Designation: A 693 – 06

Standard Specification for Precipitation-Hardening Stainless and Heat-Resisting Steel Plate, Sheet, and Strip[1]

This standard is issued under the fixed designation A 693; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope*

1.1 This specification[2] covers precipitation-hardening stainless steel plate, sheet, and strip. The mechanical properties of these steels are developed by suitable low-temperature heat treatments generally referred to as precipitation hardening.

1.2 These steels are used for parts requiring corrosion resistance and high strength at room temperature or at temperatures up to 600°F (315°C). Some of these steels are particularly suitable for moderate to severe drawing and forming in the solution-treated condition. Others are capable of mild forming only. They are suitable for machining in the solution-annealed condition, after which they may be hardened to the mechanical properties specified in this standard without danger of cracking or distortion.

1.3 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

A 480/A 480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip

E 527 Practice for Numbering Metals and Alloys (UNS)

2.2 *SAE Standard:*

SAE J 1086 Recommended Practice for Numbering Metals and Alloys (UNS)[4]

3. General Requirements

3.1 The following requirements for orders for material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 480/A 480M or as specified in the following:

3.1.1 *Ordering Information*:

3.1.1.1 In addition to the requirements of Specification A 480/A 480M, the heat treatment (see Section 6) shall be specified on the purchase order if other than the solution-annealed condition is being ordered.

4. Materials and Manufacture

4.1 The steel shall be melted by one of the following processes:

4.1.1 Electric furnace (with separate degassing and refining optional),

4.1.2 Vacuum furnace, and

4.1.3 One of the former followed by:

4.1.3.1 Consumable remelting in vacuum, inert gas, or electroslag, or

4.1.3.2 Electron beam refining.

4.1.4 Other commercial melting methods as agreed upon between purchaser and seller are acceptable.

5. Chemical Composition

5.1 The steel shall conform to the requirements as to chemical composition specified in Table 1, and shall conform to applicable requirements specified in the current edition of Specification A 480/A 480M.

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys, and is the direct responsibility of Subcommittee A01.17 on Flat-Rolled and Wrought Stainless Steel.

Current edition approved March 1, 2006. Published March 2006. Originally approved in 1974. Last previous edition approved in 2003 as A 693 – 03.

[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-693 in Section II of that Code.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001.

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

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TABLE 1 Chemical Requirements[A]

Composition, %													
UNS Designation[B]	Type	Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Aluminum	Molybdenum	Titanium	Copper	Other Elements[C]
S 17400	630	0.07	1.00	0.040	0.030	1.00	15.0–17.5	3.0–5.0	. . .	. . .	. . .	3.0–5.0	[D]
S 17700	631	0.09	1.00	0.040	0.030	1.00	16.0–18.0	6.5–7.7	0.75–1.50	. . .	. . .	. . .	. . .
S 15700	632	0.09	1.00	0.040	0.030	1.00	14.0–16.0	6.5–7.7	0.75–1.50	2.00–3.00	. . .	. . .	. . .
S 35000	633	0.07–0.11	0.50–1.25	0.040	0.030	0.50	16.0–17.0	4.0–5.0	. . .	2.5–3.2	. . .	. . .	[E]
S 35500	634	0.10–0.15	0.50–1.25	0.040	0.030	0.50	15.0–16.0	4.0–5.0	. . .	2.5–3.2	. . .	. . .	[F]
S 17600	635	0.08	1.00	0.040	0.030	1.00	16.0–17.5	6.0–7.5	0.40	. . .	0.40–1.20	. . .	. . .
S 36200	XM-9	0.05	0.50	0.030	0.030	0.30	14.0–14.5	6.5–7.0	0.10	0.30	0.60–0.90	. . .	. . .
S 15500	XM-12	0.07	1.00	0.040	0.030	1.00	14.0–15.5	3.5–5.5	. . .	. . .	. . .	2.5–4.5	[D]
S 13800	XM-13	0.05	0.20	0.010	0.008	0.10	12.3–13.2	7.5–8.5	0.90–1.35	2.00–2.50	. . .	. . .	[G]
S 45500	XM-16	0.05	0.50	0.040	0.030	0.50	11.0–12.5	7.5–9.5	. . .	0.50	0.80–1.40	1.50–2.50	[F]
S 45000	XM-25	0.05	1.00	0.030	0.030	1.00	14.0–16.0	5.0–7.0	. . .	0.50–1.00	. . .	1.25–1.75	[H]
S 46500	. . .	0.02	0.25	0.015	0.010	0.25	11.0–12.5	10.8–11.2	. . .	0.75–1.25	1.50–1.80	. . .	[G]
S46910	. . .	0.030	1.00	0.030	0.015	0.70	11.0–13.0	8.0–10.0	0.15–0.50	3.0–5.0	0.50–1.20	1.5–3.5	. . .

