted or necessary, or both, modify the specified test requirement according to Table 7 or test temperature according to codes such as ASME Boiler and Pressure Vessel Code, Section VIII, Division I Table UG-84.2, or both. Greater energies or lower test temperatures may be agreed upon by purchaser and supplier.

25. Records

25.1 The test record should contain the following information as appropriate:

25.1.1 Full description of material tested (that is, specification number, grade, class or type, size, heat number).

25.1.2 Specimen orientation with respect to the material axis.

TABLE 7 Charpy V-Notch Test Acceptance Criteria for Various Sub-Size Specimens described by Test Methods E23

Full Size 10 by 10 mm	¾ Size 10 by 7.5 mm	⅔ Size 10 by 6.7 mm	½ Size 10 by 5 mm	⅓ Size 10 by 3.3 mm	¼ Size 10 by 2.5 mm
J	J	J	J	J	J
54	41	37	27	18	14
48	35	31	24	16	12
41	30	27	20	14	11
34	26	23	16	11	8
27	20	18	14	10	7
22	16	15	11	7	5
20	15	14	11	7	5
18	14	12	8	5	4
16	12	11	8	5	4
14	11	10	7	4	3
10	7	7	5	3	3

25.1.3 Specimen size.

25.1.4 Test temperature and individual test value for each specimen broken, including initial tests and retests.

25.1.5 Test results.

25.1.6 Transition temperature and criterion for its determination, including initial tests and retests.

26. Report

26.1 The specification should designate the information to be reported.

27. Keywords

27.1 bend test; Brinell hardness; Charpy impact test; elongation; hardness test; portable hardness; reduction of area; Rockwell hardness; tensile strength; tension test; yield strength

ANNEX

(Mandatory Information)

A1. ROUNDING OF TEST DATA

A1.1 Application

A1.1.1 This annex shall apply to rounding test data for the purpose of determining conformance to product specification requirements.

A1.1.1.1 This annex shall apply only when rounding is not specified in the product specifications.

A1.1.1.2 Observed or calculated test results and records maintained by testing laboratories are not subject to this annex.

A1.2 Method

A1.2.1 Values shall be rounded in accordance with the rules of Practice E29 unless otherwise stated herein.

A1.2.2 In the special case of rounding the number "5" when no additional numbers other than "0" follow the "5," rounding shall be in accordance with Practice E29 except where this would result in rejection of the product.

A1.2.3 Requirements for rounding levels for determining conformance to product specification requirements are given in Table A1.1. Specific reported test data values shall be rounded to Table A1.1 for determining conformance to product specification requirements.

A1.2.4 Table A1.1 values are designed to provide uniformity in determining conformance to product specification requirements and should be considered when rounding requirements are stated in product specifications.

A1.2.5 When rounding requirements for product acceptance are neither stated in the product specification nor listed in Table A1.1, an observed or calculated value shall be rounded to the nearest unit in the last right hand digit used in expressing the specification requirement.

TABLE A1.1 Rounded Test Data for Determining Conformance to Specification

Test Quantity	Test Data Range	Rounded Value[A]
Yield Point, Yield Strength, Tensile Strength	<500 MPa,	1 MPa
	≥500 to <1000 MPa,	5 MPa
	≥1000 MPa	10 MPa
Elongation	0 to <10 %,	0.5 %
	≥10 %	1 %
Reduction of Area	0 to <10 %,	0.5 %
	≥10 %	1 %
Absorbed Energy	0 to ≤ 325 J	1 J
Brinell Hardness	all values	tabular value[B]
Rockwell Hardness	all values	1 Rockwell Number

[A] Round test data to the nearest integral multiple to the nearest values in this column. If the data value is exactly midway between two rounded values, round in accordance with A1.2.2.

[B] Round the mean diameter of the Brinell impression to the nearest 0.05 mm and report the corresponding Brinell hardness number from the table without further rounding.

SPECIFICATION FOR CARBON AND ALLOY STEEL EXTERNALLY THREADED METRIC FASTENERS

SF-568M

(Identical with ASTM Specification F568M-98.)

SPECIFICATION FOR CARBON AND ALLOY STEEL EXTERNALLY THREADED METRIC FASTENERS

SF-568M

(Identical with ASTM Specification F 568M-98)

1. Scope

1.1 This specification covers chemical and mechanical requirements for nine property classes of carbon and alloy steel externally threaded metric fasteners in nominal thread diameters M1.6 through M100 suited for use in general engineering applications.

1.2 This specification does not cover dimensional requirements for fasteners of any property class. When referencing this specification for procurement purposes, it is mandatory that size, type, style, and any special dimensions of the product be additionally specified.

1.2.1 In case of any conflict in requirements, the requirements of the individual product specification shall take precedence over those of this general specification.

1.2.2 The purchaser may specify additional requirements which do not negate any of the provisions of this general specification or of the individual product specification. Such additional requirements, the acceptance of which are subject to negotiation with the supplier, must be included in the order information (see Section 3).

1.3 Requirements for seven of the nine property classes, 4.6, 4.8, 5.8, 8.8, 9.8, 10.9, and 12.9, are essentially identical with requirements given for these classes in ISO 898/I. The other two, 8.8.3 and 10.9.3, are not recognized in ISO standards.

1.4 Classes 8.8.3 and 10.9.3 bolts, screws, and studs have atmospheric corrosion resistance and weathering characteristics comparable to those of the steels covered in Specification A 588. The atmospheric corrosion resistance of these steels is substantially better than that of carbon steel with or without copper addition. See 5.2. When properly exposed to the atmosphere, these steels can be used bare (uncoated) for many applications.

1.5 When agreed on by the purchaser, Class 5.8 fasteners may be supplied when either Classes 4.6 or 4.8 are ordered; Class 4.8 may be supplied when Class 4.6 is ordered; Class 8.8.3 may be supplied when Class 8.8 is ordered; and Class 10.9.3 may be supplied when Class 10.9 is ordered.

1.6 The product size range for which each property class is applicable is given in Table 1 and Table 2 on chemical composition requirements, and the mechanical requirements table (see Table 3).

1.7 Appendix X1 gives conversion guidance to assist designers and purchasers in the selection of a suitable property class.

1.8 Appendix X2 explains the significance of the property class designation numerals.

2. Referenced Documents

2.1 *ASTM Standards:*

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

A 307 Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile Strength

A 325 Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

A 325M Specification for High-Strength Bolts for Structural Steel Joints [Metric]

A 354 Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners

A 449 Specification for Quenched and Tempered Steel Bolts and Studs

A 490 Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength

A 490M Specification for High-Strength Steel Bolts, Classes 10.9 and 10.9.3, for Structural Steel Joints [Metric]

A 574 Specification for Alloy Steel Socket-Head Cap Screws

A 588/A 588M Specification for High-Strength Low-Alloy Structural Steel with 50 ksi [345 MPa] Minimum Yield Point to 4 in. [100 mm] Thick
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 606M Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, and Rivets [Metric]
F 788/F 788M Specification for Surface Discontinuities of Bolts, Screws, and Studs, Inch and Metric Series
G 101 Guide for Estimating the Atmospheric Corrosion Resistance of Low-Alloy Steels

2.2 *ISO Standard:*
ISO 898/I, Mechanical Properties of Fasteners, Part I, Bolts, Screws, and Studs

2.3 *ANSI Standards:*
B 18.2.3.1M Metric Hex Cap Screws
B 18.2.3.2M Metric Formed Hex Screws
B 18.2.3.3M Metric Heavy Hex Screws
B 18.2.3.4M Metric Hex Flange Screws
B 18.2.3.5M Metric Hex Bolts
B 18.2.3.6M Metric Heavy Hex Bolts
B 18.5.2.1M Metric Round Head Short Square Neck Bolts

2.4 *ANSI/ASME Standard:*
B18.5.2.2M Metric Round Head Square Neck Bolts

3. Ordering Information

3.1 Orders for products referencing this specification shall include the following:

3.1.1 Quantity (number of pieces),

3.1.2 Name of product (that is, type and style of bolt, screw, or stud),

3.1.3 Dimensions, including nominal thread diameter, thread pitch, and length,

3.1.4 Property class,

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

3.1.6 *Other Finishes*— Specify other protective finish, if required,

3.1.7 ASTM designation and year of issue, and

3.1.8 Any special requirements (for example, mechanical requirements, see Table 3, or proof load testing, see Table 4; stud marking, see 12.2.3; additional testing, see 8.3).

3.2 *Government Provisioning* — Government procurement and design selection criteria shall be specified in accordance with ANSI (or ANSI/ASME) B18.2.3.1M, B18.2.3.2M, B18.2.3.3M, B18.2.3.4M, B18.2.3.5M, B18.2.3.6M, B18.5.2.1M, or B18.5.2.2M, as appropriate.

4. Materials and Manufacture

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

4.2 *Heading Practice:*

4.2.1 Methods other than upsetting or extrusion, or both, are permitted only by special agreement between purchaser and producer.

4.2.2 Class 4.6 may be hot or cold headed at the option of the manufacturer.

4.2.3 Classes 4.8, 5.8, 8.8, 8.8.3, 9.8, 10.9, 10.9.3, and 12.9 bolts and screws in nominal thread diameters up to M20 inclusive with lengths up to 10 times the nominal product size or 150 mm, whichever is shorter, shall be cold headed, except that they may be hot headed by special agreement with the purchaser. Larger diameters and longer lengths may be cold or hot headed at the option of the manufacturer.

4.3 *Threading Practice:*

4.3.1 Threads on Class 4.6 bolts and screws and on all classes of studs may be cut, rolled, or ground at the option of the manufacturer.

4.3.2 Threads on Classes 4.8, 5.8, 8.8, 8.8.3, 9.8, 10.9, 10.9.3, and 12.9 bolts and screws in nominal thread diameters up to M20 inclusive, and product lengths up to 150 mm inclusive, shall be roll threaded, except by special agreement with the purchaser. Threads of these classes on bolts and screws larger than M20 or longer than 150 mm or both, may be rolled, cut, or ground at the option of the manufacturer.

4.4 *Heat Treatment:*

4.4.1 Class 4.6 bolts and screws and Classes 4.6, 4.8, and 5.8 studs need not be heat treated.

4.4.2 Classes 4.8 and 5.8 bolts and screws shall be stress relieved if necessary to assure the soundness of the head to shank junction. When stress relieving is specified by the purchaser, Class 5.8 bolts and screws shall be stress relieved at a minimum stress-relief temperature of 470°C. Where higher stress-relief temperatures are necessary to relieve stresses in severely upset heads, mechanical requirements shall be agreed upon between the purchaser and producer.

4.4.3 Classes 8.8, 8.8.3, and 9.8 bolts, screws, and studs shall be heat treated by quenching in a liquid medium from above the transformation temperature and reheating to the tempering temperature given in Table 1.

4.4.4 Classes 10.9, 10.9.3, and 12.9 bolts, screws, and studs shall be heat treated by quenching in oil from above the transformation temperature and reheating to the tempering temperature given in Table 1.

4.4.5 *Tempering-Temperature-Audit Test*— This test is a means for checking whether products were tempered at the specified temperature. The hardness (mean hardness of three hardness readings) of a bolt, screw, or stud as manufactured shall be measured. The product shall then be retempered for a minimum of 30 min per 25 mm of nominal diameter, but not less than 30 min, at a temperature 10°C less than the minimum tempering temperature specified for the property class and material in Table 1. The hardness of the retempered product shall then be measured. The difference between the hardness of the product before and after retempering shall not exceed 20 HV points.

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 Class C of Specification A 153.

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, Class C, or a mechanically deposited zinc coating in accordance with Specification B 695, Class 50. All components of mating fasteners (for example, bolts, nuts, and washers) shall be coated by the same zinc coating process, and the suppliers option is limited to one process per item with no mixed processes in a lot.

4.6 Bolts, screws, and studs of Classes 10.9 and 12.9 should not be hot-dip zinc-coated.

NOTE 1 — Research conducted on bolts with properties equivalent to Class 10.9 indicated that hydrogen-stress corrosion cracking may occur in hot-dip zinc-coated fasteners of Classes 10.9 and 12.9.

5. Chemical Composition

5.1 For all classes except 8.8.3 and 10.9.3, the bolts, screws, and studs shall conform to the chemical composition specified in Table 1.

5.2 *Classes 8.8.3 and 10.9.3:*

5.2.1 Sizes M20 and smaller shall conform to any one of the compositions (A, B, C, D, E, or F) specified in Table 2, at the suppliers option.

5.2.2 Sizes larger than M20 shall conform to Compositions A or B specified in Table 2, at the suppliers option.

5.2.3 See Guide G 101 for methods of estimation corrosion resistance of low alloy steels.

5.3 Material analyses may be made by the purchaser from finished products representing each lot. The chemical composition thus determined shall conform to the requirements specified for the product analysis in Table 1 and Table 2.

5.4 Use of heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted.

5.5 Chemical analyses shall be performed in accordance with Test Methods A 751.

6. Mechanical Properties

6.1 Bolts, screws, and studs shall be tested in accordance with the mechanical testing requirements for the applicable type, property class, size, and length of product as specified in Table 4, and shall meet the mechanical requirements specified for that product in Tables 3-5.

6.2 For products on which both hardness and tension tests are performed, acceptance based on tensile requirements shall take precedence over low readings of hardness tests.

7. Workmanship

7.1 Surface discontinuity limits shall be in accordance with Specification F 788/F 788M.

8. Number of Tests and Retests

8.1 The requirements of this specification shall be met in continuous mass production for stock; the manufacturer shall inspect to ensure that the product conforms to the specified requirements. Additional tests of individual shipments of product are not ordinarily required. 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 testing of a specific lot is specified on the purchase order, a lot, for purposes of selecting test samples, shall consist of all products of one type, that is, bolts, screws, or studs having the same nominal diameter, length, and property class, offered for inspection at one time. Unless otherwise specified, the number of tests for each specified property shall be as follows:

Number of Pieces in Lot	Number of Samples
800 and less	1
over 800 to 8 000, incl	2
over 8 000 to 22 000, incl	3
over 22 000	5

8.4 If any test specimen shows defective machining, it may be discarded and another specimen substituted.

9. Test Methods

9.1 Bolts, screws, and studs shall be tested in accordance with the methods described in Test Methods F 606M, with tension test wedge angles as specified in Table 6.

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 the inspector that the material is being furnished in accordance with this specification. All tests and inspection shall be made prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the work.

11. Responsibility

11.1 The party responsible for the fastener shall be the organization that supplies the fastener to the purchaser and certifies that the fastener was manufactured, sampled, tested and inspected in accordance with this specification and meets all of its requirements.

12. Product Marking

12.1 *Bolts and Screws:*

12.1.1 Bolts and screws of nominal thread diameters smaller than M5 need not be marked. Additionally, slotted and recessed screws of nominal thread diameters M5 and larger need not be marked.

12.1.2 Bolts and screws, except those covered in 12.1.1, shall be marked permanently and clearly to identify the property class and the manufacturer. The property class symbols shall be as given in Table 7. The manufacturer's identification symbol shall be of his design.

12.1.3 For Classes 8.8.3 and 10.9.3, the manufacturer may add other distinguishing marks indicating that the bolt or screw is atmospheric corrosion resistant and of a weathering grade of steel.

12.1.4 Markings shall be located on the top of the head with the base of the property class symbols positioned toward the closest periphery of the head. Markings may be either raised or depressed at the option of the manufacturer. Alternatively, for hex head products, the markings may be indented on the side of the head with the base of the property class symbols positioned toward the bearing surface.

12.1.5 Metric bolts and screws shall not be marked with radial line symbols.

12.2 *Studs:*

12.2.1 Studs shall be marked permanently and clearly to identify the property class. The property class symbols and sizes to be marked shall be as given in Table 7.

12.2.2 Markings shall be located on the extreme end of the stud and may be raised or depressed at the option of the manufacturer. For studs with an interference-fit thread, the markings shall be located on the nut end.

12.2.3 When ordered by the purchaser, studs shall be marked on both ends.

13. Packaging and Package Marking

13.1 *Packaging:*

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

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

13.2 *Package Marking:*

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

13.2.1.1 ASTM designation and type,

13.2.1.2 Size,

13.2.1.3 Name and brand or trademark of the manufacturer,

13.2.1.4 Number of pieces,

13.2.1.5 Purchase order number, and

13.2.1.6 Country of origin.

14. Keywords

14.1 alloy steel; bolts; carbon steel; metric; screws; steel; structural; weathering steel

TABLE 1
CHEMICAL COMPOSITION REQUIREMENTS

Property Class	Nominal Product Diameter, mm	Material and Treatment	Product Analysis Element (% by Weight) C Min	C Max	Mn Min	B Min	P Max	S Max	Tempering Temperature, °C Min
4.6	M5–M100	low or medium carbon steel	...	0.55	...	...	0.048	0.058	...
4.8	M1.6–M16	low or medium carbon steel, partially or fully annealed as required	...	0.55	...	...	0.048	0.058	...
5.8	M5–M24	low or medium carbon steel, cold worked	0.13	0.55	...	...	0.048	0.058[A]	...
8.8	M20–M80	medium carbon steel, product is quenched and tempered[B]	0.25	0.55	...	...	0.048	0.058[C]	425
8.8	M20–M36	low carbon martensite steel, product is quenched and tempered[D]	0.15	0.40	0.74	0.0005	0.048	0.058	425
8.8.3	M20–M36	atmospheric corrosion resistant steel, product is quenched and tempered				see Table 2			425
9.8	M1.6–M16	medium carbon steel, product is quenched and tempered	0.25	0.55	...	...	0.048	0.058	425
9.8	M1.6–M16	low carbon martensite steel, product is quenched and tempered[D]	0.15	0.40	0.74	0.0005	0.048	0.058	425
10.9	M5–M20	medium carbon steel, product is quenched and tempered[E,F]	0.25	0.55	...	...	0.048	0.058	425
10.9	M5–M100	medium carbon alloy steel, product is quenched and tempered[E]	0.20	0.55	...	...	0.040	0.045	425
10.9	M5–M36	low carbon martensite steel, product is quenched and tempered[E,F]	0.15	0.40	0.74	0.0005	0.048	0.058	340
10.9.3	M16–M36	atmospheric corrosion resistant steel, product is quenched and tempered[E]				see Table 2			425
12.9	M1.6–M100	alloy steel, product is quenched and tempered[E,G]	0.31	0.65	...	...	0.045	0.045	380

[A] For studs only, sulfur content may be 0.33%, max.

[B] At the manufacturer's option, medium-carbon-alloy steel may be used for nominal thread diameters over M24.