[A] Limits are in percent maximum unless shown as a range or stated otherwise.
[B] New designation established in accordance with Practice E 527 and SAE J 1086.
[C] The terms Columbium (Cb) and Niobium (Nb) both relate to the same element.
[D] Columbium plus tantalum 0.15–0.45.
[E] Nitrogen 0.07–0.13.
[F] Columbium plus tantalum 0.10–0.50.
[G] Nitrogen 0.01.
[H] Columbium 8 times carbon minimum.

6. Heat Treatment of Product

6.1 Material of types other than Type UNS S46910 shall be furnished in the solution-annealed condition as noted in Tables 2 and 3 unless otherwise specified by the purchaser on the purchase order.

6.2 Type UNS S46910 shall be furnished in cold-worked condition.

7. Mechanical Properties

7.1 The material, as represented by mechanical test specimens, shall conform to the mechanical property requirements specified in Table 4 and shall be capable of developing the properties in Table 5 when heat treated as specified in 9.1.

8. Bending Requirements

8.1 Samples cut from the solution-annealed plate, sheet, or strip shall withstand cold bending as specified in Table 6 without cracking on the outside of the bent portion.

9. Heat Treatment of Test Specimens

9.1 Samples cut from the plate, sheet, or strip shall conform to the mechanical properties of Table 5 when precipitation hardened as specified in Table 2 and Table 3.

10. Keywords

10.1 plate; precipitation hardening; sheet; stainless steel; strip

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TABLE 2 Heat Treatment, °F

UNS Designation	Type	Solution Treatment	Precipitation Hardening Treatment[A]
S17400	630	1925 ± 50°F (cool as required)	900 ± 15°F, 1 h, air cool. 925 ± 15°F, 4 h, air cool. 1025 ± 15°F, 4 h, air cool. 1075 ± 15°F, 4 h, air cool. 1100 ± 15°F, 4 h, air cool. 1150 ± 15°F, 4 h, air cool. (1400 ± 15°F, 2 h, air cool + 1150 ± 15°F, 4 h, air cool).
S17700	631	1950 ± 25°F (cool as required) *Alternative Treatment:* 1400 ± 25°F, hold 90 min, cool to 55 ± 5°F within 1 h. Hold not less than 30 min, heat to 1050 ± 10°F, hold for 90 min, air cool.	1750 ± 15°F, hold 10 min, cool rapidly to room temperature. Cool within 24 h, to –100 ± 10°F, hold not less than 8 h. Warm in air to room temperature. Heat to 950 ± 10°F, hold 1 h, air cool.
S15700	632	1950 ± 25°F (cool as required)	Same as Type 631
S35000	633	1710 ± 25°F (water quench), hold not less than 3 h at –100°F or lower.	850 ± 15°F, 3 h, air cool. 1000 ± 15°F, 3 h, air cool.
S35500	634[B]	1900 ± 25°F (quench), hold not less than 3 h at –100°F or lower.	1750 –10°F for not less than 10 min, but not more than 1 h, water quench. Cool to not higher than –100°F, hold for not less than 3 h. Temper at 1000 ± 25°F, holding for not less than 3 h.
S17600	635	1900 ± 25°F (air cool)	950 ± 15°F, 30 min, air cool. 1000 ± 15°F, 30 min, air cool. 1050 ± 15°F, 30 min, air cool.
S36200	XM-9	1550 ± 25°F (air cool)	900 ± 10°F, 8 h, air cool.
S15500	XM-12	1900 ± 25°F (cool as required)	Same as Type 630
S13800	XM-13	1700 ± 25°F (cool as required to below 60°F)	950 ± 10°F, 4 h, air cool. 1000 ± 10°F, 4 h, air cool.
S45500	XM-16	1525 ± 25°F (water quench)	900 ± 10°F, 4 h, air cool. or 950 ± 10°F, 4 h, air cool.
S45000	XM-25	1900 ± 25°F (cool rapidly)	900 ± 15°F, 4 h, air cool. 1000 ± 15°F, 4 h, air cool. 1150 ± 15°F, 4 h, air cool.
S46500	. . .	1875 ± 25°F (cool rapidly to room temperature) followed by subzero cooling within 24 h after solution treatment; –100 ± 10°F, hold not less than 8 h; warm in air to room temperature	900 ± 10°F, 4 h, air cool 950 ± 15°F, 4 h, air cool 1000 ± 15°F, 4 h, air cool 1050 ± 15°F, 4 h, air cool 1100 ± 15°F, 4 h, air cool
S46910[C]			890 + 15°F, 4 h, air cool