[C] For studs only, sulfur content may be 0.13%, max.

[D] Products made using this material shall be specially identified as specified in Section 12.

[E] Steel for Classes 10.9, 10.9.3, and 12.9 products shall be fine grain and have a hardenability that will achieve a structure of approximately 90% martensite at the center of a transverse section one diameter from the threaded end of the product after oil quenching.

[F] Carbon steel may be used at the option of the manufacturer for products of nominal thread diameters M12 and smaller. When approved by the purchaser, carbon steel may be used for products of diameters larger than M12 through M20, inclusive.

[G] Alloy steel shall be used. Steel is considered to be alloy by the American Iron and Steel Institute when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: manganese, 1.65%; silicon, 0.60%; copper, 0.60%; or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels: aluminum, chromium up to 3.99%, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, or any other alloying elements added to obtain a desired alloying effect.

TABLE 2
CHEMICAL COMPOSITION REQUIREMENTS FOR CLASSES 8.8.3 AND 10.9.3

Element	Composition, %[A]					
	A	B	C	D	E	F
Carbon:						
Heat analysis	0.33–0.40	0.38–0.48	0.15–0.25	0.15–0.25	0.20–0.25	0.20–0.25
Product analysis	0.31–0.42	0.36–0.50	0.14–0.26	0.14–0.26	0.18–0.27	0.19–0.26
Manganese:						
Heat analysis	0.90–1.20	0.70–0.90	0.80–1.35	0.40–1.20	0.60–1.00	0.90–1.20
Product analysis	0.86–1.24	0.67–0.93	0.76–1.39	0.36–1.24	0.56–1.04	0.86–1.24
Phosphorus:						
Heat analysis	0.040 max	0.06–0.12	0.035 max	0.040 max	0.040 max	0.040 max
Product analysis	0.045 max	0.06–0.125	0.040 max	0.045 max	0.045 max	0.045 max
Sulfur:						
Heat analysis	0.050 max	0.050 max	0.040 max	0.050 max	0.040 max	0.040 max
Product analysis	0.055 max	0.055 max	0.045 max	0.055 max	0.045 max	0.045 max
Silicon:						
Heat analysis	0.15–0.35	0.30–0.50	0.15–0.35	0.25–0.50	0.15–0.35	0.15–0.35
Product analysis	0.13–0.37	0.25–0.55	0.13–0.37	0.20–0.55	0.13–0.37	0.13–0.37
Copper:						
Heat analysis	0.25–0.45	0.20–0.40	0.20–0.50	0.30–0.50	0.30–0.60	0.20–0.40
Product analysis	0.22–0.48	0.17–0.43	0.17–0.53	0.27–0.53	0.27–0.63	0.17–0.43
Nickel:						
Heat analysis	0.25–0.45	0.50–0.80	0.25–0.50	0.50–0.80	0.30–0.60	0.20–0.40
Product analysis	0.22–0.48	0.47–0.83	0.22–0.53	0.47–0.83	0.27–0.63	0.17–0.43
Chromium:						
Heat analysis	0.45–0.65	0.50–0.75	0.30–0.50	0.50–1.00	0.60–0.90	0.45–0.65
Product analysis	0.42–0.68	0.47–0.83	0.27–0.53	0.45–1.05	0.55–0.95	0.42–0.68
Vanadium:						
Heat analysis	. . .	. . .	0.020 min	. . .	. . .	. . .
Product analysis	. . .	. . .	0.010 min	. . .	. . .	. . .
Molybdenum:						
Heat analysis	. . .	0.06 max	. . .	0.10 max	. . .	. . .
Product analysis	. . .	0.07 max	. . .	0.11 max	. . .	. . .
Titanium:						
Heat analysis	. . .	. . .	. . .	0.05 max	. . .	. . .
Product analysis	. . .	. . .	. . .	. . .	. . .	. . .

[A] A, B, C, D, E, and F are types of material used for Property Classes 8.8.3 and 10.9.3 bolts, screws, and studs. Selection of composition shall be at the option of the product manufacturer except that sizes M20 and larger shall conform to Composition A or B only.

TABLE 3
MECHANICAL REQUIREMENTS FOR BOLTS, SCREWS, AND STUDS

Property Class	Nominal Diameter of Product	Full Size Bolts, Screws, and Studs			Machined Test Specimens of Bolts, Screws, and Studs				Surface Hardness	Product Hardness			
		Proof Load[A]								Rockwell		Vickers	
		Length Measurement Method, MPa	Yield Strength Method, MPa	Tensile Strength, MPa[A] min	Yield Strength, MPa[B] min	Tensile Strength, MPa min	Elongation, % min	Reduction of Area, % min	Rockwell 30N max	min	max	min	max
4.6	M5–M100	225	240	400	240[C]	400	22	35	. . .	B67	B95	120	220
4.8	M1.6–M16	310	340	420	340	420	14	35	. . .	B71	B95	130	220
5.8	M5–M24[D]	380	420	520	420	520	10	35	. . .	B82	B95	160	220
8.8	M20–M80	600	660	830	660	830	12	35	53	C23	C34	255	336
8.8.3	M20–M36	600	660	830	660	830	12	35	53	C23	C34	255	336
9.8	M1.6–M16	650	720	900	720	900	10	35	56	C27	C36	280	360
10.9	M5–M100	830	940	1040	940	1040	9	35	59	C33	C39	327	382
10.9.3	M16–M36	830	940	1040	940	1040	9	35	59	C33	C39	327	382
12.9[E]	M1.6–M100	970	1100	1220	1100	1220	8	35	63	C38	C44	372	434

[A] Proof load and tensile strength values for full size products of each property class are given in Table 5.
[B] Yield strength is stress at which a permanent set of 0.2% of gage length occurs.
[C] Yield point shall apply instead of yield strength at 0.2% offset for Class 4.6 products.
[D] Class 5.8 applies only to bolts and screws with lengths 150 mm and shorter and to studs of all lengths.
[E] Caution is advised when considering the use of Class 12.9 bolts, screws, and studs. Capability of the bolt manufacturer, as well as the anticipated in-use environment, should be considered. High-strength products of Class 12.9 require rigid control of heat-treating operations and careful monitoring of as-quenched hardness, surface discontinuities, depth of partial decarburization, and freedom from carburization. Some environments may cause stress corrosion cracking of nonplated as well as electroplated products.

TABLE 4
MECHANICAL TESTING REQUIREMENTS FOR BOLTS, SCREWS, AND STUDS[A]

Item	Product	Property Class	Specified Min Tensile Strength of Product (See Table 5) kN	Length of Product[B]	Product Hardness		Surface Hardness[C] max	Tests Conducted Using Full-Size Products			Tests Conducted Using Machined Test Specimens			
					max	min		Proof Load	Wedge Tensile Strength[D]	Axial Tensile Strength	Yield Strength	Tensile Strength	Elongation	Reduction of Area
1	short length bolts and screws	all	all	less than *x*	●	●	●	...	...	...	...	...	...	...
2	special head bolts and screws[E]	all	all	all	●	●	●	...	...	...	...	...	...	...
3	bolts and screws with hex or hex flange heads except items 1 and 2	all	450 and less	*x* to 8D or 200 mm, whichever is greater	●	...	●	○	●	...	...	...	...	...
				over 8D or 200 mm, whichever is greater through and incl 300 mm	●	...	●	○	●	...	...	...	...	...
				over 300 mm	●	...	●	○	A	...	B	B	B	B
			over 450	*x* and longer	●	...	●	○	A	...	B	B	B	B
4	all bolts and screws except items 1, 2, and 3	all	450 and less	*x* to 8D or 200 mm, whichever is greater	●	...	●	○	...	●	...	...	...	...
				over 8D or 200 mm, whichever is greater	●	...	●	○	...	A	B	B	B	B
			over 450	*x* and longer	●	...	●	○	...	A	B	B	B	B
5	short length studs	all	all	less than *x*	●	●	●	...	...	...	...	...	...	...
6	all studs except item 5	all	450 and less	*x* to 8D or 200 mm, whichever is greater	●	...	●	○	●	...	...	...	...	...
				over 8D or 200 mm, whichever is greater	●	...	●	○	A	...	B	B	B	B
			over 450	*x* and longer	●	...	●	○	A	...	B	B	B	B
Tests to be conducted in accordance with the following paragraph of Method F 606:					3.1			3.2.1	3.5	3.4	3.6			

[A] ● denotes a mandatory test. For each product all mandatory tests (●) shall be performed. In addition, either all tests denoted A (which apply to full-size products) or all tests denoted B (which apply to machined test specimens) shall be performed. ○ denotes tests to be performed when specifically required in the original inquiry and purchase order. In case arbitration is necessary, A tests and proof load test shall be performed. Leaders (. . .) indicate tests that are not required.

[B] D equals nominal diameter of product. *x* equals the minimum length of product subject to tensile testing. Values of *x* are as follows:

Nominal Product Diameter	*x*, mm
M5	12
M6	14
M8	20
M10	25
M12	30
M14	35
M16	40
M20	45
M24 and larger	30

[C] Surface hardness requirements apply only to Property Classes 8.8, 8.8.3, 9.8, 10.9, 10.9.3, and 12.9.

[D] Tensile test wedge angles are specified in Table 6.

[E] Special head bolts and screws are those with special configurations or with drilled heads which are weaker than the threaded section.

TABLE 5
PROOF LOAD AND TENSILE STRENGTH VALUES, kN[A]

Nominal Product Diameter and Thread Pitch	Stress Area,[B] mm^2	Class 4.6			Class 4.8			Class 5.8			Classes 8.8 and 8.8.3			Class 9.8			Classes 10.9 and 10.9.3			Class 12.9		
		Proof Load[C]			Proof Load			Proof Load			Proof Load			Proof Load			Proof Load			Proof Load		
		Method 1	Method 2	Tensile Strength, min	Method 1	Method 2	Tensile Strength, min	Method 1	Method 2	Tensile Strength, min	Method 1	Method 2	Tensile Strength, min	Method 1	Method 2	Tensile Strength, min	Method 1	Method 2	Tensile Strength, min	Method 1	Method 2	Tensile Strength, min
M1.6 × 0.35	1.27	. . .	. . .	. . .	0.39	0.43	0.53	. . .	. . .	. . .	. . .	. . .	. . .	0.83	0.91	1.14	. . .	. . .	. . .	1.23	1.40	1.55
M2 × 0.4	2.07	. . .	. . .	. . .	0.64	0.70	0.87	. . .	. . .	. . .	. . .	. . .	. . .	1.35	1.49	1.86	. . .	. . .	. . .	2.01	2.28	2.53
M2.5 × 0.45	3.39	. . .	. . .	. . .	1.05	1.15	1.42	. . .	. . .	. . .	. . .	. . .	. . .	2.20	2.44	3.05	. . .	. . .	. . .	3.29	3.73	4.14
M3 × 0.5	5.03	. . .	. . .	. . .	1.56	1.71	2.11	. . .	. . .	. . .	. . .	. . .	. . .	3.27	3.62	4.53	. . .	. . .	. . .	4.88	5.53	6.14
M3.5 × 0.6	6.78	. . .	. . .	. . .	2.10	2.31	2.85	. . .	. . .	. . .	. . .	. . .	. . .	4.41	4.88	6.10	. . .	. . .	. . .	6.58	7.13	8.27
M4 × 0.7	8.78	. . .	. . .	. . .	2.72	2.99	3.69	. . .	. . .	. . .	. . .	. . .	. . .	5.71	6.32	7.90	. . .	. . .	. . .	8.52	9.66	10.7
M5 × 0.8	14.2	3.20	3.41	5.68	4.40	4.83	5.96	5.40	5.96	7.38	. . .	. . .	. . .	9.23	10.2	12.8	11.8	13.3	14.8	13.8	15.6	17.3
M6 × 1	20.1	4.52	4.82	8.04	6.23	6.83	8.44	7.64	8.44	10.5	. . .	. . .	. . .	31.1	14.5	18.1	16.7	18.9	20.9	19.5	22.1	24.5
M8 × 1.25	36.6	8.24	8.78	14.6	11.3	12.4	15.4	13.9	15.4	19.0	. . .	. . .	. . .	23.8	26.4	32.9	30.4	34.4	38.1	35.5	40.3	44.7
M10 × 1.5	58.0	13.1	13.9	23.2	18.0	19.7	24.4	22.0	24.4	30.2	. . .	. . .	. . .	37.7	41.8	52.2	48.1	54.5	60.3	56.3	63.8	70.8
M12 × 1.75	84.3	19.0	20.2	33.7	26.1	28.7	35.4	32.0	35.4	43.8	. . .	. . .	. . .	54.8	60.7	75.9	70.0	79.2	87.7	81.8	92.7	103
M14 × 2	115	25.9	27.6	46.0	35.7	39.1	48.3	43.7	48.3	59.8	. . .	. . .	. . .	74.8	82.8	104	95.5	108	120	112	127	140
M16 × 2	157	35.3	37.7	62.8	48.7	53.4	65.9	59.7	65.9	81.6	[D]	[D]	[D]	102	113	141	130	148	163	152	173	192
M20 × 2.5	245	55.1	58.8	98.0	. . .	. . .	. . .	93.1	103	127	147	162	203	. . .	. . .	. . .	203	230	255	238	270	299
M22 × 2.5[E]	303	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	182	200	251	. . .	. . .	. . .	251	285	315	. . .	. . .	. . .
M24 × 3	353	79.4	84.7	141	. . .	. . .	. . .	134	148	184	212	233	293	. . .	. . .	. . .	293	332	367	342	388	431
M27 × 3[E]	459	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	275	303	381	. . .	. . .	. . .	381	431	477	. . .	. . .	. . .
M30 × 3.5	561	126	135	224	. . .	. . .	. . .	. . .	. . .	. . .	337	370	466	. . .	. . .	. . .	466	527	583	544	617	684
M36 × 4	817	184	196	327	. . .	. . .	. . .	. . .	. . .	. . .	490	539	678	. . .	. . .	. . .	678	763	850	792	899	997
M42 × 4.5	1120	252	269	448	. . .	. . .	. . .	. . .	. . .	. . .	672	739	930	. . .	. . .	. . .	930	1050	1160	1090	1230	1370
M48 × 5	1470	331	353	588	. . .	. . .	. . .	. . .	. . .	. . .	882	970	1220	. . .	. . .	. . .	1220	1380	1530	1430	1620	1790
M56 × 5.5	2030	457	487	812	. . .	. . .	. . .	. . .	. . .	. . .	1220	1340	1680	. . .	. . .	. . .	1680	1910	2110	1970	2230	2480
M64 × 6	2680	603	643	1070	. . .	. . .	. . .	. . .	. . .	. . .	1610	1790	2220	. . .	. . .	. . .	2220	2520	2790	2600	2850	3270
M72 × 6	3460	779	830	1380	. . .	. . .	. . .	. . .	. . .	. . .	2080	2280	2870	. . .	. . .	. . .	2870	3250	3600	3360	3810	4220
M80 × 6	4340	977	1040	1740	. . .	. . .	. . .	. . .	. . .	. . .	2600	2860	3600	. . .	. . .	. . .	3600	4080	4510	4210	4770	5290
M90 × 6	5590	1260	1340	2240	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	4640	5250	5810	5420	6150	6820
M100 × 6	6990	1570	1680	2800	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	5800	6570	7270	6780	7690	8530

[A] Proof loads and tensile strengths are computed by multiplying the stresses given in Table 3 by the stress area of the thread.

[B] Stress area, mm^2 = 0.7854 (D − 0.9382 P)^2, where D = nominal product size, mm, and P = thread pitch, mm.

[C] Proof load, Method 1, is the length measurement method as described in 3.2.3 of Test Methods F 606. Proof load, Method 2, is the yield strength method as described in 3.2.5 of Test Methods F 606.

[D] For Classes 8.8 and 8.8.3 sizes M16 and smaller are not covered by Specification F 568M. Class 9.8 may be suitable for applications requiring sizes M16 and smaller after consideration of design parameters, application and service environment.

[E] M22 and M27 are standard sizes for high-strength structural bolts only as covered in Specifications A 325M and A 490M.

TABLE 6
TENSION TEST WEDGE ANGLE

Product	Property Class	Nominal Product Diameter, (*D*)	Wedge Angle,*
Hex bolts and screws threaded 1*D* or closer to underside of head	4.6, 4.8, 5.8	through M24	10
		over M24	6
	8.8, 8.8.3, 9.8, 10.9, 10.9.3	through M20	6
		over M20	4
Hex bolts and screws with unthreaded length greater than 1*D*	4.6, 4.8, 5.8, 8.8, 8.8.3, 9.8, 10.9, 10.9.3	through M24	10
		over M24	6
Hex bolts and screws threaded 2*D* or closer to underside of head	12.9	all	4
Hex bolts and screws with unthreaded length greater than 2*D*	12.9	through M20	6
		over M20	4
Hex flange screws	5.8, 9.8, 10.9	all	6
Studs	all	through M20	6
		over M20	4

TABLE 7
PROPERTY CLASS IDENTIFICATION SYMBOLS

	Identification Symbol					
				Studs		
Property Class	Specification A 325M Bolts	Specification A 490M Bolts	Other Bolts and Screws	M4 and Smaller	M5 to M10 incl.	M12 and Larger
4.6	[A]	[A]	4.6	[A]	[A]	4.6
4.8	[A]	[A]	4.8	[A]	[A]	4.8
5.8	[A]	[A]	5.8	[A]	[A]	5.8
8.8[B]	8S	[A]	8.8	[A]	[A]	8.8
8.8.3	8S3	[A]	8.8.3	[A]	[A]	8.8.3
9.8[B]	[A]	[A]	9.8	[A]	+	9.8
10.9[B]	[A]	10S	10.9	[A]	□	10.9
10.9.3	[A]	10S3	10.9.3	[A]	[A]	10.9.3
12.9	[A]	[A]	12.9	[A]	△	12.9

[A] Not applicable.
[B] Products made of low-carbon martensite steel shall be additionally marked by underlining the property class symbol.

APPENDIXES

(Nonmandatory Information)

X1 CONVERSION GUIDANCE

X1.1 For guidance purposes only, to assist designers and purchasers in the selection of a property class, the following conversion guidance is provided:

X1.1.1 Class 4.6 mechanical properties are approximately equivalent to those of Specification A 307, Grade A.

X1.1.2 Class 8.8 mechanical properties are approximately equivalent to those of Specification A 449, and Specification A 325, Types 1 and 2.

X1.1.3 Class 8.8.3 mechanical properties are approximately equivalent to those of Specification A 325, Type 3.

X1.1.4 Class 9.8 mechanical properties are approximately 9% higher than those of Specification A 449.