[A] Times refer to time material is at temperature.
[B] Equalization and over-tempering treatment: 1425 ± 50°F for not less than 3 h, cool to room temperature, heat to 1075 ± 25°F for not less than 3 h.
[C] Furnished in cold-worked condition.

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TABLE 3 Heat Treatment, °C

UNS Designation	Type	Solution Treatment	Precipitation Hardening Treatment[A]
S17400	630	1050 ± 25°C (cool as required)	482 ± 8°C, 1 h, air cool. 496 ± 8°C, 4 h, air cool. 552 ± 8°C, 4 h, air cool. 579 ± 8°C, 4 h, air cool. 593 ± 8°C, 4 h, air cool. 621 ± 8°C, 4 h, air cool. (760 ± 8°C, 2 h, air cool + 621 ± 8°C, 4 h, air cool).
S17700	631	1065 ± 15°C (water quench)	954 ± 8°C, hold 10 min, cool rapidly to room temperature. Cool within 24 h to –73°C ± 6°C, hold not less than 8 h. Warm in air to room temperature. Heat to 510 ± 6°C, hold 1 h, air cool.
		Alternative Treatment	
		760 ± 15°C, hold 90 min, cool to 15 ± 3°C within 1 h. Hold not less than 30 min, heat to 566 ± 6°C, hold for 90 min, air cool.	
S15700	632	1038 ± 15°C (water quench)	Same as Type 631
S35000	633	930 ± 15°C (water quench), hold not less than 3 h at –75°C or lower.	455 ± 8°C, 3 h, air cool. 540 ± 8°C, 3 h, air cool.
S35500	634[B]	1038 ± 15°C (quench), hold not less than 3 h at –73°C or lower.	954 ± 6°C for not less than 10 min, but not more than 1 h, water quench. Cool to not higher than –73°C, hold for not less than 3 h. Temper at 538 ± 15°C, holding for not less than 3 h.
S17600	635	1038 ± 15°C (air cool)	510 ± 8°C, 30 min, air cool. 538 ± 8°C, 30 min, air cool. 566 ± 8°C, 30 min, air cool.
S36200	XM-9	843 ± 15°C (air cool)	482 ± 8°C, 8 h, air cool.
S15500	XM-12	1038 ± 15°C (cool as required)	Same as Type 630
S13800	XM-13	927 ± 15°C (cool as required to below 60°C)	510 ± 6°C, 4 h, air cool. 538 ± 6°C, 4 h, air cool.
S45500	XM-16	829 ± 15°C (water quench)	482 ± 6°C, 4 h, air cool. or 510 ± 6°C, 4 h, air cool.
S45000	XM-25	1038 ± 15°C (cool rapidly)	482 ± 8°C, 4 h, air cool. 538 ± 8°C, 4 h, air cool. 621 ± 8°C, 4 h, air cool.
S46500	. . .	1024 ± 15°C, (cool rapidly to room temperature) followed by subzero cooling within 24 h after solution treatment; –73 ± 6°C; hold not less than 8 h; warm in air to room temperature	482 ± 6°C, 4 h, air cool 510 ± 8°C, 4 h, air cool 538 ± 8°C, 4 h, air cool 566 ± 8°C, 4 h, air cool 593 ± 8°C, 4 h, air cool
S46910[C]			475 + 8°C, 4 h, air cool

[A] Times refer to time material is at temperature.
[B] Equalization and over-tempering treatment: 774 ± 25°C for not less than 3 h, cool to room temperature, heat to 579 ± 15°C for not less than 3 h.
[C] Furnished in cold-worked condition.

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TABLE 4 Mechanical Test Requirements in Solution-Treated Condition

Type		Tensile Strength, max		Yield Strength, max		Elongation in 2 in. or 50 mm, min, %	Hardness, max	
		ksi	MPa	ksi	MPa		Rockwell	Brinell
630	0.015 to 4.0 in. (0.38 to 102 mm)	...	...	...	...	...	C38	363
631	0.010 in. (0.25 mm) and under	150	1035	65	450	...	...	...
	Over 0.010 to 4.0 in. (0.25 to 102 mm)	150	1035	55	380	20	B92	...
632	0.0015 to 4.0 in. (0.038 to 102 mm)	150	1035	65	450	25	B100	...
633	0.001 to 0.0015 in. (0.03 to 0.038 mm), excl	200	1380	90	620	8	C30	...
	0.0015 to 0.002 in. (0.03 to 0.05 mm), excl	200	1380	88	605	8	C30	...
	0.002 to 0.005 in. (0.05 to 0.13 mm), excl	200	1380	86	595	8	C30	...
	0.005 to 0.010 in. (0.13 to 0.25 mm), excl	200	1380	85	585	8	C30	...
	Over 0.010 in. (0.254 mm)	200	1380	85	585	12	C30	...
634[A]	Plate	...	...	...	...	...	C40	...
635	0.030 in. (0.76 mm) and under	120	825	75	515	3	C32	...
	Over 0.030 to 0.060 in. (0.76 to 1.52 mm)	120	825	75	515	4	C32	...
	Over 0.060 in. (1.52 mm)	120	825	75	515	5	C32	...
XM-9	Over 0.010 in. (0.25 mm)	150	1035	125	860	4	C28	...
XM-12	0.0015 to 4.00 in. (0.038 to 101.6 mm)	...	...	...	...	...	C38	363
XM-13	0.0015 to 4.00 in. (0.038 to 101.6 mm)	...	...	...	...	...	C38	363
XM-16	0.010 in. (0.25 mm) and greater	175	1205	160	1105	3	C36	331
XM-25[B]	0.010 in. (0.25 mm) and greater	165	1205	150	1035	4	C33	311
S46500	0.140 in. (3.56 mm) and under	160	1105	150	1035	4	C33	...
[A] Solution-treated, equalized, and over-tempered plate only.								
[B] XM-25 also furnished to the following minimum properties:		130	895	90	620	4	C25	255

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TABLE 5 Mechanical Test Requirements After Precipitation Hardening Treatment