X1.1.5 Class 10.9 mechanical properties are approximately equivalent to those of Specification A 354, Grade BD and Specification A 490, Types 1 and 2.

X1.1.6 Class 10.9.3 mechanical properties are approximately equivalent to those of Specification A 490, Type 3.

X1.1.7 Class 12.9 mechanical properties are approximately equal to those of Specification A 574.

X1.2 Class 9.8 is applicable to fasteners of nominal thread diameters M16 and smaller; Class 8.8 is applicable to fasteners larger than M16, except for Specification A 325M bolts where M16 and larger bolt diameters are Class 8.8.

X2. SIGNIFICANCE OF PROPERTY CLASS DESIGNATION

X2.1 Property classes are designated by numbers where increasing numbers generally represent increasing tensile strengths. The designation symbol has the following significance:

X2.1.1 The one or two numerals preceding the first decimal point approximates 1/1000 of the minimum tensile strength in MPa.

X2.1.2 The numeral following the first decimal point approximates 1/10 of the ratio, expressed as a percentage, between minimum yield stress and minimum tensile strength.

X2.1.3 The numeral 3, following the second decimal point, is an indicator that the material has atmospheric corrosion resistance and weathering characteristics comparable to steels covered in Specification A 588/A 588M.

SPECIFICATION FOR FINE GRAINED, WELDABLE STEEL PLATES FOR PRESSURE EQUIPMENT

SA/AS 1548

(Identical with International Specification AS 1548-2008(R2018) with these additional requirements.)

SPECIFICATION FOR FINE GRAINED, WELDABLE STEEL PLATES FOR PRESSURE EQUIPMENT

SA/AS 1548

(Identical with International Specification AS 1548-2008(R2018) with these additional requirements.)

1. Additional Requirements

1.1 *Steelmaking Process:*
The ratio of reduction of thickness from a strandcast slab to plate shall be at least 3.0:1.

1.2 *Marking:*
In addition to the marking requirements of this specification, the prefix, SA/, shall be added ahead of the marking on all products required to be marked by this specification, and to the material identification used on all documentation required by the specification.

1.3 *Chemical Composition:*
The requirements of paras. 7.1.2 and 7.1.3 on heat analysis, and of paras. 7.2.3 and 7.2.4 on product analysis, of SA-20/SA-20M shall apply.

1.4 *Test Reports:*

1.4.1 The designation of this SA/AS specification shall include the edition year.

1.4.2 Copies of the original manufacturer's test report shall be included with any subsequent test report.

2. Appendix

2.1 The appendix "Interchangeability of Strength Grades" does not apply for SA/AS 1548.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of AS 1548 and its references.

SPECIFICATION FOR STRUCTURAL QUALITY STEELS

SA/CSA-G40.21 (23)

(Identical with International Specification CSA-G40.21-2013(R2018) including Update No. 1 (May 2014), with these additional requirements.)

SPECIFICATION FOR STRUCTURAL QUALITY STEELS

SA/CSA-G40.21

(Identical with International Specification CSA-G40.21-13(R2018) with these additional requirements.)

1. Additional Requirements

1.1 *Marking:*

1.1.1 In addition to the marking requirements of this specification, all products are to be identified by this SA/CSA specification designation.

1.1.2 Plates that are required to be heat treated, but have not been so heat treated, shall be marked by the manufacturer or processor with the letter "G" (denoting green) following the required specification mark.

1.1.3 When such plates are subsequently heat treated, they shall be marked by the party that performed the heat treatment, with the letters "MT" (denoting material treated) following the required specification mark.

1.1.4 The heat number and manufacturer's name or brand shall be marked on each plate irrespective of its thickness.

1.1.5 For secured lifts of all sizes of plates $^{3}/_{8}$ in. (10 mm) or under in thickness, the manufacturer or processor shall have the option of placing such markings on only the top piece of each lift, or showing such markings on a substantial tag attached to each lift, unless otherwise specified.

1.1.6 The sole use of color code marking to indicate material standard designation and grade, as described in para. 9 of this standard, is not permitted.

1.2 *Controlled Rolling or Normalizing Rolling:*
Controlled rolling or normalizing rolling shall not be used as normalizing procedure.

1.3 *Chemical Composition:*
The requirements of paras. 7.1.2 and 7.1.3 on heat analysis, and of paras. 7.2.3 and 7.2.4 on product analysis, of SA-20/SA-20M shall apply.

1.4 *Test Reports:*
Test reporting shall be in accordance with SA-6/SA-6M.

2. Source

2.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of CSA-G40.21 and its references.

SPECIFICATION FOR HOT ROLLED PRODUCTS OF STRUCTURAL STEELS

Part 2: Technical Delivery Conditions for Non-Alloy Structural Steels

SA/EN 10025-2 (23)

(Identical with International Specification EN 10025-2:2019 with these additional requirements.)

SPECIFICATION FOR HOT ROLLED PRODUCTS OF STRUCTURAL STEELS
Part 2: Technical Delivery Conditions for Non-Alloy Structural Steels

SA/EN 10025-2

(Identical with International Specification EN 10025-2:2019 with these additional requirements.)

1. Additional Requirements

1.1 *Marking:*

(a) In addition to the marking requirements of this specification, all products required to be marked and material identification used on all documentation required by this specification are to be identified by this SA/EN specification designation.

(b) Products that have been given the full heat treatment required by para. 6.3 shall be marked by the party performing the heat treatment with the letters designating the applicable heat treatment condition following the stamped steel name or number.

(c) Products that have received a normalizing treatment shall be marked "+N." Products that have received a normalizing rolling treatment shall be marked "+NR" instead of "+N."

(d) Products that are not heat treated but are qualified on the basis of heat treated specimens shall be stamped with letter "G" following the stamped specification designation.

(e) When such products are subsequently heat treated, they shall be marked by the party that performed the heat treatment, as required by *(b)* following the required stamped specification designation.

1.2 *Chemical Composition:*

These materials shall conform to SA-20/SA-20M Table 1, whenever SA-20/SA-20M Table 1 is more restrictive.

1.3 *Resurfacing by Welding:*

If resurfacing by welding is acceptable by agreement with the purchaser the following requirements have to be fulfilled:

(a) Preparation for repair welding shall include inspection to assure complete removal of the defect.

(b) Repairs shall be made utilizing welding procedures qualified in accordance with ASME Section IX and repair welding shall be done by welders or welding operators meeting the qualification requirements of ASME Section IX.

1.4 *Test Reports:*

1.4.1 For all products, a test report shall be furnished; it shall include all elements required in this SA/EN specification.

1.4.2 The designation of this SA/EN specification shall include the edition year.

1.4.3 Copies of the original manufacturer's test report shall be included with any subsequent test report.

2. National Parts

2.1 The National Foreword and the National Annexes, if any, do not apply for SA/EN 10025-2.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10025-2 and its references.

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SPECIFICATION FOR FLAT PRODUCTS MADE OF STEELS FOR PRESSURE PURPOSES

Part 2: Non-Alloy and Alloy Steels With Specified Elevated Temperature Properties

SA/EN 10028-2 (23)

(Identical with International Specification EN 10028-2:2017 with these additional requirements.)

SPECIFICATION FOR FLAT PRODUCTS MADE OF STEELS FOR PRESSURE PURPOSES
Part 2: Non-Alloy and Alloy Steels With Specified Elevated Temperature Properties

SA/EN 10028-2

(Identical with International Specification EN 10028-2:2017 with these additional requirements.)

1. Additional Requirements

1.1 *General Requirements:*
All "see EN 10028-1" shall be read as "shall be according to EN 10028-1."

1.2 *Marking:*
(a) In addition to the marking requirements of this specification, all products required to be marked and material identification used on all documentation required by this specification are to be identified by this SA/EN specification designation.
(b) Plates that have been given the full heat treatment required by para. 8.2.1 or 8.2.2 shall be marked by the party performing the heat treatment with the letters designating the applicable heat treatment condition in Table 3 of EN 10028-2 following the stamped steel name or number.
(c) Plates for which normalizing has been replaced by normalizing rolling as permitted by para. 8.2.2 shall be marked "+NR" instead of "+N."
(d) Plates that are not heat treated but are qualified on the basis of heat treated specimens per para. 8.2.3 shall be stamped with letter "G" following the stamped specification designation.
(e) When such plates are subsequently heat treated, they shall be marked, by the party that performed the heat treatment, as required by (b) above following the required stamped specification designation.

1.3 *Delivery Condition:*
Normalizing shall not be replaced by normalizing rolling for plates of steel Grade 16Mo3.

1.4 *Chemical Composition:*
The requirements of paras. 7.1.2 and 7.1.3 on heat analysis, and of paras. 7.2.3 and 7.2.4 on product analysis, of SA-20/SA-20M shall apply.

1.5 *Tension Tests:*
For quenched and tempered plates one tension test shall be taken from each end of the heat treated plate. The gage length of the tension test specimens shall be taken at least 1T from any heat treated edge, where T is the thickness of the plate, and shall be at least $\frac{1}{2}$ in. (12.5 mm) from flame cut or heat-affected-zone surfaces.

1.6 *Impact Test Sampling:*
Deviation from the requirement for preparation of test pieces for impact testing in EN 10028-1 shall not be permitted in SA/EN 10028-2.

1.7 *Steelmaking Process:*
The ratio of reduction of thickness from a strand-cast slab to plate shall be at least 3.0:1.

1.8 *Quality:*
All surface imperfections, the removal of which will reduce the plate thickness below its permissible minimum, shall be cause for rejection of the plate; however by agreement with the purchaser, the metal so removed may be replaced with weld metal.

Preparation for repair welding shall include inspection to assure complete removal of the defect.

Repairs shall be made utilizing welding procedures qualified in accordance with ASME Section IX and repair welding shall be done by welders or welding operators meeting the qualification requirements of ASME Section IX.

1.9 *Test Reports:*

1.9.1 The designation of this SA/EN specification shall include the edition year.

1.9.2 Copies of the original manufacturer's test report shall be included with any subsequent test report.

2. National Parts

2.1 The National Foreword and the National Annexes, if any, do not apply for SA/EN 10028-2.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10028-2 and its references.

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SPECIFICATION FOR FLAT PRODUCTS MADE OF STEELS FOR PRESSURE PURPOSES

Part 3: Weldable Fine Grain Steels, Normalized

SA/EN 10028-3 (23)

(Identical with International Specification EN 10028-3:2017 with these additional requirements.)

SPECIFICATION FOR FLAT PRODUCTS MADE OF STEELS FOR PRESSURE PURPOSES
Part 3: Weldable Fine Grain Steels, Normalized

SA/EN 10028-3

(Identical with International Specification EN 10028-3:2017 with these additional requirements.)

1. Additional Requirements

1.1 *General Requirements:*

All "see EN 10028-1" shall be read as "shall be according to EN 10028-1."

1.2 *Marking:*

(a) In addition to the marking requirements of this specification, all products required to be marked and material identification used on all documentation required by this specification are to be identified by this SA/EN specification designation.

(b) Plates that have been given the full heat treatment required by para. 8.2.1 or 8.2.2 shall be marked by the party performing the heat treatment with the letters designating the applicable heat treatment condition in Table 4 of EN 10028-3 following the stamped steel name or number.

(c) Plates for which normalizing has been replaced by normalizing rolling as permitted by para. 8.2.2 shall be marked “+NR” instead of “+N.”

(d) Plates that are not heat treated but are qualified on the basis of heat treated specimens per para. 8.2.3 shall be stamped with letter “G” following the stamped specification designation.

(e) When such plates are subsequently heat treated, they shall be marked, by the party that performed the heat treatment, as required by (b) above following the required stamped specification designation.

1.3 *Chemical Composition:*

The requirements of paras. 7.1.2 and 7.1.3 on heat analysis, and of paras. 7.2.3 and 7.2.4 on product analysis, of SA-20/SA-20M shall apply. In addition, the copper content shall be per SA-20/SA-20M Table 1.

1.4 *Impact Test Sampling:*

Deviation from the requirement for preparation of test pieces for impact testing in EN 10028-1 shall not be permitted in SA/EN 10028-3.

1.5 *Steelmaking Process:*

The ratio of reduction of thickness from a strand-cast slab to plate shall be at least 3.0:1.

1.6 *Quality:*

All surface imperfections, the removal of which will reduce the plate thickness below its permissible minimum, shall be cause for rejection of the plate; however by agreement with the purchaser, the metal so removed may be replaced with weld metal.

Preparation for repair welding shall include inspection to assure complete removal of the defect.

Repairs shall be made utilizing welding procedures qualified in accordance with ASME Section IX and repair welding shall be done by welders or welding operators meeting the qualification requirements of ASME Section IX.

1.7 *Test Reports:*

1.7.1 The designation of this SA/EN specification shall include the edition year.

1.7.2 Copies of the original manufacturer’s test report shall be included with any subsequent test report.

2. National Parts

2.1 The National Foreword and the National Annexes, if any, do not apply for SA/EN 10028-3.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10028-3 and its references.

SPECIFICATION FOR FLAT PRODUCTS MADE OF STEELS FOR PRESSURE PURPOSES

Part 4: Nickel Alloy Steels With Specified Low Temperature Properties

SA/EN 10028-4 (23)

(Identical with International Specification EN 10028-4:2017 with these additional requirements.)

SPECIFICATION FOR FLAT PRODUCTS MADE OF STEELS FOR PRESSURE PURPOSES
Part 4: Nickel Alloy Steels With Specified Low Temperature Properties

SA/EN 10028-4

(Identical with International Specification EN 10028-4:2017 with these additional requirements.)

1. Additional Requirements

1.1 *General Requirements:*

All "see EN 10028-1" shall be read as "shall be according to EN 10028-1."

1.2 *Marking:*

(a) In addition to the marking requirements of this specification, all products required to be marked and material identification used on all documentation required by this specification are to be identified by this SA/EN specification designation.

(b) Plates that have been given the full heat treatment required by para. 8.2.2 shall be marked by the party performing the heat treatment with the letters designating the applicable heat treatment condition in Table A.1 of EN 10028-4 following the stamped steel name or number.

(c) Plates that are not heat treated but are qualified on the basis of heat treated specimens per para. 8.2.3 shall be stamped with letter “G” following the stamped specification designation.

(d) When such plates are subsequently heat treated, they shall be marked by the party that performed the heat treatment, as required by (b) above following the required stamped specification designation.

1.3 *Chemical Composition:*

The requirements of paras. 7.1.2 and 7.1.3 on heat analysis, and of paras. 7.2.3 and 7.2.4 on product analysis, of SA-20/SA-20M shall apply.

1.4 *Tension Tests:*

For quenched and tempered plates one tension test shall be taken from each end of the heat treated plate. The gage length of the tension test specimens shall be taken at least 1*T* from any heat treated edge, where *T* is the thickness of the plate, and shall be at least $\frac{1}{2}$ in. (12.5 mm) from flame cut or heat-affected-zone surfaces.

1.5 *Impact Tests:*

1.5.1 *Impact Test Sampling:*

Deviation from the requirement for preparation of test pieces for impact testing in EN 10028-1 shall not be permitted in SA/EN 10028-4.

1.5.2 The impact test specimens shall be taken from a location adjacent to the tension test specimens and shall be at least 1*T* from any heat treated edge.

1.6 *Steelmaking Process:*

The ratio of reduction of thickness from a strand-cast slab to plate shall be at least 3.0:1.

1.7 *Quality:*

1.7.1 *Surface Imperfections*

(a) Shallow imperfections shall be ground to sound metal; the ground area shall be well faired and the thickness of the ground plate shall not be reduced below the minimum thickness permitted.

(b) All surface imperfections, the removal of which reduce the plate thickness below the minimum thickness permitted, shall be cause for rejection of the plate, except that, by agreement with the purchaser, the metal so removed may be replaced with weld metal.

1.7.2 *Repair Welding*

(a) Repair by welding shall be permitted only with the approval of the purchaser

(b) Preparation for repair welding shall include inspection to confirm complete removal of the defect.

(c) Repairs shall be made utilizing welding procedures qualified in accordance with Section IX of the ASME Code and repair welding shall be done by welders or welding operators meeting the requirements of ASME Section IX.

(d) If Charpy impact tests of the plate are required, the welding procedure qualification tests shall also include Charpy impact tests of the weld, heat affected zone, and the plate, and the test results shall be reported to the purchaser.

(e) If the plate is subjected to normalizing, quenching and tempering, hot forming, or post-weld heat treating, the welding procedure qualification test plates and the weld repaired plate shall be subjected to the thermal heat treatment as specified by the purchaser.

(f) In addition, repair welds shall meet the requirements of the construction code specified by the purchaser.

(g) The location and size of the repaired area(s), the welding procedure and welding consumables shall be documented and reported to the purchaser.

1.8 *Test Reports:*

1.8.1 The designation of this SA/EN specification shall include the edition year.

1.8.2 Copies of the original manufacturer's test report shall be included with any subsequent test report.

2. National Parts

2.1 The National Foreword and the National Annexes, if any, do not apply for SA/EN 10028-4.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10028-4 and its references.

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SPECIFICATION FOR FLAT PRODUCTS MADE OF STEELS FOR PRESSURE PURPOSES

Part 7: Stainless Steels

SA/EN 10028-7

(Identical with International Specification EN 10028-7:2016 with these additional requirements.)

SPECIFICATION FOR FLAT PRODUCTS MADE OF STEELS FOR PRESSURE PURPOSES
Part 7: Stainless Steels

SA/EN 10028-7

(Identical with International Specification EN 10028-7:2016 with these additional requirements.)

1. Additional Requirements

1.1 *Marking:*

In addition to the marking requirements of this specification, all products required to be marked and material identification used on all documentation required by this specification are to be identified by this SA/EN specification designation.

1.2 *Heat Treatment:*

Heat treatment shall be per the Tables of Annex A.

1.3 *Test Reports:*

1.3.1 The designation of this SA/EN specification shall include the edition year.

1.3.2 Copies of the original manufacturer's test report shall be included with any subsequent test report.

2. National Parts

2.1 The National Foreword and the National Annexes, if any, do not apply for SA/EN 10028-7.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10028-7 and its references.

SPECIFICATION FOR STAINLESS STEELS

Part 2: Technical Delivery Conditions for Sheet/Plate and Strip of Corrosion Resisting Steels for General Purposes

SA/EN 10088-2

(Identical with International Specification EN 10088-2:2014 with these additional requirements.)

SPECIFICATION FOR STAINLESS STEELS
Part 2: Technical Delivery Conditions for Sheet/Plate and Strip of Corrosion Resisting Steels for General Purposes

SA/EN 10088-2

(Identical with International Specification EN 10088-2:2014 with these additional requirements.)