Grade	Hardening or Precipitation Treatment or both, °F(°C)	Thickness, in. (mm)	Tensile Strength, min		Yield Strength, min		Elongation in 2 in. or 50 mm, min, %[A]	Reduction of Area, min, %[A]	Hardness, min		Impact Charpy V, min[B]	
			ksi	MPa	ksi	MPa			Rockwell, min/max	Brinell, min/max	ft·lbf	J
630 and	900 (482)	Under 0.1875 (4.762)	190	1310	170	1170	5	...	C40/C48	...	...	...
XM-12		0.1875 to 0.625 (4.762 to 15.88)	190	1310	170	1170	8	25	C40/C48	388/477	...	...
		0.626 to 4.0 (15.90 to 102)	190	1310	170	1170	10	30	C40/C48	388/477	...	...
	925 (496)	Under 0.1875 (4.762)	170	1170	155	1070	5	...	C38/C46	...	...	...
		0.1875 to 0.625 (4.762 to 15.88)	170	1170	155	1070	8	25	C38/C47	375/477	...	...
		0.626 to 4.0 (15.90 to 102)	170	1170	155	1070	10	30	C38/C47	375/477	...	...
	1025 (552)	Under 0.1875 (4.762)	155	1070	145	1000	5	...	C35/C43	...	...	...
		0.1875 to 0.625 (4.762 to 15.88)	155	1070	145	1000	8	30	C33/C42	321/415	10	14
		0.626 to 4.0 (15.90 to 102)	155	1070	145	1000	12	35	C33/C42	321/415	15	20
	1075 (579)	Under 0.1875 (4.762)	145	1000	125	860	5	...	C31/C40	...	...	...
		0.1875 to 0.625 (4.762 to 15.88)	145	1000	125	860	9	30	C29/C38	293/375	15	20
		0.626 to 4.0 (15.88 to 102)	145	1000	125	860	13	35	C29/C38	293/375	20	27
	1100 (593)	Under 0.1875 (4.762)	140	965	115	790	5	...	C31/C40	...	...	...
		0.1875 to 0.625 (4.762 to 15.88)	140	965	115	790	10	30	C29/C38	293/375	15	20
		0.626 to 4.0 (15.88 to 102)	140	965	115	790	14	35	C29/C38	293/375	20	27
	1150 (621)	Under 0.1875 (4.762)	135	930	105	725	8	...	C28/C38	...	...	...
		0.1875 to 0.625 (4.762 to 15.88)	135	930	105	725	10	35	C26/C36	269/352	25	34
		0.626 to 4.0 (15.88 to 102)	135	930	105	725	16	40	C26/C36	269/352	30	41
	1400 + 1150	Under 0.1875 (4.762)	115	790	75	515	9	...	C26/C36	255/331	...	...
	(760 + 621)	0.1875 to 0.625 (4.762 to 15.88)	115	790	75	515	11	40	C24/C34	248/321	55	75
		0.626 to 4.0 (15.88 to 102)	115	790	75	515	18	45	C24/C34	248/321	55	75
631	1400 (760) +	0.0015 to 0.0049 (0.038 to 0.124)	180	1240	150	1035	3	...	C38	...	...	...
	plus 55 (15) +	0.0050 to 0.0099 (0.127 to 0.251)	180	1240	150	1035	4	...	C38	...	...	...
	1050 (566)	0.010 to 0.0199 (0.25 to 0.505)	180	1240	150	1035	5	...	C38	...	...	...
		0.020 to 0.1874 (0.51 to 4.760)	180	1240	150	1035	6	...	C38	...	...	...
		0.1875 to 0.625 (4.762 to 15.88)	170	1170	140	965	7	20	C38	352	...	...
	1750 (954) +	0.0015 to 0.0049 (0.038 to 0.124)	210	1450	190	1310	1	...	C44	...	...	...
	minus 100 (73)	0.0050 to 0.0099 (0.127 to 0.251)	210	1450	190	1310	2	...	C44	...	...	...
	+ 950 (510)	0.010 to 0.0199 (0.25 to 0.505)	210	1450	190	1310	3	...	C44	...	...	...
		0.020 to 0.1874 (0.51 to 4.760)	210	1450	190	1310	4	...	C44	...	...	...

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TABLE 5 *Continued*

Grade	Hardening or Precipitation Treatment or both, °F(°C)	Thickness, in. (mm)	Tensile Strength, min		Yield Strength, min		Elongation in 2 in. or 50 mm, min, %[A]	Reduction of Area, min, %[A]	Hardness, min		Impact Charpy V, min[B]	
			ksi	MPa	ksi	MPa			Rockwell, min/max	Brinell, min/max	ft·lbf	J
		0.1875 to 0.625 (4.762 to 15.88)	200	1380	180	1240	6	20	C43	401	. . .	. . .
	Cold rolled at mill	0.0015 to 0.050 (0.038 to 1.27)	200	1380	175	1205	1	. . .	C41	. . .	. . .	. . .
	Cold rolled at mill + 900 (482)	0.0015 to 0.050 (0.038 to 1.27)	240	1655	230	1580	1	. . .	C46	. . .	. . .	. . .
632	1400 (760) +	0.0015 to 0.0049 (0.038 to 0.124)	190	1310	170	1170	2	. . .	C40	. . .	. . .	. . .
	plus 55 (15) +	0.0050 to 0.0099 (0.127 to 0.251)	190	1310	170	1170	3	. . .	C40	. . .	. . .	. . .
	1050 (566)	0.010 to 0.0199 (0.25 to 0.505)	190	1310	170	1170	4	. . .	C40	. . .	. . .	. . .
		0.020 to 0.1874 (0.51 to 4.760)	190	1310	170	1170	5	. . .	C40	. . .	. . .	. . .
		0.1875 to 0.625 (4.762 to 15.88)	190	1310	170	1170	4	20	C40	375	. . .	. . .
	1750 (954) +	0.0015 to 0.0049 (0.038 to 0.124)	225	1550	200	1380	1	. . .	C46	. . .	. . .	. . .
	minus 100 (73)	0.0050 to 0.0099 (0.127 to 0.251)	225	1550	200	1380	2	. . .	C46	. . .	. . .	. . .
	+ 950 (510)	0.010 to 0.0199 (0.25 to 0.505)	225	1550	200	1380	3	. . .	C46	. . .	. . .	. . .
		0.020 to 0.1874 (0.51 to 4.760)	225	1550	200	1380	4	. . .	C46	. . .	. . .	. . .
		0.1875 to 0.625 (4.762 to 15.88)	225	1550	200	1380	4	20	C45	429	. . .	. . .
	Cold rolled at mill	0.0015 to 0.050 (0.038 to 0.13)	200	1380	175	1205	1	. . .	C41	. . .	. . .	. . .
	Cold rolled at mill + 900 (482)	0.0015 to 0.050 (0.038 to 0.13)	240	1655	230	1585	1	. . .	C46	. . .	. . .	. . .
633	850 (455)	0.0005 to 0.0015 (0.022 to 0.038)	185	1275	150	1035	2	. . .	C42	. . .	. . .	. . .
		0.0015 to 0.0020 (0.038 to 0.041)	185	1275	150	1035	4	. . .	C42	. . .	. . .	. . .
		0.0020 to 0.0100 (0.041 to 0.254)	185	1275	150	1035	6	. . .	C42	. . .	. . .	. . .
		0.0100 to 0.1875 (0.254 to 4.762)	185	1275	150	1035	8	. . .	C42	. . .	. . .	. . .
	1000 (540)	0.0005 to 0.0015 (0.022 to 0.038)	165	1140	145	1000	2	. . .	C36	. . .	. . .	. . .
		0.0015 to 0.0020 (0.038 to 0.041)	165	1140	145	1000	4	. . .	C36	. . .	. . .	. . .
		0.0020 to 0.0100 (0.041 to 0.254)	165	1140	145	1000	6	. . .	C36	. . .	. . .	. . .
		0.0100 to 0.1875 (0.254 to 4.762)	165	1140	145	1000	8	. . .	C36	. . .	. . .	. . .
634	850 (455)		190	1310	165	1140	10	. . .	. . .	. . .	. . .	. . .
	1000 (540)		170	1170	150	1035	12	. . .	C37	. . .	. . .	. . .
635	950 (510)	0.030 (0.76) and under	190	1310	170	1170	3	. . .	C39	. . .	. . .	. . .
		0.030 to 0.060 (0.76 to 1.52)	190	1310	170	1170	4	. . .	C39	. . .	. . .	. . .
		Over 0.060 (1.52)	190	1310	170	1170	5	. . .	C39	. . .	. . .	. . .
		Plate	190	1310	170	1170	8	25	C39	363	. . .	. . .
	1000 (540)	0.030 (0.76) and under	180	1240	160	1105	3	. . .	C37	. . .	. . .	. . .
		0.030 to 0.060 (0.76 to 1.52)	180	1240	160	1105	4	. . .	C37	. . .	. . .	. . .
		Over 0.060 (1.52)	180	1240	160	1105	5	. . .	C37	. . .	. . .	. . .
		Plate	180	1240	160	1105	8	30	C38	352	. . .	. . .