1. Additional Requirements

1.1 *Marking:*

In addition to the marking requirements of this specification, all products required to be marked and material identification used on all documentation required by this specification are to be identified by this SA/EN specification designation.

1.2 *Dimensions:*

Cold rolled strip, hot rolled strip and hot rolled plate thickness, shall not be greater than the applicable thickness shown in the tables of mechanical properties at room temperature.

1.3 *Delivery Condition:*

Plates of martensitic Grades X12Cr13, X15Cr13, X20Cr13, and X30Cr13, shall not be delivered in the annealed condition.

1.4 *Resurfacing by Welding:*

If repairs are authorized by the purchaser, the following requirements have to be fulfilled:

(a) Preparation for repair welding shall include inspection to assure complete removal of the defect.

(b) Repairs shall be made utilizing welding procedures qualified in accordance with ASME Section IX and repair welding shall be done by welders or welding operators meeting the qualification requirements of ASME Section IX.

1.5 *Extent of Testing:*

The tensile tests at room temperature for strips and sheets cut from strips (C, H) in rolling width less than 600 mm, shall be performed on one test sample from each coil.

1.6 *Test Reports:*

1.6.1 Results of the mandatory tests marked by “m” in Table 21, second column, shall be reported.

1.6.2 The designation of this SA/EN specification shall include the edition year.

1.6.3 Copies of the original manufacturer’s test report shall be included with any subsequent test report.

2. National Parts

2.1 The National Foreword and the National Annexes, if any, do not apply for SA/EN 10088-2.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10088-2 and its references.

SPECIFICATION FOR STAINLESS STEEL

Part 3: Technical Delivery Conditions for Semi-Finished Products, Bars, Rods, Wire, Sections, and Bright Products of Corrosion Resisting Steels for General Purposes

SA/EN 10088-3

(Identical with International Specification EN 10088-3:2014 with these additional requirements.)

SPECIFICATION FOR STAINLESS STEEL Part 3: Technical Delivery Conditions for Semi-Finished Products, Bars, Rods, Wire, Sections, and Bright Products of Corrosion Resisting Steels for General Purposes

SA/EN 10088-3

(Identical with International Specification EN 10088-3:2014 with these additional requirements.)

1. Additional Requirements

1.1 *Marking:*

In addition to the marking requirements of this specification, all products required to be marked and material identification used on all documentation required by this specification are to be identified by this SA/EN specification designation.

Products shall be marked by the party performing the heat treatment with the letters designating the applicable heat treatment condition in Tables of Annex A of EN 10088-3 following the marked steel name or number.

Products that are not heat treated but are qualified on the basis of heat treated specimens per para. 6.5.1 shall be marked with letter "G" following the marked specification designation.

1.2 *Dimensions:*

1.2.1 Product thickness or diameter as applicable, shall not be greater than the dimension shown in the tables of mechanical properties at room temperature.

1.2.2 Diameter of bright bars delivered in conditions 2H, 2B, 2G, or 2P, shall be equal to or greater than 5 mm.

1.2.3 Thickness or diameter of bright bars of Grade X2CrNiMoCuN25-6-3 delivered in conditions 2H, 2B, 2G, or 2P, shall be greater than 16 mm.

1.3 *Tests and Inspection:*

1.3.1 *Reports:*

1.3.1.1 A Material Test Report shall be provided and, if required by the referencing Code Section or Purchase Order, a Certificate of Conformance shall be supplied in addition to any test reports or inspection certificates described in para. 7.2. Certified Material Test Reports shall be provided when applicable.

1.3.1.2 Results of the mandatory tests marked by "m" in Table 21, second column, shall be reported.

1.3.1.3 The designation of this SA/EN specification shall include the edition year.

1.3.1.4 Copies of the original manufacturer's test report shall be included with any subsequent test report.

1.3.2 For tension tests, impact tests, hardness tests, and intergranular corrosion tests of round and rectangular cross-section products greater than 1 in. (25 mm), specimens shall be taken at a location corresponding to the ¼ T-plane or deeper.

1.4 *Repair by Welding:*

Repair by welding is acceptable only by agreement with the purchaser, and the following additional requirements shall apply:

(a) Preparation for repair welding shall include inspection to assure complete removal of the defect.

(b) Repairs shall be made utilizing welding procedures qualified in accordance with ASME Section IX, and repair welding shall be done by welders or welding operators meeting the qualification requirements of ASME Section IX.

1.5 *Heat Treatment:*

Austenitic stainless steel material shall be supplied in the solution annealed condition.

1.6 *Surface Quality:*

In Table 1 — Maximum depth of acceptable discontinuities for bars, rods and sections, the permissible depth of discontinuities and the maximum % of delivered weight in excess of permissible depth of discontinuities for

rounds and rod in conditions 1U, 1C, 1E, and 1D shall be EN 10221 class A za2 unless specified otherwise at the time of inquiry and order.

2. National Parts

2.1 The National Foreword and the National Annexes, if any, do not apply for SA/EN 10088-3.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10088-3 and its references.

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SPECIFICATION FOR SEAMLESS STEEL TUBES FOR PRESSURE PURPOSES

Part 2: Technical Delivery Conditions for Non-Alloy and Alloy Steel Tubes With Specified Elevated Temperature Properties

SA/EN 10216-2

(Identical with International Specification EN 10216-2:2013 with these additional requirements.)

SPECIFICATION FOR SEAMLESS STEEL TUBES FOR PRESSURE PURPOSES
Part 2: Technical Delivery Conditions for Non-Alloy and Alloy Steel Tubes With Specified Elevated Temperature Properties

SA/EN 10216-2

(Identical with International Specification EN 10216-2:2013 with these additional requirements.)

1. Additional Requirements

1.1 *Marking:*

In addition to the marking requirements of this specification, all products required to be marked and material identification used on all documentation required by this specification are to be identified by this SA/EN specification designation.

1.2 *Test Reports:*

The designation of this SA/EN specification shall include the edition year.

2. National Parts

2.1 The National Foreword and the National Annexes, if any, do not apply for SA/EN 10216-2.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10216-2 and its references.

SPECIFICATION FOR WELDED STEEL TUBES FOR PRESSURE PURPOSES

Part 1: Technical Delivery Conditions for Electric Welded and Submerged Arc Welded Non-Alloy Steel Tubes With Specified Room Temperature Properties

SA/EN 10217-1

(Identical with International Specification EN 10217-1:2019 with these additional requirements.)

SPECIFICATION FOR WELDED STEEL TUBES FOR PRESSURE PURPOSES
Part 1: Technical Delivery Conditions for Electric Welded and Submerged Arc Welded Non-Alloy Steel Tubes With Specified Room Temperature Properties

SA/EN 10217-1

(Identical with International Specification EN 10217-1:2019 with these additional requirements.)

1. Additional Requirements

1.1 *Material:*

Tubes shall be made using the HFW process only. The tubes shall not be delivered in the "As welded" condition.

1.2 *Inspection:*

Tubes of Quality TR2 shall be submitted to specific inspection.

1.3 *Marking:*

In addition to the marking requirements of this specification, all products required to be marked and material identification used on all documentation required by this specification are to be identified by this SA/EN specification designation.

1.4 *Resurfacing by Welding:*

Repair welding is not permitted without specific approval by the purchaser. If repairs are authorized by the purchaser, the following requirements have to be fulfilled:

(a) Preparation for repair welding shall include inspection to assure complete removal of the defect.

(b) Repairs shall be made utilizing welding procedures qualified in accordance with ASME Section IX and repair welding shall be done by welders or welding operators meeting the qualification requirements of ASME Section IX.

1.5 *Test Reports:*

The designation of this SA/EN specification shall include the edition year.

2. National Parts

2.1 The National Foreword and the National Annexes, if any, do not apply for SA/EN 10217-1.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10217-1 and its references.

SPECIFICATION FOR STEEL FORGINGS FOR PRESSURE PURPOSES

Part 2: Ferritic and Martensitic Steels With Specified Elevated Temperature Properties

SA/EN 10222-2 (23)

(Identical with International Specification EN 10222-2:2017 with these additional requirements.)

SPECIFICATION FOR STEEL FORGINGS FOR PRESSURE PURPOSES
Part 2: Ferritic and Martensitic Steels With Specified Elevated Temperature Properties

SA/EN 10222-2

(Identical with International Specification EN 10222-2:2017 with these additional requirements.)

1. Additional Requirements

1.1 *General Requirements:*

All "see EN 10222-1" shall be read as "shall be according to EN 10222-1."

1.2 *Marking:*

In addition to the marking requirements of this specification, the marking on products, and the material identification used on all documentation shall include:

(a) this SA/EN specification designation

(b) the steel grade or number

(c) heat treatment condition as described below

Forgings shall be marked by the party performing the heat treatment with the letters designating the applicable heat treatment condition in Table 1 of EN 10222-2 following the stamped steel name or number.

1.3 *Resurfacing by Welding:*

If resurfacing by welding is acceptable by agreement with the purchaser and in accordance with para. 6.7.2.3 of EN 10222-1 the following requirements have to be fulfilled:

(a) Preparation for repair welding shall include inspection to assure complete removal of the defect.

(b) Repairs shall be made utilizing welding procedures qualified in accordance with ASME Section IX and repair welding shall be done by welders or welding operators meeting the qualification requirements of ASME Section IX.

1.4 *Test Reports:*

1.4.1 In addition to information listed in EN 10222-1, para. 15, test reports shall include:

(a) the purchaser's order number

(b) the heat number

1.4.2 The designation of this SA/EN specification shall include the edition year.

2. National Parts

2.1 The National Foreword and the National Annexes, if any, do not apply for SA/EN 10222-2.

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of EN 10222-2 and its references.

SPECIFICATION FOR STEEL PLATES FOR BOILERS AND PRESSURE VESSELS

SA/GB 713

(Identical with International Specification GB 713-2014 with these additional requirements.)

SPECIFICATION FOR STEEL PLATES FOR BOILERS AND PRESSURE VESSELS

SA/GB 713

(Identical with International Specification GB 713-2014 with these additional requirements.)

1. Additional Requirements

1.1 *Chemical Composition:*

In addition to the chemical composition requirements of this specification, the limits on elements listed in SA-20/SA-20M, Table 1 shall be observed..

1.2 *Marking:*

In addition to the marking requirements of this specification, all products are to be identified by this SA/GB specification designation.

1.3 *Controlled Rolling:*

Controlled rolling shall be as defined in Figure X1.1 of SA-841/SA-841M.

1.4 *Heat Treatment:*

For material Grades Q245R and Q345R, plates over 1.50 in. (40 mm) in thickness shall be normalized.

1.5 *Test Reports:*

1.5.1 The designation of this SA/GB specification shall include the edition year.

1.5.2 The delivery state shall be indicated on the test report.

1.5.3 Copies of the original manufacturer's test report shall be included with any subsequent test report.

2. Source

2.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of GB 713 and its references.

SPECIFICATION FOR HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL

SA/IS 2062 (23)

(Identical with International Specification IS 2062-2011 (Seventh Revision) as translated and published in the English language by the Bureau of Indian Standards, with these additional requirements.)

SPECIFICATION FOR HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL

SA/IS 2062

(Identical with International Specification IS 2062-2011 (Seventh Revision), as translated and published in the English language by the Bureau of Indian Standards, with these additional requirements.)

1. Additional Requirements

1.1 *Marking:*

1.1.1 In addition to the marking requirements of this specification, all products are to be identified by this SA/IS specification designation.

The designation of the steel, grade designation, and quality shall be marked and followed by letters designating the applied heat treatment (+AR, +N, or +NR).

1.1.2 The required markings for plates shall be by steel die stamping, paint marking, or by means of permanently affixed labels or tags.

1.2 *Chemical Composition:*

In addition to the chemical requirements of Table 1 and Table 3 of this specification, the limits on elements listed in SA-20/SA-20M shall be observed.

1.3 *Mechanical Properties:*

Note 1 of Table 2 shall not apply to SA/IS 2062.

1.4 *Delivery Conditions:*

The products shall be supplied only in the as-rolled, normalized or normalized-rolled condition. Steel shall be killed by use of not less than 0.02% total aluminum content. Semi-killed steel shall not be used.

1.5 *Repair by Welding:*

Repairs shall be made by utilizing welding procedures qualified in accordance with ASME Section IX, and repair welding shall be done by welders or welding operators meeting the qualification requirements of ASME Section IX.

1.6 *Test Reports:*

1.6.1 For all products, a test report shall be furnished. As a minimum, it shall include the following:

(a) this SA/IS specification designation including the edition year

(b) grade designation and quality to which the product is furnished

(c) delivery condition

(d) heat number, heat analysis, and nominal sizes

(e) the results of all tests required by this SA/IS specification

1.6.2 Copies of the original manufacturer's test report shall be included with any subsequent test report.

2. Source

2.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of IS 2062 and its references.

SPECIFICATION FOR CARBON STEEL PLATES FOR PRESSURE VESSELS FOR INTERMEDIATE AND MODERATE TEMPERATURE SERVICE

SA/JIS G3118 (**23**)

(Identical with International Specification JIS G3118:2017 as translated and published in the English language by the Japanese Standards Association, with these additional requirements.)

SPECIFICATION FOR CARBON STEEL PLATES FOR PRESSURE VESSELS FOR INTERMEDIATE AND MODERATE TEMPERATURE SERVICE

SA/JIS G3118

(Identical with International Specification JIS G3118:2017, as translated and published in the English language by the Japanese Standards Association, with these additional requirements.)

1. Additional Requirements

1.1 *Marking:*

1.1.1 In addition to the marking requirements of this specification in para. 4.5, all products are to be identified by this SA/JIS specification designation.

1.1.2 Plates that are required to be heat treated per para. 4.2(b), but have not been so heat treated as allowed in para. 4.2(d), shall be marked with the letter "G" following the stamped specification designation.

1.1.3 When such plates are subsequently heat treated, they shall be marked per para. 4.5, by the party that performed the heat treatment, following the required stamped specification designation.

1.1.4 The required markings shall be by paint marking or by steel die stamping.

1.1.5 The required markings shall be in at least one place on each finished plate.

1.2 *Trace Elements:*
The requirements of SA-20/SA-20M shall apply.

1.3 *Plates Produced by TMCP:*
Steel plates subjected to thermo-mechanical controlled processing shall be excluded.

1.4 *Steelmaking Process:*
The ratio of reduction of thickness from a strand-cast slab to plate shall be at least 3.0:1.

1.5 *Test Reports:*

1.5.1 The designation of this SA/JIS specification shall include the edition year.

1.5.2 The heat number, plate identifier of the plate tested, and nominal plate thickness shall be shown on the test report.

1.5.3 Copies of the original manufacturer's test report shall be included with any subsequent test report.

1.6 *Mechanical Properties:*

1.6.1 Tension testing is mandatory. Metric symbol materials (Table 1) shall use the values in Table 5 only.

1.6.2 Note c of Table 5 shall be understood as concerning Test pieces No. 10 for steel plates of thickness over 90 mm.

1.7 *Repair Welding:*
Weld repairs may be performed when permitted by the purchaser. The requirements of SA-20/SA-20M shall apply.

1.8 *Inspection:*
When sulphur print test, or nondestructive test, or impact test is performed in accordance with para. 11, the result shall comply with the acceptance criterion set upon agreement between the purchaser and the manufacturer.

2. Austenitic Grain Size

2.1 "5 or more" in para. 8 shall mean "5 or finer."

3. Source

3.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of JIS G3118 and its references.

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SPECIFICATION FOR STAINLESS STEEL BARS

SA/JIS G4303

(Identical with International Specification JIS G4303:2012 with these additional requirements.)

SPECIFICATION FOR STAINLESS STEEL BARS

SA/JIS G4303

(Identical with International Specification JIS G4303:2012 with these additional requirements.)

1. Additional Requirements

1.1 *Marking:*

In addition to the marking requirements of this specification in para. 13, all products are to be identified by this SA/JIS specification designation.

1.2 *Dimensions:*

The dimension of austenitic bars shall not be greater than 180 mm. The dimension of austenitic-ferritic, ferritic, martensitic, and precipitation hardening bars shall not be greater than 75 mm.

1.3 *Mechanical Properties:*

The mechanical properties, including proof stress, shall conform to the requirements of the tables of clause "Mechanical Properties."

1.4 *Test Reports:*

A test report shall be furnished. It shall include this SA/JIS specification designation including the edition year and the results of all tests required by this SA/JIS specification.

1.5 *Mechanical Testing:*

Tensile testing and hardness testing are mandatory requirements of this specification.

2. Source

2.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of JIS G4303 and its references.

SPECIFICATION FOR HEAVY-WALLED FERRITIC SPHEROIDAL GRAPHITE IRON CASTINGS FOR LOW TEMPERATURE SERVICE

SA/JIS G5504

(Identical with International Specification JIS G5504:2005 as translated and published in the English language by the Japanese Standards Association, with these additional requirements.)

SPECIFICATION FOR HEAVY-WALLED FERRITIC SPHEROIDAL GRAPHITE IRON CASTINGS FOR LOW TEMPERATURE SERVICE

SA/JIS G5504

(Identical with International Specification JIS G5504:2005, as translated and published in the English language by the Japanese Standards Association, with these additional requirements.)

1. Additional Requirements

1.1 *Marking:*

In addition to the marking requirements of this specification in para. 16, all products are to be identified by this SA/JIS specification designation.

1.2 *Mechanical Properties:*

The mechanical properties, including proof stress, shall conform to the requirements of Table 1.

1.3 *Test Reports:*

A test report shall be furnished containing the results of all tests performed. It shall include this SA/JIS specification designation including the edition year.

1.4. *Repair:*

Castings shall not be repaired by plugging, welding, brazing, impregnation, or any other means.

2. Source

2.1 See Nonmandatory Appendix A for ordering information to obtain an English language copy of JIS G5504 and its references.

MANDATORY APPENDIX I
STANDARD UNITS FOR USE IN EQUATIONS

Table I-1
Standard Units for Use in Equations

Quantity	U.S. Customary Units	SI Units
Linear dimensions (e.g., length, height, thickness, radius, diameter)	inches (in.)	millimeters (mm)
Area	square inches ($in.^2$)	square millimeters (mm^2)
Volume	cubic inches ($in.^3$)	cubic millimeters (mm^3)
Section modulus	cubic inches ($in.^3$)	cubic millimeters (mm^3)
Moment of inertia of section	$inches^4$ ($in.^4$)	$millimeters^4$ (mm^4)
Mass (weight)	pounds mass (lbm)	kilograms (kg)
Force (load)	pounds force (lbf)	newtons (N)
Bending moment	inch-pounds (in.-lb)	newton-millimeters (N·mm)
Pressure, stress, stress intensity, and modulus of elasticity	pounds per square inch (psi)	megapascals (MPa)
Energy (e.g., Charpy impact values)	foot-pounds (ft-lb)	joules (J)
Temperature	degrees Fahrenheit (°F)	degrees Celsius (°C)
Absolute temperature	Rankine (°R)	kelvin (K)
Fracture toughness	ksi square root inches (ksi $\sqrt{in.}$)	MPa square root meters (MPa$\sqrt{m}$)
Angle	degrees or radians	degrees or radians
Boiler capacity	British thermal units per hour (Btu/hr)	watts (W)

(23)

MANDATORY APPENDIX II
FRAMEWORK OF ASME MATERIAL SPECIFICATIONS

II-100 GENERAL

An ASME material specification is a standard originally published by an external organization, then modified to conform to ASME BPVC requirements. A list of all ASME material specifications is in the "Specification" column of Tables II-200-1 and II-200-2.

II-200 SOURCE STANDARDS

The standards forming the framework of ASME material specifications are produced by organizations from around the world. The source standard from which an ASME material specification was derived is part of the specification's designation, as shown below.

ASME Material Specification Designation	Source Standard
SA-217/SA-271M	ASTM A217/A217M
SA/AS-1548	AS 1548
SA/CSA-G40.21	CSA G40.21
SB-166	ASTM B166
SF-568M	ASTM F568M
SA/EN 10028-2	EN 10028-2
SA/GB 713	GB 713
SA/IS 2062	IS 2062
SA/JIS G3118	JSA-JIS G 3118

The "Latest Adopted" column of Tables II-200-1 and II-200-2 states which edition (revision) of the source standard is the framework for the ASME material specification. The "Description" column explains any changes made to the source standard when it was adopted as an ASME material specification.

II-300 PERMISSIBILITY OF SUPERSEDED EDITIONS FOR ASME CONSTRUCTION

At times, the publishing organization will update its standard and supersede the previous edition. When this occurs, the BPVC II committee may choose to evaluate the update and adopt it as the framework for the ASME material specification.

The Section II committee may also choose to continue to allow for Code construction a previously accepted but now superseded edition. Superseded editions permitted are referenced in the column "All Acceptable Editions" of Tables II-200-1 and II-200-2. Any caveats listed in the "Description" column shall be met.

If no superseded editions are currently permitted for use, then an ellipse (...) will appear in the "All Acceptable Editions" column.

II-400 STRUCTURE OF ASME MATERIAL SPECIFICATIONS

This paragraph gives examples of deciphering from Tables II-200-1 and II-200-2 the structure of ASME material specifications as well as which editions of a source standard are permitted for use. These examples are based on Figure II-400-1. The specifications in the figure are based on editions found in BPVC Section II, Parts A and B, 2021 Edition.

(a) SA-217/SA-217M. The standard adopted was ASTM A217/A217M. The 2007 edition (A217/A217M-07) is the latest adopted. The word "Identical" is listed in the "Description" column; this means that ASME material specification SA-217/SA-217M is identical to ASTM A217/A217M-07. The "All Acceptable Editions" column indicates that revisions 1993 through 2007, inclusive, are permitted for construction.

(b) SA-513. The standard adopted was ASTM A513. The 2000 edition (A513-00) is the latest adopted. The "Description" column indicates that for the ASTM specification to be used as ASME material specification SA-513, its Supplementary Requirements S6 and either S7 or S8 are mandatory. Ellipses (...) are listed under the "All Acceptable Editions" column. This means that only the edition listed under the "Latest Adopted" column — ASTM A513-00 — is permitted for Code construction.

(c) SA/CSA-G40.21. The standard adopted was CSA G40.21. The latest edition adopted is 2013(R2018). This means that the 2018 edition is the latest adopted, and that it is a reapproval of the 2013 edition [(CSA-G40.21-2013 (R2018)]. The ASME material specification was modified to have additional requirements for marking, chemical composition, controlled and normalized rolling, and providing a test report. The only CSA-G40.21 editions permitted for construction are 1992, and 2004 through 2018, inclusive.

(d) SB-166. The standard adopted was ASTM B166, 2011 edition (B166-11). The ASME material specification has been modified to require certification and test report be given to the purchaser; and that the details of N06617's heat treatment are provided on the certification. The B166 editions permitted for construction are 1986 through 2011, inclusive.

(e) SB-516. The standard adopted was ASTM B516, 2014 edition [B516-03(2014)]. The ASME material specification has been modified to require certification and test report be given to the purchaser. Any ASTM B516 specification having a year-date between 1985 and 2014, inclusive, is permitted for construction with an exception to alloy N06025. If alloy N06025 certified to ASTM A516 is to be used, then it can only be certified to a year-date between 1998 and 2014.

(23)

Table II-200-1
Material Specifications Acceptable for ASME Construction

Specification	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA-6/SA-6M	21	Identical General Requirements, Rolled Products	88c through 21
SA-20/SA-20M	20	Identical except for revision in para. 11.5.3. General Requirements, Plates	88 through 20
SA-29/SA-29M	20	Identical General Requirements, Bars	88 through 20
SA-31	14	Identical except that 3.1.7 has been deleted, Note 1 has been revised for ASME and certification is mandatory in 14.	00 through 14
SA-36/SA-36M	19	Identical	88 through 19
SA-47/SA-47M	99(2018)$^{\varepsilon 1}$	Identical except for the deletion of welded repair references in 11.2 and 11.3 and mandatory certification in 14.1.	84 through 99(2018)$^{\varepsilon 1}$
SA-53/SA-53M	20	Identical	10 through 20
SA-105/SA-105M	21	Identical except for addition of Footnote A call out next to vanadium composition limit in Table 1 and deletion of [mm] from the thickness variable (*T*) in Table 3 Note minimum elongation formula.	87a through 21
SA-106/SA-106M	19a	Identical	88a through 19a
SA-134/SA-134M	19	Identical. For products ordered to Section III, Division 1, Supplementary Requirement S1 is mandatory.	85 through 19
SA-135/SA-135M	19	Identical except certification has been made mandatory. The 06, 09, and 09(2014) ASTM editions are acceptable provided the minimum metric hydrostatic pressure is 17200 kPa.	88 through 19
SA-178/SA-178M	95	Identical	89 through 95
SA-179/SA-179M	19	Identical	88a through 19
SA-181/SA-181M	06	Identical	87 through 06
SA-182/SA-182M	21	Identical except for the inclusion of Grade F316Ti in para. 7.3.1, the removal of reduced strength levels for thicker sections of Grade F53 in Table 3, the removal of Grade F53 Classes in Table 3, the removal of Note (G) in Table 3, the increase of minimum yield strength for Grade F60 in Table 3 and clarification of requirements for parts machined from bar or hollow bar in 6.4 and para. 7.2.1 revised to include F12, Classes 1 and 2. *(a)* S32202 (F66) heat treatment range shall be 1,870°F to 1,975°F (1,020°F to 1080°C) for ASTM editions prior to 09a *(b)* S32205 (F60) min YS in Table 3 shall be 70 (485) in all ASTM editions *(c)* S30815 (F45) and S32228 (F56) direct or indirect in-process heat treatment is prohibited for ASTM editions prior to 07 *(d)* K90901 (F91), other acceptable editions are limited to 18 *(e)* K91061 (F911), other acceptable editions are limited to 05 or later	87a through 21
SA-192/SA-192M	17	Identical	88 through 17
SA-193/SA-193M	20	Identical	14 through 20

Table II-200-1
Material Specifications Acceptable for ASME Construction (Cont'd)

Specification	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA-194/SA-194M	22	Identical	14 through 22
SA-203/SA-203M	17	Identical	82 through 17
SA-204/SA-204M	17	Identical	88 through 17
SA-209/SA-209M	03(2017)	Identical	88 through 03(2017)
SA-210/SA-210M	95	Identical except for editorial differences in Table 2	88 through 95
SA-213/SA-213M	22	Identical except for the additional H Grade heat treatment requirements in para. 6.2 and correction of UNS number for Grade T9 in Table 3. For Grade T91, other acceptable editions are limited to 18 and later. For UNS S31035 and UNS K91060, the acceptable edition is limited to 18b.For UNS S31050, other acceptable ASTM editions are limited to 15a and later. For UNS S31002, the ASTM edition is limited to 22.	10 through 22
SA-214/SA-214M	19	Identical	88 through 19
SA-216/SA-216M	07	Identical except for addition of 2.3 and editorial differences in 2.1 and 10.1	84b through 07
SA-217/SA-217M	07	Identical	93 through 07
SA-225/SA-225M	17	Identical	86 through 17
SA-231/SA-231M	96	Identical except that certification requirements in 13.1 are mandatory	...
SA-232/SA-232M	91	Identical	...
SA-234/SA-234M	19	Identical. For Grade WP91, other acceptable ASTM editions are limited to 18 and later. For welded and filler metal products ordered to Section III, Division 1, Supplementary Requirement S4 is mandatory.	82a through 19
SA-240/SA-240M	17	Identical except for UNS S31050, other acceptable ASTM editions are limited to 04 and later. For UNS S32906, other acceptable ASTM editions are limited to 07$^{\varepsilon 1}$ and later. For UNS S38815, other acceptable ASTM editions are limited to 16 and later. For UNS S32101, other acceptable ASTM editions are limited to -05 and later.	88c through 17
SA-249/SA-249M	18a	Identical except for the deletion of S5, which allows lower mechanical properties, and for Section I only, S9 is mandatory when 100% joint efficiency is required. For UNS S31040, other acceptable ASTM editions are limited to 10a and later.	88b through 18a
SA-250/SA-250M	05(2014)	Identical except that Supplementary Requirement S1 is mandatory when 100% weld joint efficiency is required.	88a through 05(2014)
SA-263	12(2019)	Identical. In cases where cladding is used in the design strength calculations and welding is used to join multiple alloy cladding plates, ASTM editions prior to 12 are not acceptable unless welding was performed by an ASME Certificate Holder.	88 through 12(2019)

Table II-200-1
Material Specifications Acceptable for ASME Construction (Cont'd)

Specification	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA-264	12(2019)	Identical. In cases where cladding is used in the design strength calculations and welding is used to join multiple alloy cladding plates, ASTM editions prior to 12 are not acceptable unless welding was performed by an ASME Certificate Holder.	88 through 12(2019)
SA-265	12(2019)	Identical. In cases where cladding is used in the design strength calculations and welding is used to join multiple alloy cladding plates, ASTM editions prior to 12 are not acceptable unless welding was performed by an ASME Certificate Holder.	88 through 12(2019)
SA-266/SA-266M	21	Identical. ASTM editions 03 through 11 are acceptable provided the term "hubbed flanges" is replaced with "hubbed flat heads" in para. 3.4.	99 through 21
SA-268/SA-268M	20	Identical	88b through 20
SA-276/SA-276M	17	Identical	02 through 17
SA-278/SA-278M	01(2015)	Identical except for an editorial change to 5.1.1 and a change to 16.1 making certification mandatory.	85 through 01(2015)
SA-283/SA-283M	13	Identical	88 through 13
SA-285/SA-285M	17	Identical	82(R87) through 17
SA-299/SA-299M	17	Identical	82(R87) through 17
SA-302/SA-302M	17	Identical. ASTM editions prior to 12 are acceptable provided that any accelerated cooling of plates as permitted in 5.3 is followed by tempering.	82 through 17
SA-307	10	Identical except for the deletion of the term “private label distributor” and “as appropriate” in para. 13.1.1.	00 through 10
SA-311/SA-311M	04(2015)	Identical except for the deletion of 5.1.11, revision of Table 1 footnote A, and editorial change to 5.1.9, and 11.1 revised to make certification mandatory.	90b through 04(2015)
SA-312/SA-312M	18a	Identical except for the revision to para. 6.2 to add "H" grade heat treatment requirements. For UNS S31035, the acceptable ASTM edition is limited to 18a. For UNS S34051, ASTM editions prior to 14b are acceptable provided that the nickel composition in Table 1 is met.	88a through 18a
SA-320/SA-320M	22	Identical	21 through 22
SA-325	10	Identical except for the deletion of the term “private label distributor” in 15.1 and 15.5	86a through 10
SA-333/SA-333M	16	Identical. For Grade 6, acceptable ASTM editions are limited to 11 and later.	94 through 16
SA-334/SA-334M	04a(2016)	Identical	88$^{\varepsilon 1}$ through 04a(2016)
SA-335/SA-335M	18	Identical except for the revision to 9.5 to replace the words "as agreed upon in accordance with Note D in Table 2" with "performed." For Grades 23, 91, and 911, other acceptable ASTM editions are limited to 18.	10b through 18

Table II-200-1
Material Specifications Acceptable for ASME Construction (Cont'd)

Specification	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA-336/SA-336M	18	Identical. ASTM editions prior to 15 are acceptable provided the term "hubbed flanges" is replaced with "hubbed flat heads" in 3.4. For Grade F5a, ASTM editions prior to 15 are acceptable provided the minimum temperature is 1,250°F.	06a through 18
SA-350/SA-350M	02b	Identical except for the deletion of 6.1.2 and 14.1, revision to 14.2.5, and test reports have been made mandatory. SA-350/SA-350M Grade LF2 forgings made to revisions earlier than the 2001 ASME Boiler and Pressure Vessel Code or to ASTM Specification A350/A350M with year dates from 1987 through 1997 are acceptable for either Class 1 or Class 2 applications unless Supplementary Requirement S4 was used to test forgings at a higher test temperature.	87 through 02b
SA-351/SA-351M	18$^{\varepsilon 1}$	Identical. For Grades CK3MCuN and CN3MN, acceptable ASTM editions are limited to 13a and later.	86 through 18$^{\varepsilon 1}$
SA-352/SA-352M	06(2012)	Identical	88 through 06(2012)
SA-353/SA-353M	17	Identical	87 through 17
SA-354	11	Identical except for the deletion of the term “private label distributor” in 15.1 and 15.3.5.	86 through 11
SA-358/SA-358M	19	Identical except for the deletion of 6.3.2.2 for HT-O pipe and 6.3.2.3 for HT-SO pipe. For products ordered to Section III and Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code, Supplementary Requirement S8 is mandatory.	88 through 19
SA-369/SA-369M	18	Identical	88 through 18
SA-370	21	Identical Mechanical Testing of Steel Products	77 through 21
SA-372/SA-372M	20$^{\varepsilon 1}$	Identical. ASTM editions prior to -20$^{\varepsilon 1}$ are acceptable provided that the minimum tensile strength for Class 55 in Table 2 is 585 MPa.	02 through 20$^{\varepsilon 1}$
SA-376/SA-376M	19	Identical except for the deletion of HT-O option from 5.2.1 and 13.1, and clarification of heat-treatment requirements in 5.2.1.	88 through 19
SA-387/SA-387M	17a	Identical. For Grade 91, acceptable ASTM editions are limited to 11 and later.	88 through 17a
SA-395/SA-395M	99(2018)	Identical	80 through 99(2018)
SA-401/SA-401M	18	Identical	...
SA-403/SA-403M	19a	Identical except for clarified heat treatment requirements in 6.1 and 6.4, the deletion of 5.14 and 5.15, and the deletion of revised tensile requirements for Grades 321 and 321H in Table 5. For H Grades, other acceptable ASTM editions are limited to 02 and later. For Grade S38815, other acceptable ASTM editions are limited to 16 and later. For welded with filler metal products ordered to Section III, Division 1 of the ASME Boiler and Pressure Vessel Code, Supplementary Requirement S3 is mandatory.	86 through 19a

Table II-200-1
Material Specifications Acceptable for ASME Construction (Cont'd)

Specification	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA-409/SA-409M	19	Identical except for clarified heat treatment requirements for H grade stainless steels and S30815 in 5.3.1, deletion of 5.3.2.2 and 5.3.2.3 for the non-heat treated pipe provisions, and the inclusion of a grain size requirement in 5.1.1 for H grade stainless steels and S30815, and mandatory certification in 17. For grade S31727 and S32053, ASTM editions are limited to 08a and later. For S20100, S20153, and S31254, ASTM editions are limited to 13 and later. For S31266, the ASTM edition is limited to 15. For products ordered to Section III, Division 1 or Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code, Supplementary Requirement S7 is mandatory	01 through 19
SA-414/SA-414M	14(2019)	Identical	10 through 14(2019)
SA-420/SA-420M	19a	Identical. For products welded with filler metal ordered to Section III, Division 1, Supplementary Requirement S1 is mandatory.	85a through 19a
SA-423/SA-423M	19	Identical	89 through 19
SA-426/SA-426M	13	Identical	10 through 13
SA-437/SA-437M	15(2021)	Identical	84b through 15(2021)
SA-439/SA-439M	18	Identical except for repair by welding and plugging is not permitted, and certification made mandatory.	...
SA-449	10	Identical except for requiring all mating fastener components to be coated by the same zinc-coating process in 5.1.4, the removal of reference to bolts in 6.4, and the deletion of the term "private label distributor" in 16.1 and 16.3.2.	87 through 10
SA-450/SA-450M	21	Identical General Requirements for Tubes	88a through 21
SA-451/SA-451M	06(2010)	Identical except for editorial differences in 15.1.	80(R85) through 06(2010)
SA-453/SA-453M	17	Identical	00 through 17
SA-455/SA-455M	12a(2017)	Identical	82(1987) through 12a(2017)
SA-476/SA-476M	00(2018)	Identical except for editorial changes in 4.1.6 and 13.1 to make certification mandatory.	82 through 00(2018)
SA-479/SA-479M	21	Identical. For Grade S32654, ASTM editions are limited to 11 and later.	87b through 21
SA-480/SA-480M	17	Identical General Requirements — Flat Products	88 through 17
SA-484/SA-484M	21	Identical General Requirements Wrought SS Products	87 through 21
SA-487/SA-487M	21	Identical except no welding for Grade 17 per Table 4	...
SA-508/SA-508M	18	Identical except for revision prior to 05b. For these A966/A966M added to 2.1, 3.1, and 7.2.1 revised to allow A966 in revisions prior to $05^{\varepsilon 1}$ reference to Notes 2 and 3 in 6.1.2.2 should be 3 and 4 respectively.	87 through 18
SA-513	00	Identical except that Supplementary Requirements S6 and either S7 or S8 at the manufacturer's option are mandatory.	...
SA-515/SA-515M	17	Identical	82 through 17

Table II-200-1
Material Specifications Acceptable for ASME Construction (Cont'd)

Specification	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA-516/SA-516M	17	Identical. The reference to Footnote B in Table 1 shall apply to the 04, 05, and 05e editions.	86 through 17
SA-517/SA-517M	17	Identical except that Footnote A also applies to Boron in Table 1.	87a $^{\varepsilon 1}$ through 17
SA-522/SA-522M	07	Identical	87 through 07
SA-524/SA-524M	21	Identical except for the deletion of alternate elongation and deletion of SI Units from Table 2 Note on Grade I.	88 through 21
SA-530/SA-530M	18	Identical General Requirements for Pipe	88a through 18
SA-533/SA-533M	16	Identical	87 through 16
SA-537/SA-537M	20	Identical	86 through 20
SA-540/SA-540M	15(2021)	Identical	84a through 15(2021)
SA-541/SA-541M	05(2015)	Identical	...
SA-542/SA-542M	19	Identical	88 through 19
SA-543/SA-543M	09(2014)	Identical	87 through 09(2014)
SA-553/SA-553M	17	Identical	87b through 17
SA-556/SA-556M	90a(1995) $^{\varepsilon 1}$	Identical	88 through 90a(1995) $^{\varepsilon 1}$
SA-562/SA-562M	10	Identical	82(1987) through 10
SA-563	07a(2014)	Identical except for deletion of the term “private label distributor” in paras. 14.7 and 14.9 and editorially corrected title.	84 through 07a(2014)
SA-564/SA-564M	04(2009)	Identical	87b through 04(2009)
SA-568/SA-568M	07a	Identical General Requirements for Steel Sheet	02 through 07a
SA-572/SA-572M	21 $^{\varepsilon 1}$	Identical	01 through 21 $^{\varepsilon 1}$
SA-574	04 $^{\varepsilon 1}$	Identical except that Table 1 on chemical requirements has been deleted and Supplementary Requirement S1 is now mandatory. Paragraphs 6.1 and 6.2 have been revised to refer to Table S1.1 and para. 6.3 has been deleted.	97a through 04 $^{\varepsilon 1}$
SA-587	96(2005)	Identical except for deletion of 1.5.	88 through 96(2005)
SA-592/SA-592M	04(2009)	Identical	85 through 04(2009)
SA-609/SA-609M	91(2007)	Identical Ultrasonic Longitudinal Beam — Castings	83 through 91(2007)
SA-612/SA-612M	12(2019)	Identical	87 through 12(2019)
SA-638/SA-638M	00(2004)	Identical except for an editorial correction in 6.2.	87 through 00(2004)
SA-645/SA-645M	10(2016)	Identical	87(1991) through 10(2016)
SA-649/SA-649M	04	Identical	91a through 04
SA-656/SA-656M	18	Identical	00a through 18
SA-660	96(2010)	Identical	88 through 96(2010)
SA-662/SA-662M	17	Identical	86 through 17

Table II-200-1
Material Specifications Acceptable for ASME Construction (Cont'd)

Specification	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA-666	03	Identical	90 through 03
SA-667/SA-667M	87(2018)	Identical	...
SA-671/SA-671M	19	Identical except for additional requirements that apply as shown in Specification and, for editions prior to 16, certification for designations CF and CJ shall include the appropriate ASTM plate specification grade. For products ordered to Section III, Division 1, Supplementary Requirement S15 is mandatory.	85 through 19
SA-672/SA-672M	19	Identical. For products ordered to Section III, Division 1, Supplementary Requirement S15 is mandatory.	81 through 19
SA-675/SA-675M	03(2009)	Identical except that Supplementary Requirement S7 is mandatory and Grades 65 [450] and 70 [485] have been added to S7. Certification is mandatory.	...
SA-688/SA-688M	15	Identical. For products ordered to Section III, Division 1 of the ASME Boiler and Pressure Vessel Code, Supplementary Requirement S13 is mandatory	88a through 15
SA-691/SA-691M	19	Identical. For products ordered to Section III, Division 1 or the ASME Boiler and Pressure Vessel Code, Supplementary Requirement S13 is mandatory.	85a through 19
SA-693	02$^{\varepsilon 1}$	Identical except for aligning the elongation requirements for Gr. XM-16 and correction of the max. hardness for Gr. XM-12 and 630 in Table 5. Also a revision to Note B of Table 1.	88 through 02$^{\varepsilon 1}$
SA-696	90a(2012)	Identical	85 through 90a(2012)
SA-703/SA-703M	18a	Identical General Requirements for Castings	87b through 18a
SA-705/SA-705M	95(2009)	Identical	87a through 95(2009)
SA-723/SA-723M	10(2015)	Identical. ASTM edition 02 is acceptable except that for Class 2a the minimum elongation shall be 13.5%.	02 through 10(2015)
SA-724/SA-724M	09(2018)	Identical	88 through 09(2018)
SA-727/SA-727M	14(2009)	Identical	02(2007) through 14(2019)
SA-736/SA-736M	17	Identical	88 through 17
SA-737/SA-737M	17	Identical	87(1991) through 17
SA-738/SA-738M	19	Identical	87a through 19
SA-739	90a(2016)	Identical	81a through 90a(2016)
SA-747/SA-747M	04	Identical except for the revision of the mandatory ordering requirements of 4.1.6 and the mandatory use of Supplementary Requirement S15 of SA-781/SA-781M.	86 through 04
SA-748/SA-748M	87(2018)	Identical	...
SA-749/SA-749M	97(2002)	Identical General Requirements for Steel Strip	...
SA-751	21	Identical except for editorial corrections to an element designation in Tables 1 and 2.	89a through 21

Table II-200-1
Material Specifications Acceptable for ASME Construction (Cont'd)

Specification	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA-765/SA-765M	07(2017)	Identical. ASTM editions prior to 04 are acceptable provided the term "hubbed flanges" is replaced with "hubbed flat heads" in S9.	94 through 07(2017)
SA-770/SA-770M	03(2018)	Identical except for editorial correction to Table 2. Tension Testing of Steel Plates	86(1990)$^{\varepsilon 1}$ through 03 (2018)
SA-781/SA-781M	06	Identical Common Requirements for Castings	87a through 06
SA-788/SA-788M	15	Identical. ASTM editions prior to 13 are acceptable, provided the term “hubbed flanges” is replaced with “hubbed flat heads” in S12. General Requirements for Forgings	05c through 15
SA-789/SA-789M	18	Identical	10a through 18
SA-790/SA-790M	19	Identical	10 through 19
SA-803/SA-803M	16	Identical	96 through 16
SA-813/SA-813M	14(2019)	Identical except for the addition of grain size requirements for H grades and S30815, the addition of E112 to section 2, the deletion of heat treat omitted options, and adding a minimum heat treat temperature for S30815.	88a through 14(2019)
SA-814/SA-814M	15(2019)	Identical	88a through 15(2019)
SA-815/SA-815M	10a	Identical except for the deletion of para. 5.9, 5.14 (Class CR fittings), and 5.15.4. *(a)* Paragraphs 5.14 and 5.15 deleted for all editions prior to 10a *(b)* S32202, para. 7.2.3 filler metal with nominal 23.5% Cr, 12.00% Ni is not permitted, minimum HT temperature in Table 2 to be 1,870°F to 1,975°F (1 020°C to 1 080°C) *(c)* S32808, maximum *S* in Table 2 shall be 0.010 in all editions	86 through 10a
SA-832/SA-832M	17	Identical	84(1989) through 17
SA-834	95(2015)	Identical Common Requirements for Iron Castings	84 through 95(2015)
SA-836/SA-836M	14(2020)	Identical	02(2007) through 14(2020)
SA-841/SA-841M	17	Identical	88 through 17
SA-874/SA-874M	98(2018)$^{\varepsilon 1}$	Identical	98(2018)$^{\varepsilon 1}$
SA-905	93	Identical	91 through 93
SA-941	22a	Identical	99b through 22a
SA-960/SA-960M	20	Identical	99b through 20
SA-961/SA-961M	21	Identical except for the editions prior to 13, certification is mandatory.	99 through 21
SA-962/SA-962M	22	Identical	99 through 22
SA-965/SA-965M	21a	Identical	06a through 21a
SA-985/SA-985M	04a	Identical General Requirements, Castings	03 through 04a

Table II-200-1
Material Specifications Acceptable for ASME Construction (Cont'd)

Specification	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA-988/SA-988M	17	Identical except for addition of para. 5.1.6; Supplementary Requirements S19, S20, S21, and S22 are mandatory; correction to S20 to add powder storage requirements.	17
SA-989/SA-989M	18	Identical except for addition of para. 5.1.7; Supplementary Requirements S2, S4, and S5 are mandatory.	18
SA-995/SA-995M	20	Identical except for Grade 6A editions prior to 19 are obsolete.	98(2007) through 20
SA-999/SA-999M	18	Identical except for the editions prior to 04a, para. 6.2.1 on grade substitution of the 04a edition or later applies. General Requirements, Pipes	04a through 18
SA-1008/SA-1008M	01a	Identical except for the addition of 8.1.1.1 on mechanical properties for pressure vessel design.	00 through 01a
SA-1010/SA-1010M	01(2009)	Identical except for an editorial correction to a column heading in Table 2.	...
SA-1011/SA-1011M	06b	Identical	01a through 06b
SA-1016/SA-1016M	17a	Identical General Requirements, Tubes	10 through 17a
SA-1017/SA-1017M	17	Identical. For Grade 122, acceptable editions 07 and later. For Grade 23, acceptable editions 11 and later.	01 through 17
SA-1058	19	Identical	...
SF-568M	98	Identical Threaded Metric Fasteners	93a through 98

NOTE:

(1) The source standards for specifications listed in this table are ASTM standards. ASTM technical committees review the standards under their jurisdiction on a 5-yr cycle. If no changes are needed, then the standard is simply reapproved. At times, editorial errors are discovered within an ASTM standard between the 5-yr review cycle. If the technical committee decides to fix the errors immediately, then the standard will be republished with a superscript epsilon (ε) in the designation. BPVC II Committee has taken the position that a reapproved or editorially corrected edition is technically and substantively identical to the base edition. For example, edition 15(2020), $15^{\varepsilon 1}$, or $15(2020)^{\varepsilon 1}$ is technically and substantively identical to 15. Therefore, for the purposes of ASME construction, a reapproved or editorially corrected edition of an ASTM specification shall be considered acceptable for use, even if the edition is beyond the range listed in this column, provided that its base edition is within range.

Table II-200-2
Material Specifications Acceptable for ASME Construction

(23)

Specifications	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA/AS-1548	2008 (R2018)	Identical except for steelmaking process, marking, chemical composition, and test reports as shown in the specification. Appendix "Interchangeability of Strength Grades" does not apply.	2008
SA/CSA-G40.21	2013 (R2018)	Identical except for marking, chemical composition, controlled and normalized rolling, and test reports as shown in the specification.	2004 through 2013(R2018)
SA/EN 10025-2	2019	Identical except for marking, chemical composition, resurfacing by welding, and test reports as shown in the specification.	...
SA/EN 10028-2	2017	Identical except for general requirements, marking, delivery condition, chemical composition, tension test, impact test sampling, steelmaking process, quality, and test reports as shown in the specification. For Grade 13CrMo4-5, other acceptable editions are limited to 2009 and later. For other acceptable editions prior to 2017, plate thickness shall not be greater than 250 mm.	2003 through 2017
SA/EN 10028-3	2017	Identical except for general requirements, marking, chemical composition, impact test sampling, steelmaking process, quality, and test reports as shown in the specification. For other acceptable editions prior to 2017, plate thickness of Grades P460NH, P460NL1, and P460NL2, shall not be greater than 100 mm.	2003 through 2017
SA/EN 10028-4	2017	Identical except for general requirements, marking, chemical composition, tension, impact tests, steelmaking process, surface imperfections, repair welding, and test reports as shown in the specification.	2003 through 2017
SA/EN 10028-7	2016	Identical except for marking, heat treatment and test reports, as shown in the specification. For the latest adopted edition, heat treatment shall be per the Tables of Annex A; for other acceptable editions prior to 2007, heat treatment shall be per the Tables of Annex B. For other acceptable editions prior to 2016, plate thickness of Grades X2CrNi12 and X6CrNiTi12, shall not be greater than 25 mm.	2000 through 2016
SA/EN 10088-2	2014	Identical except for marking, dimensions, delivery condition, resurfacing by welding, extent of testing, and test reports as shown in the specification.	2005 through 2014
SA/EN 10088-3	2014	Identical except for marking, dimensions, test/inspection documents, repair welding, heat treatment, and surface quality as shown in the specification.	2005 through 2014
SA/EN 10216-2	2013	Identical except for marking and test reports as shown in the specification.	2002+A2:2007 through 2013
SA/EN 10217-1	2019	Identical except for material, inspection, marking, resurfacing by welding, and test reports as shown in the specification.	...
SA/EN 10222-2	2017	Identical except for general requirements, marking, resurfacing by welding, and test reports as shown in the specification.	...
SA/GB 713	2014	Identical except for chemical composition, marking, controlled rolling, heat treatment, and test reports as shown in the specification.	...

Table II-200-2
Material Specifications Acceptable for ASME Construction (Cont'd)

Specifications	Latest Adopted	Description	All Acceptable Editions [Note (1)]
SA/IS 2062	2011	Identical except for chemical composition, marking, mechanical property limits, delivery condition, repair qualification, and test reports as shown in the specification.	...
SA/JIS G3118	2017	Identical except for marking, trace elements, plates produced by TMCP, steelmaking process, test reports, mechanical properties, repair welding, and inspection as shown in the specification. Annex, supplementary quality requirements, does not apply.	2000 through 2017
SA/JIS G4303	2012	Identical except for marking, dimensions, mechanical properties, test reports, and mechanical testing as shown in the specification.	1998 through 2012
SA/JIS G5504	2005	Identical except for marking, mechanical properties, test reports, and repairs as shown in the specification.	...

GENERAL NOTE: The source standards for specifications listed in this table are produced by standards organizations from around the world with the exclusion of ASTM. The date of publication of the European standards considered in this table is the year of approval of the standard by CEN. This date appears in the body of the standard on the page starting with EN; dates appearing on the front page of an XX EN standard (e.g., XX = BS or NF or DIN) correspond only to the date of adoption by each member country.

NOTE:

(1) BPVC II Committee has taken the position that a reapproval is technically and substantively identical to the base edition. Therefore, for the purposes of ASME construction, a reapproval shall be considered acceptable for use, even if the edition is beyond the range listed in this column, provided that its base edition is within range.

Figure II-400-1
Illustrative Table of ASME Material Specifications (for II-400 Explanation Purposes Only)

Material Specifications Acceptable for ASME Construction

Specification	Latest Adopted	Description	All Acceptable Editions
SA-217/SA-217M	07	Identical	93 through 07
SA-513	00	Identical except that Supplementary Requirements S6 and either S7 or S8 at the manufacturer's option are mandatory.	...
SA/CSA-G40.21	2013 (R2018)	Identical except for marking, chemical composition, controlled and normalized rolling, and test reports as shown in the specification.	1992 and 2004 through 2013 (R2018)
SB-166	11	Identical except for the addition of UNS N06617 heat treatment requirements. Certification and test reports have been made mandatory.	86 through 11
SB-516	03(2014)	Identical except that certification and a test report have been made mandatory, and all ASTM editions prior to 98 are obsolete for N06025 only.	85 through 03(2014)

MANDATORY APPENDIX III
GUIDELINES ON MULTIPLE MARKING OF MATERIALS

III-100 BACKGROUND

A common inquiry topic is the permissibility of using material that is identified with two or more specifications (or grades, classes, or types), even if they have different strengths, or even if one of them is not permitted for use in the construction code of application. The Committee has addressed variants of these questions in several interpretations: I-89-11, IIA-92-08, VIII-1-89-269, and VIII-1-89-197.

III-200 GUIDELINES

The construction codes individually define what materials may be used in boilers, vessels, and components constructed in compliance to their rules. If a material meets all of the requirements for a specification for which it is marked, including documentation, if any, and if it meets all requirements for use imposed by the construction code, it may be used. The construction codes, in general, do not address the case of materials marked with more than one specification, grade, class, or type, so these guidelines are offered for clarification.

III-210 ACCEPTABILITY OF MULTIPLE MARKING

Dual or multiple marking is acceptable, as long as the material so marked meets all of the requirements of all the specifications, grades, classes, and types with which it is marked.

All of the measured and controlled attributes of the multiply marked grades or specifications must overlap (e.g., chemistry, mechanical properties, dimensions, and tolerances) and the material so marked must exhibit values that fall within the overlaps. Further, the controlled but unmeasured attributes of the specifications or grades must overlap (e.g., melting practices, heat treatments, and inspection).

Many specifications or grades have significant overlap of chemistry ranges or properties. It is common for material manufacturers to produce materials that satisfy more than one specification, grade, class, or type. Examples are SA-53 and SA-106 (some grades and classes), SA-213 TP304L and TP304, SA-213 TP304 and TP304H, and SA-106 B and C.

III-220 PROHIBITION ON MULTIPLE MARKING

Dual or multiple marking is not acceptable if two or more specifications to which the material is marked have mutually exclusive requirements.

This prohibition includes more than just chemistry and property requirements. One example is SA-515 and SA-516; the former requires melting to coarse grain practice while the latter requires melting to fine grain practice. Another example is SA-213 TP304L and TP304H; the carbon content ranges of these grades have no overlap.

III-230 GRADE SUBSTITUTION

Grade substitution is not permitted. Grade substitution occurs when

(a) the material contains an element (other than nitrogen) that is unspecified for one of the grades marked

(b) the amount of that element present in the material meets the minimum and maximum composition limits for that element in another grade of a specification contained in Section II, Part A or Part B, whether or not it is also so marked

For example, a material meets all of the composition limits for SA-240 304, contains 0.06C and 0.02N, but also contains 0.45% Ti. This material cannot be marked or provided as meeting SA-240 304 because the Ti content meets the requirements of SA-240 321 [which is Ti greater than 5× (C + N) but less than 0.70].

Another material, with identical composition, except 0.35% Ti, may be marked SA-240 304 because the Ti content does not meet the minimum requirement for 321. The Ti content is just a residual.

III-240 MARKING SELECTION

If a material is marked with specifications, grades, classes, or types, it may be used with the allowable stresses, design stress intensities, or ratings appropriate for any of the markings on the material, as long as the material specification, grade, class, and type is permitted by the code of construction governing the boiler, vessel, or component in which the material is to be used. However, once the designer has selected which marking applies (specification, grade, class, type, etc.), the designer must use all the design values appropriate for that selection and may not mix and match values from any other specifications, grades, classes, types, etc., with which the material may be marked.

III-250 OTHER MARKINGS

Any other markings, such as marking of non-ASME or non-ASTM material specifications, have no relevance, even if those markings are for materials explicitly prohibited by the construction code being used. That is, as long as the *one* marking, and the documentation required by the material and by the construction code, shows that it meets all the requirements for use of that material in that construction code, any additional markings are irrelevant.

MANDATORY APPENDIX IV
GUIDELINES ON THE APPROVAL OF NEW MATERIALS UNDER THE ASME BOILER AND PRESSURE VESSEL CODE

IV-100 CODE POLICY

It is expected that requests for Code approval will normally be for materials for which there is a recognized national or international specification. It is the policy of the ASME Boiler and Pressure Vessel (BPV) Committee on Materials to approve, for inclusion in the Code Sections, only materials covered by specifications that have been issued by standards-developing organizations such as, but not limited to, American Petroleum Institute (API), American Society for Testing and Materials (ASTM), American Welding Society (AWS), Canadian Standards Association (CSA), European Committee for Standardization (CEN), Japan Industrial Standards (JIS), Standards Association of Australia (SAA), and China Standardization Committee (CSC).

Material specifications of other than national or international organizations, such as those of material producers/suppliers or equipment manufacturers, will not be considered for approval. The Committee will consider only official requests for specifications authorized by the originating standardization body and available in the English language and in U.S. Customary and/or SI/Metric units.

For materials made to a recognized national or international specification other than that of ASTM or AWS, the inquirer shall give notice to the standards-developing organization that a request has been made to ASME for approval of the specification under the ASME Code and should request that the issuing organization grant ASME permission to at least reproduce copies of the specification for Code Committee internal use and, if possible, reprint the specification. For other materials, a request shall be made to ASTM, AWS, or a recognized national or international standardization body to include the material in a specification that can be presented to the BPV Committee on Materials.

It is the policy of the ASME BPV Committee on Materials to consider requests to approve new materials only from boiler, pressure vessel, transport tank, nuclear facility component manufacturers, architect–engineers, or end users. Such requests should be for wrought, cast, or hot isostatically pressed powder materials for which there is a reasonable expectation of use in a boiler, pressure vessel, transport tank, or nuclear facility component constructed to the rules of one of the Sections of this Code. When a grade does exist in a defined wrought product form, a material producer/supplier may request the inclusion of additional wrought product forms or, provided all of the requirements of Table IV-100-1 of this Appendix are met, the inclusion of hot isostatically pressed (HIP) powder metallurgy components of this grade. When a grade does exist in a defined cast product form, a material producer/supplier may request the inclusion of additional cast product forms.

Any qualified organization requesting that an ASME BPV Committee approve a “new” material for use in their Code book should be aware that only the BPV Committee on Materials provides the appropriate design values for the Construction Codes (Sections I, III, IV, VIII, and XII of the BPV Code and B31 Codes).

The design values are calculated in accordance with the appropriate mandatory Code rules. If the inquirer considers the material to be essentially identical to one that has been approved by the BPV Committee on Materials, the inquirer shall so state in its request, and the BPV Committee on Materials shall evaluate that judgment. If the material is not essentially identical to one that has been approved by the BPV Committee on Materials, the inquirer shall provide all of the data cited in these Guidelines. Based on those data, the BPV Committee on Materials will provide the appropriate design values.

Before approval of a new material for inclusion in one of the Sections of the Code, use of this material may be permitted in the form of a Code Case. This Case shall fix at least the conditions of use and the necessary requirements linked to these conditions. It is the policy of the ASME BPV Committee to admit, in this way, material for which full experience on all working parameters has not yet been acquired.

IV-200 APPLICATION

The inquirer shall identify to the BPV Committee the following:

(a) the Section or Sections and Divisions of the Code in which the new material is to be approved

(b) the temperature range of intended application

(c) whether cyclic service is to be considered

(d) whether external pressure is to be considered

The inquirer shall identify all product forms, size ranges, and specifications or specification requirements for the material for which approval is desired. When

Table IV-100-1
Hot Isostatically Pressed Component Requirements for Austenitic Stainless Steels, Austenitic–Ferritic (Duplex) Stainless Steels, Martensitic Stainless Steels, Ferritic Steels, and Nickel Alloys

Category	Requirement
Chemistry	The chemistry requirements of the hot isostatically pressed components shall be identical to those of the corresponding wrought product form.
Mechanical properties	The room-temperature mechanical properties of hot isostatically pressed components shall be identical to those that apply to the corresponding wrought product form.
Heat treatment	The heat-treatment requirements that apply to the hot isostatically pressed components shall be identical to those that apply to the corresponding wrought product form.
Grain size	The grain size requirements that apply to the hot isostatically pressed components shall be identical to those that apply to the corresponding wrought product form.
Control of powder prior to hot isostatic pressing	The maximum allowable powder size shall be 0.020 in. (5 mm) and the powder shall be produced by the gas atomization process. Immediately following atomization, the powder shall remain shielded by an inert gas until the powder is below a temperature of 105°F (40°C), to ensure that the detrimental absorption of oxygen and other deleterious contaminants is no longer possible. For austenitic stainless steels, duplex stainless steels, martensitic stainless steels, and nickel alloys, powder should be protected during storage to prevent the detrimental pickup of oxygen and other contaminants. For ferritic steels, following atomization, powders shall be stored under a positive nitrogen or argon atmosphere or vacuum to minimize potential oxidation or contamination.
Mandatory testing of hot isostatically pressed components	The chemical composition of a sample from one part from each lot of parts shall be determined by the manufacturer. The composition of the sample shall conform to the chemistry requirements of the defined wrought product form. The microstructure shall be examined at 20–50X, 100–200X, and 1,000–2,000X. The microstructure shall be reasonably uniform and shall be free of voids, laps, cracks, and porosity. One sample from each production lot shall be examined. The sample shall be taken from the component, stem, protrusion, or test part made from a single powder blend consolidated in the same hot isostatic press, using the same pressure, temperature, and time parameters, and heat treated in the same final heat-treatment charge at the option of the producer, after hot isostatic pressing or after final heat treatment. Samples for mechanical testing shall be from the component, stem, protrusion, or test part made from a single powder blend consolidated in the same hot isostatic press, using the same pressure, temperature, and time parameters, and heat-treated in the same final heat-treatment charge.
Material certification requirements	A manufacturer's certification shall be furnished to the purchaser stating that material has been manufactured, tested, and inspected in accordance with the applicable specification, and that the test results on representative samples meet specification requirements. A report of the test results shall be furnished.

GENERAL NOTES:

(a) When a grade does exist in a defined wrought product form for alloys other than those cited, an inquirer may request the inclusion of hot isostatically pressed (HIP) components of this grade. However, the Committee may have additional requirements placed on the grade to accept this request.

(b) If the material is to be used at temperatures where the time-dependent performance will determine the allowable stress values, the requirements of Mandatory Appendix IV relative to the provision of data for new materials shall apply.

available, the inquirer shall furnish information describing service experience in the temperature range requested.

IV-300 CHEMICAL COMPOSITION

The inquirer shall recommend to the BPV Committee on Materials whether the chemical composition specified in the reference specification applies or whether restrictions to this composition shall be imposed for the intended application. When coverage by a recognized national or international standardization body has been requested but not yet obtained, the inquirer shall indicate the detailed chemical composition in the inquiry. The inquirer shall explain the reasons for the chemistry and chemistry limits, and their relationship to the metallurgical structure (e.g., influence on precipitates and their morphology, grain size, and phases), heat treatment effect (e.g., strengthening mechanisms and their stability), and mechanical properties. Elements that significantly influence strength, ductility, toughness, weldability, and behavior under service conditions should be identified.

After review of the submitted data, the Committee reserves the right to modify the permitted compositional ranges for key elements so that they more accurately reflect the range of the elements of the submitted test heats.

IV-400 METALLURGICAL STRUCTURE AND HEAT TREATMENT

When applicable for the proposed material, the inquirer shall indicate the intended metallurgical structure(s) to be achieved in order to comply with the mechanical properties requirements and, where applicable, fully describe the heat treatment (including cooling rates) to be applied to achieve this (or these) structure (s), the mechanical properties, and the expected behavior under service conditions.

An explanation for the proposed heat treatment temperature ranges shall be furnished. When such concepts apply, metallurgical transformation curves and information on the transformation points and conditions for appearance of the major phases in the microstructure (e.g., continuous cooling transformation diagram or time–temperature precipitation plots) would be beneficial for the Committee's consideration.

IV-500 MECHANICAL PROPERTIES

Test methods employed for the properties tested shall be those referenced in or by the material specifications, or shall be the appropriate ASTM test methods, recommended practices, or test methods described in accepted international standards. The test methods used shall be indicated in the data package.

It is desired that the data be obtained using material representative of the range of effects of the key variables of composition, thickness, mechanical working, and heat treatment. It is desirable that, when applicable, test data also be provided for the range of heat treatment exposures that may influence properties such as tensile strength, toughness, and stress rupture behavior. After consideration of the submitted data, the Committee reserves the right to modify the specification requirements.

IV-600 DEFINITIONS FOR DATA COLLECTION PURPOSES

casting lot: single production pour from a master heat.

heat: quantity of metal with one chemical composition, produced by a recognized production process from a single primary melt of the metal. Remelted ingot material is not recognized as a separate heat unless it is produced from a melt having a different chemical composition than the other heats.

hot isostatically pressed component lot: a number of parts made from a single powder blend consolidated in the same hot isostatic press using the same pressure, temperature, and time parameters, and heat treated in the same final heat-treatment charge.

powder blend: a homogeneous mixture of powder from one or more heats of the same grade. The term "powder blend" shall be substituted for the term "heat" for hot isostatically pressed powder material in IV-300, IV-700, IV-900, IV-1200, IV-1400, and IV-1800.

wrought lot: quantity of metal made by melting followed by working or by working and heat treatment as a unique batch. Different lots may come from the same heat and may be made into different product forms. Lot definitions are expected to be found in the applicable material specifications.

IV-700 REQUIRED SAMPLING

For all mechanical properties, data shall be provided over the required range of test temperatures from at least three heats of material meeting all of the requirements of the applicable specifications. Data submitted on three heats of one wrought product form for which coverage is requested may be considered to be applicable for all other wrought product forms having the same chemistry.

For wrought materials and especially for those materials whose mechanical properties are enhanced by heat treatment, forming practices, or a combination thereof, and for other materials for which the mechanical properties may be reasonably expected to be thickness dependent, data from one additional lot from material of at least 75% of the maximum thickness for which coverage

is requested shall be submitted. If no maximum thickness is given, information shall be provided to support the suitability of the thickness used for the tested samples.

When adoption of cast product forms is requested, data from at least three heats for one of the cast product forms shall be submitted. The cast material shall be considered as a separate material even if its nominal composition is the same or very similar to that of an approved wrought material.

If the hot isostatically pressed powder material meets all of the requirements of Table IV-100-1, it shall be considered the same material as that of the approved wrought material for temperatures approximately 50°F (25°C) below the temperature where time-dependent properties, as defined by the Time-Dependent Properties Notes (T Notes) in the applicable allowable stress table for the approved wrought material, govern.

If the hot isostatically pressed material is to be used at temperatures where the time-dependent properties, as defined by the Time-Dependent Properties Notes (T Notes) in the applicable allowable stress table for the approved wrought material, govern, the requirements of this Appendix relative to the provision of data for new materials shall apply.

If the hot isostatically pressed powder material does not meet all of the requirements of Table IV-100-1, it shall be considered as a separate material to that of the approved wrought material. In this case, the requirements of this Appendix relative to the provision of data for new materials shall apply.

Additional data for other heats tested to a lesser degree than described herein would be beneficial to the Committee's consideration.

IV-800 TIME-INDEPENDENT PROPERTIES

For time-independent properties at and above room temperature, the required data include values of ultimate tensile strength, 0.2% offset yield strength, reduction of area (when specified in the material specification), and elongation. For steels, nickel alloys, cobalt alloys, and aluminum alloys, data shall be provided at room temperature and 100°F (50°C) intervals, beginning at 200°F (100°C) to 100°F (50°C) above the maximum intended use temperature, unless the maximum intended use temperature does not exceed 100°F (40°C). For copper alloys, titanium alloys, and zirconium alloys, data shall be provided at room temperature, 150°F (65°C), and 200°F (100°C), and then at 100°F (50°C) intervals, to 100°F (50°C) above the maximum intended use temperature, unless the maximum intended use temperature does not exceed 100°F (40°C). The test methods shall be as given in ASTM A370, ASTM A1058, ASTM E8, ASTM E21, or other equivalent national or international test standards. In addition, when specified in the material specification, hardness values shall be provided at room temperature and shall be determined as specified in the material specification. Data provided shall be expressed in the units and to the number of significant figures shown in Table IV-800-1. When either the material specification or the applicable construction code (e.g., Section XII) permits or requires that yield strength be determined by other than the 0.2% offset method, those other yield strength values shall also be reported.

IV-900 TIME-DEPENDENT PROPERTIES

If approval is desired for temperatures where time-dependent properties may be expected to control design, time-dependent data, as itemized below, shall be provided, starting at temperatures approximately 50°F (25°C) below the temperature where time-dependent properties may govern and extending at least 100°F (50°C) above the maximum intended use temperature. Exceptions to this rule are permitted, provided the inquirer provides suitable justification for the deviation. The creep–rupture test method shall be in accordance with ASTM E139 or other equivalent national or international test standard.

For time-dependent tests, the interval between successive temperatures shall be chosen such that it permits, in all cases, an accurate estimation of the slope of the stress-rupture curves. For normally stable materials (e.g., solid solution-strengthened materials), test temperatures shall be at intervals of 100°F (50°C) or less. Where there is a possibility of degradation of strength related to metallurgical instability (e.g., for precipitation-strengthened materials), test temperatures shall be at intervals of 50°F (25°C) or less. Data provided shall be expressed in the units and to the number of significant figures shown in Table IV-800-1.

In addition, for certain types of steels or alloys, it may be necessary to choose different temperature intervals in order to adequately reflect the evolution of the properties. In such cases, the interval between successive test temperatures shall be chosen such that rupture lives do not differ by more than a factor of 10 at any given stress for two adjacent temperatures. Data to be reported include stress, temperature, time to rupture, and, when available, either or both elongation and reduction of area. Additional comments regarding post-test specimen appearance (e.g., oxidation, necking, intergranular fracture, etc.), as well as photographs and photomicrographs, may be beneficial for the analysis.

Except as provided further below, the longest rupture time at each test temperature shall be in excess of 10,000 hr for each required heat. At least three additional tests shall be conducted for each required heat at each test temperature, at stresses selected to provide shorter rupture times but at least 500 hr (e.g., 500 hr, 1,400 hr, and 4,000 hr).

Tests of shorter duration than about 500 hr are not desired for long-term stress rupture prediction. Obviously, longer times and additional test data are beneficial. At

Table IV-800-1
ASTM Test Methods and Units for Reporting

ASTM Designation	Title	Property	U.S. Customary Units	U.S. Customary Significant Figures	Metric Units	Metric Significant Figures
A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products	Tensile strength and yield strength	ksi	3	...	...
A1058	Standard Test Methods for Mechanical Testing of Steel Products—Metric	Tensile strength and yield strength	...	...	MPa	3
D2766	Standard Test Method for Specific Heat of Liquids and Solids	Specific heat [Note (1)]	Btu/lb-°F	3	J/kg-K	3
E8	Standard Test Methods for Tension Testing of Metallic Materials	Tensile strength and yield strength	ksi	3	MPa	3
		Density	$lb/in.^3$	3	kg/m^3	4
E21	Standard Test Methods for Elevated Temperature Tension Tests of Metallic Materials	Tensile strength and yield strength	ksi	3	MPa	3
E132	Standard Test Method for Poisson's Ratio at Room Temperature	Poisson's ratio	...	2	...	2
E139	Standard Test Methods for Conducting Creep, Creep–Rupture, and Stress–Rupture Tests of Metallic Materials	Rupture time	hr	5	h	5
E228	Standard Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer	Instantaneous coefficient	$(in./in./°F) \times 10^{-6}$	3	$(mm/mm/°C) \times 10^{-6}$	3
		Mean linear coefficient	$(in./in./°F) \times 10^{-6}$		$(mm/mm/°C) \times 10^{-6}$	
		Linear coefficient	in./100 ft		mm/m	
E289	Standard Test Method for Linear Thermal Expansion of Rigid Solids With Interferometry	Instantaneous coefficient	$in./in./°F \times 10^{-6}$	3	$(mm/mm/°C) \times 10^{-6}$	3
		Mean coefficient	$in./in./°F \times 10^{-6}$		$(mm/mm/°C) \times 10^{-6}$	
		Linear coefficient	in./100 ft		mm/m	
E831	Standard Test Method for Linear Thermal Expansion of Solid Materials by Thermomechanical Analysis	Instantaneous coefficient	$(in./in./°F) \times 10^{-6}$	3	$(mm/mm/°C) \times 10^{-6}$	3
		Mean linear coefficient	$(in./in./°F) \times 10^{-6}$		$(mm/mm/°C) \times 10^{-6}$	
		Linear coefficient	in./100 ft		mm/m	
E1225	Standard Test Method for Thermal Conductivity of Solids Using the Guarded-Comparative-Longitudinal Heat Flow Technique	Thermal conductivity	Btu/hr-ft-°F	3, except 2 for $x < 10$	W/m × °C	4, except 3 for $x < 100$
E1461	Standard Test Method for Thermal Diffusivity by the Flash Method	Thermal diffusivity	ft^2/hr	3	$m^2/sec \times 10^{-6}$	3
		Thermal conductivity	Btu/hr-ft-°F	3, except 2 for $x < 10$	W/m × °C	4, except 3 for $x < 10$
E1875	Standard Test Method for Dynamic Young's Modulus, Shear Modulus, and Poisson's Ratio by Sonic Resonance	Modulus of elasticity	$psi \times 10^6$	3	$MPa \times 10^3$	3

NOTE:
(1) Specific heat is not published but may be used to calculate thermal diffusivity from thermal conductivity.

successive temperatures, two or more test stresses should be selected to be preferably identical or in a close range.

Alternative test plans that deviate from the prior description but achieve the overall objective may be considered. This may, in particular, apply to solid solution alloys for which the stability of strength-controlling microstructures is certain.

For new materials for which the expectation of reasonable stability of strength-controlling microstructures is uncertain or suspect, and for extension of allowable stresses of more familiar classes of alloys into much higher temperature applications where such stability might come into question, either creep–rupture data with duration of more than 30,000 hr or equivalent experience in service is required. A Code Case may be approved based on shorter duration test data, but inclusion of the material into one of the sections of the BPV Code may be deferred until longer-term creep–rupture data are available or until sufficient service experience is obtained to provide confidence that extrapolations from the existing database reasonably describe the long-term behavior of the material.

For at least two heats, strain–time plots or minimum creep rate (MCR) data shall be provided for at least two test stresses at each test temperature, including at least one stress for each material resulting in MCR values below 3×10^{-4} %/hr. If it can be conclusively demonstrated that creep rate does not control the design stresses, the creep rate data may be sparse in relation to the above requirement. Creep rate data may be obtained in the course of stress–rupture testing or may be obtained on additional specimens.

IV-1000 LOW-TEMPERATURE PROPERTIES

If use of the material below room temperature is contemplated, data should be provided at appropriate temperatures down to the lowest contemplated use temperature.

IV-1100 TOUGHNESS DATA

Toughness data shall be provided for materials for which Construction Code toughness rules would be expected to apply. The test requirements shall be as required by the requested Construction Code(s). The data shall include test results for the intended lowest service metal temperature and for the range of material thicknesses desired.

IV-1200 STRESS–STRAIN CURVES

If the material is to be used in components that operate under compressive loads (e.g., external pressure), stress–strain plots (tension or compression) shall be furnished for each of the three heats of material at 100°F (50°C) intervals from room temperature up to 100°F (50°C) above the maximum temperature desired.[1] Engineering stress–strain data (stress versus strain) shall be provided in the form of stress–strain plots and digitized data, from which the plots were derived, in tabular form up to 1.2% strain. Digitized data shall be provided at intervals no greater than 0.01% strain. In addition, the minimum yield strength,[2] modulus of elasticity,[3] and proportional limit, for materials where a proportional limit can be identified, shall be reported for each temperature. The stress–strain plots (not load versus extension) shall be determined using a Class B-2 or better-accuracy extensometer as defined in ASTM E83. The plots shall include gridlines with the units marked on the gridlines: for strain, minor gridlines at intervals of 0.01% and major gridlines at 0.1%, up to 1.2% strain; and for stress, minor gridlines at 0.2 ksi (2 MPa) and major gridlines at 2.0 ksi (20 MPa).

IV-1300 FATIGUE DATA

If the material is to be used in cyclic service and the Construction Code in which adoption is desired requires explicit consideration of cyclic behavior, fatigue data for characterized samples shall also be furnished over the range of design temperatures desired, from 10^3 to at least 10^6 cycles.

IV-1400 PHYSICAL PROPERTIES

For at least one heat meeting the requirements of the material specification, the inquirer shall furnish to the Boiler and Pressure Vessel Committee on Materials adequate data necessary to establish values for coefficient of thermal expansion, coefficients of thermal conductivity and diffusivity, modulus of elasticity, Poisson's ratio, and density. Test methods shall be as follows:

(a) ASTM E228, E289, or E831 for thermal expansion coefficients

[1] Since most materials are, in many applications, used in components that operate under compressive loads, the Committee recommends that stress–strain plots as described above should always be included in the data package submitted in support of the application for any new material.

[2] The term *minimum yield strength*, as used here, means the yield strength values that are derived from the analysis of the tensile data required elsewhere in these Guidelines.

[3] Modulus of elasticity values shall be determined by dynamic methods such as ASTM Test Method E1876 (latest edition) or other international equivalent.

(b) ASTM D2766, E1225, and E1461, for thermal conductivity and thermal diffusivity

(c) ASTM E1875 for modulus of elasticity

(d) ASTM E1875 or ASTM E132 for Poisson's ratio

Data from other equivalent national or international test standards shall be acceptable in lieu of those listed above. Instantaneous, mean, and linear coefficients of thermal expansion shall be reported. Data for all physical properties shall be provided at least over the range of temperatures for which the material is to be used. It is recommended that data be collected at temperature intervals not greater than 100°F (50°C). If the material is intended to be used below room temperature, data should be provided for temperatures down to the minimum use temperature. Data provided shall be expressed in the units and to the number of significant figures shown in Table IV-800-1.

IV-1500 DATA REQUIREMENTS FOR WELDS, WELDMENTS, AND WELDABILITY

The following three types of welding information are required for a new base metal for use in welded construction in an ASME BPV Construction Code: data on weldability, data on strength and toughness in the time-independent regime, and data on strength in the time-dependent regime.

The data requirements for weldability and for strength in the time-independent regime are the responsibility of the BPV IX Standards Committee and are to be found in Section II, Part C, Guideline on the Approval of New Welding and Brazing Material Classifications Under the ASME Boiler and Pressure Vessel Code; and in Section IX, Mandatory Appendix J, Guideline for Requesting P-Number Assignments for Base Metals Not Listed in Table QW/QB-422. The requirements for weld metal and weldment toughness data vary with the class of materials and their application, and are to be found in the Construction Codes that have toughness rules — Sections III, VIII, and XII.

Data for welds and weldments for a new base material for use in the time-dependent regime are the responsibility of the BPV II and BPV IX Standards Committees, and particularly of their joint Subgroup on Strength of Weldments. The following welding information shall be provided by the Inquirer, to support the request for a Code Case for, or incorporation of, a new base material for use in elevated temperature service:

(a) When there is one or more AWS, ASME, or equivalent consumable specification and classification suitable for use with the new base material, and when such consumable/process combinations can produce welds and weldments that have both good weldability and as high or higher strengths as the base metal over the range of expected service temperatures, no time-dependent test data is required. Rather, the inquirer shall submit a tabular or graphical comparison of time-dependent allowable stresses for base metals nominally matching the compositions of such welding consumables against the allowable stresses proposed for the new base metal. (Note that since neither ASME nor any other organization publishes allowable stresses for all-weld metal or for weldments, it is necessary to use, in this comparison, the allowable stresses for the base metals equivalent to the welding consumables as a reasonable first approximation.) An example of such a comparison appears in Table IV-1500-1.

(b) When there is no such suitable consumable having an AWS, ASME, or equivalent specification and classification, or when it is necessary or desirable to use a new, perhaps nominally matching, welding consumable, the following information shall be provided to the Committee:

(1) the chemistry ranges for each element specified for the consumable to be used. If the chemistry ranges vary for the consumables to be used for different processes, then the chemistry ranges of the consumables appropriate for each process shall be provided.

(2) creep–rupture data for weldments made with one lot of consumables for each process intended to be used with the new base material

(-a) at temperature intervals not greater than 200°F (100°C)

(-b) over a temperature range spanning the range from the first rational temperature above the temperature at which time-dependent properties control the allowable stresses of the new base material to about 100°F (50°C) above the maximum temperature for which allowable stresses for the base material are requested

(-c) at a minimum of four stresses calculated to produce rupture times of about 1000, 2500, and 4500 hr, and beyond 6000 hr

(-d) the test temperature; stress; rupture time; specimen size and configuration, including weld location; and failure location (base metal, weld metal, or heat affected zone), for each test condition

(-e) the creep–rupture data shall be compared to the scatter bands of data for the base metal

IV-1600 LONG-TERM PROPERTIES STABILITY

For new materials, and particularly for those whose creep–rupture properties are affected by heat treatment or deformation processes or a combination of these, it is important to know the structural stability characteristics and the degree of retention of properties with long-term exposure at temperature. Where particular temperature ranges of service exposure or fabrication heat treatment, cooling rates, and combination of mechanical working and thermal treatments cause significant changes in the microstructure on which the creep–rupture properties depend, these shall be brought to the attention of the BPV Committee.

Table IV-1500-1
Example of a Comparison of Allowable Stresses of Base Metals With Compositions Similar to Those of Selected Welding Consumables and the Proposed New Base Metal

Comparison of Nominal Chemical Compositions, %, and Specified Mechanical Properties of Ni-Base Alloys in Section II, Part B

Grade	Ni	Cr	Fe	Mn	Mo	Co	Al	C	Cu	B	Si	Ti	W	Cb + Ta	Ultimate Tensile Strength, ksi (MPa)	Yield Strength, ksi (MPa)
N06230	Bal. ≈ 53	22	3	0.65	2	5	0.5	0.1	...	...	0.5	...	14	...	110 (760)	45 (310)
N06600	72 min.	15.5	8	0.5	...	...	...	0.1	0.25	...	0.25	...	...	...	80 (550)	35 (240)
N06617	44	22	1.5	0.5	9	12	1.2	0.1	0.25	0.005	0.5	0.4	...	...	95 (665)	35 (240)
N06625	58 min.	21.5	5	0.5	9	1	0.4	0.1	0.4	...	0.5	0.4	...	3.65	120 (827)	60 (414)
N06696	Bal. ≈ 60	30	4	0.2	2	...	...	0.07	2	...	1.5	0.2	...	...	85 (586)	35 (240)

Comparison of Allowable Stresses of Ni-Base Alloys in Section II, Part B (ksi at Temperature, °F, Estimated for N06696)

Grade	P-No.	950	1,000	1,050	1,100	1,150	1,200	1,250	1,300	1,350	1,400	1,450	1,500	1,550	1,600	1,650	1,700	1,750	1,800
N06230	43	20.9	20.9	20.9	20.9	19.0	15.6	12.9	10.6	9.5	6.7	5.3	4.1	2.9	2.1	1.5	1.1	0.70	0.45
N06600	43	10.6	7.0	4.5	3.0	2.2	2.0	...	...	...	...	...	...	...	...	...	...	...	...
N06617	43	21.0	20.9	20.9	20.8	20.7	18.1	14.5	11.2	8.7	6.6	5.1	3.9	3.0	2.3	1.8	1.4	1.1	0.73
N06625	43	26.6	26.4	26.3	26.2	26.1	20.0	15.0	11.6	8.5	6.7	4.9	3.8	2.6	1.9	...	...	...	...
N06696	TBD	17.9	14.1	11.0	8.6	6.7	5.2	4.1	3.2	2.4	1.8	1.4	1.1	0.76	0.59	0.47	0.37	0.29	0.23

Comparison of Allowable Stresses of Ni-Base Alloys in Section II, Part B (MPa at Temperature, °C, Estimated for N06696)

Grade	P-No.	500	550	600	650	700	750	800	850	900	950	1 000
N06230	43	194	194	151	102	75.5	50.4	32.9	18.4	10.2	5.2	2.4
N06600	43	79.7	40.1	19.0	13.8	...	...	...	...	...	...	...
N06617	43	108	106	106	105	81.0	50.4	31.3	19.4	12.3	7.5	...
N06625	43	184	182	178	136	84.3	50.2	30.3	16.5	...	...	...
N06696	TBD	139	87.0	55.6	35.5	22.8	13.9	9.0	4.9	3.2	2.1	1.4

GENERAL NOTE: In this example, the proposed new base metal is N06696.

IV-1700 REQUESTS FOR ADDITIONAL DATA

The Committee may request additional data, including data on properties or material behavior not explicitly treated in the Construction Code for which approval is desired.

IV-1800 NEW MATERIALS CHECKLIST

To assist inquirers desiring Code coverage for new materials, or extending coverage of existing materials, the Committee has developed the following checklist of items that ought to be addressed in each inquiry. While taking into account the intended application of the product, the Committee may require specific information from the inquirer, as shown above for certain material characteristics.

(a) Has a qualified inquirer request been provided?

(b) Has a request either for revision to existing Code requirements or for a Code Case been defined?

(c) Has a letter to ASTM or AWS been submitted requesting coverage of the new material in a specification? Alternatively, is this material already covered by a specification issued by a recognized national or international organization and has an English language version been provided?

(d) Has the Construction Code and, if applicable, a Division, Subsection, or Part been identified?

(e) Have product forms, size range, and the applicable specification(s) been defined?

(f) Has the range (maximum/minimum) of temperature application been defined?

(g) Has the chemistry been submitted and the related requirements been addressed?

(h) Have the metallurgical structure and heat treatment requirements been submitted?

(i) Have mechanical property data been submitted (ultimate tensile strength, yield strength, reduction of area, and elongation at 100°F (50°C) intervals, from room temperature to 100°F (50°C) above the maximum intended use temperature, for three heats of appropriate product forms and sizes?

(j) If requested temperatures of coverage are above those at which time-dependent properties begin to govern design values, have appropriate time-dependent property data for base metal and weldments been submitted?

(k) If higher allowable stresses for material to be used below room temperature are requested, have appropriate mechanical property data below room temperature been submitted?

(l) Have toughness considerations required by the Construction Code been defined and have appropriate data been submitted?

(m) Have stress–strain curves been submitted for the establishment of External Pressure Charts?

(n) If cyclic service considerations are required by the requested Construction Code application, have appropriate fatigue data been submitted?

(o) Have physical properties data (coefficient of thermal expansion, thermal conductivity and diffusivity, modulus of elasticity, Poisson's ratio, and density) been submitted?

(p) Have welding requirements been defined, and weld metal and weldment data been submitted?

(q) Has the influence of fabrication practices on material properties been defined?

IV-1900 REQUIREMENTS FOR RECOGNIZED NATIONAL OR INTERNATIONAL SPECIFICATIONS

Acceptable material specifications will be identified by date or edition. The latest approved edition(s) will be stated in the subtitle of the ASME specification. Eventually, acceptable previous editions will be listed in Section II, Parts A and B. Minimum requirements that shall be contained in a material specification for which acceptance is being requested include such items as the name of the national or international organization, scope, reference documents, process, manufacture, conditions for delivery, heat treatment, chemical and tensile requirements, forming properties, testing specifications and requirements, workmanship, finish, marking, inspection, and rejection.

IV-2000 PUBLICATION OF RECOGNIZED NATIONAL OR INTERNATIONAL SPECIFICATIONS

Specifications for which ASME has been given publishing permission by the originating organization will be published in Section II, Parts A and B. Specifications for which ASME has not been given publishing permission by the originating organization will be referenced on a cover sheet in Section II, Parts A and B. Information on obtaining a copy of those referenced documents will be maintained in those Parts. Additions and exceptions to the material specification will be noted in the subtitle of the specification and in Table II-200-1 or II-200-2 in Section II, Parts A and B.

IV-2100 CEN SPECIFICATIONS

European Standards are adopted by CEN in three official languages (English, French, and German) as an EN standard. After the CEN adoption, to become applicable in a member country of CEN, an EN standard shall be given the status of a national standard. During this process

(a) the text of the EN standard shall remain unaltered and shall be included as adopted by CEN

(b) national forewords and/or annexes may be added to cover specific national practices, but shall not be in contradiction with the EN standard

(c) a prefix XX (e.g., XX = BS for the United Kingdom, NF for France, and DIN for Germany) is added to the designation of the EN standard (e.g., BS EN 10028-1 or NF EN 10028-1)

(d) the date of adoption as a national standard will differ from the date of adoption as an EN standard, and may differ from one country to another

Written or electronic copies can only be obtained from European National Standardization Bodies as XX EN (CEN does not sell standards). Consequently, in order to maintain coherence and homogeneity in the reference system, the mentions in the subtitle of the corresponding ASME specification will only refer to the EN standard number without any prefix and to the year of approval by CEN. It will also be mentioned in the cover sheet that the national parts do not apply for the ASME specification.

NONMANDATORY APPENDIX A
SOURCES OF STANDARDS

This Nonmandatory Appendix provides information for obtaining official English language copies of specifications and their references for which ASME has not been given permission to publish by the originating organization.

Standard Type	Standards Organization	Contact Information
AS	Standards Australia Limited (Standards Association of Australia)	Level 10, The Exchange Centre 20 Bridge Street GPO Box 476 Sydney NSW 2001 Australia Tel: +61 2 9237 6171 Fax: +02 9237 6010 www.standards.org.au
BS	British Standards Institution	389 Chiswick High Road GB-London W4 4AL, Great Britain Tel: +44 20 8996 9000 Fax: + 44 20 8996 7001 12110 Sunset Hills Road, Suite 200 Reston, VA 20190-5902 Tel: 1.800.862.4977 Fax: 703.437.9001 www.bsigroup.com
CSA	Canadian Standards Association	178 Rexdale Blvd. Toronto, Ontario Canada M9W 1R3 Tel: 416-747-4000; (800) 463-6727 www.csa.ca
DIN	Deutsches Institut für Normung e.V.	Burggrafenstrasse 6 10787 Berlin, Germany Tel: + 49 30 2601-0 Fax: + 49 30 2601-1231 www.din.de
EN	Any member of the European Committee for Standardization (CEN)	A list of CEN members can be obtained from www.cenorm.be; alternatively standards may be obtained directly from any of the CEN members listed herein.
GB	China Standardization Committee on Boilers and Pressure Vessels	No. 24 Xiaoguan Street Anwai Chaoyang District Beijing, China 100029 Tel: + 86 10 644 157 59 Fax: + 86 10 644 157 49 sale.gb168.cn/saleagent/Customer_En/Default.aspx
IS	Bureau of Indian Standards	Manak Bhawan 9, Bahadur Shah Zafar Marg New Delhi 110002, India Tel: + 91 11 23230131 Fax: + 91 11 23234062 www.bis.org.in
JIS	Japanese Standards Association	Mita MT Building 3-13-12, Mita, Minato-ku Tokyo, 108-0073 Japan Tel: + 81 3 4231 8500 Fax: + 81 3 4231 8650

Table continued

Standard Type	Standards Organization	Contact Information
NBN	Institut Belge de Normalisation (Belgisch Instituut voor Normalisatie)	Bureau de Normalisation Rue Joseph II 40/6 1070 Brussels, Belgium Tel: +32 2 738 01 11 Fax: +32 2 733 42 64 www.nbn.be
NF	Association Française de Normalisation	11, avenue Francis de Pressensé F-93571 Saint-Denis La Plaine Cedex, France Tel:+33141628000 Fax:+33149179000 www.afnor.org
ÖNORM	Österreichisches Normungsinstitut (Austria)	Heinestraße 38 1020 Wien Austria Tel: +43 1 21 300 - 805 Fax: +43 1 21 300 - 815 www.austrian-standards.at/en/home/

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2023 ASME Boiler and Pressure Vessel Code

AN INTERNATIONAL CODE

The ASME Boiler and Pressure Vessel Code (BPVC) is a globally recognized and trusted source of technical requirements and guidance for the design, construction, and certification of boilers, pressure vessels, and nuclear components. With each new edition, the Code continues to evolve, introducing new technologies and processes to promote safety across pressure equipment applications and disciplines. Developed through a rigorous consensus process and fueled by the foresight of leading industry experts from around the world, the ASME BPVC is an ever-evolving set of standards that meets the needs of a changing world.

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