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TABLE 5 *Continued*

Grade	Hardening or Precipitation Treatment or both, °F(°C)	Thickness, in. (mm)	Tensile Strength, min		Yield Strength, min		Elongation in 2 in. or 50 mm, min, %[A]	Reduction of Area, min, %[A]	Hardness, min		Impact Charpy V, min[B]	
			ksi	MPa	ksi	MPa			Rockwell, min/max	Brinell, min/max	ft·lbf	J
	1050 (565)	0.030 (0.76) and under	170	1170	150	1035	3	...	C35	...	...	...
		0.030 to 0.060 (0.76 to 1.52)	170	1170	150	1035	4	...	C35	...	...	...
		Over 0.060 (1.52)	170	1170	150	1035	5	...	C35	...	...	...
		Plate	170	1170	150	1035	8	30	C36	331	...	...
XM-13	950 (510)	Under 0.020 (0.51)	220	1515	205	1410	6	...	C45	...	...	...
		0.020 to 0.1874 (0.51 to 4.760)	220	1515	205	1410	8	...	C45	...	...	...
		0.1875 to 0.625 (4.760 to 15.88)	220	1515	205	1410	10	...	C45	...	...	...
		0.626 to 4.0 (15.90 to 102)	220	1515	205	1410	10	...	C45	429	...	...
	1000 (538)	Under 0.020 (0.51)	200	1380	190	1310	6	...	C43	...	...	...
		0.020 to 0.1874 (0.51 to 4.760)	200	1380	190	1310	8	...	C43	...	...	...
		0.1875 to 0.625 (4.760 to 15.88)	200	1380	190	1310	10	...	C43	...	...	...
		0.626 to 4.0 (15.90 to 102)	200	1380	190	1310	10	...	C43	401	...	...
XM-16	950 (510)	Up to 0.020 (0.51)	222	1525	205	1410	...	...	C44	...	...	...
		Over 0.020 to 0.062 (0.51 to 1.57)	222	1525	205	1410	3	...	C44	...	...	...
		Over 0.062 (1.57)					4	...		...	...	...
XM-25	900 (482)	Up to 0.020 (0.51)	180	1240	170	1170	3	...	C40	...	...	...
		Over 0.020 to 0.062 (0.51 to 1.57)	180	1240	170	1170	4	...	C40	...	...	...
		Over 0.062 (1.57)	180	1240	170	1170	5	...	C40	...	...	...
	1000 (538)	Up to 0.020 (0.51)	160	1105	150	1035	5	...	C36	...	...	...
		Over 0.020 to 0.062 (0.51 to 1.57)	160	1105	150	1035	6	...	C36	...	...	...
		Over 0.062 (1.57)	160	1105	150	1035	7	...	C36	...	...	...
	1150 (621)	Up to 0.020 (0.51)	125	860	75	515	8	...	C26	...	...	...
		Over 0.020 to 0.062 (0.51 to 1.57)	125	860	75	515	9	...	C26	...	...	...
		Over 0.062 (1.57)	125	860	75	515	10	...	C26	...	...	...
XM-9	900 (482)	Over 0.010 (0.25)	180	1240	160	1105	3	...	C38	...	...	...
S46500	900 (482)	0.140 (3.56) and under	245	1690	235	1620	2	...	C48	...	...	...
	950 (510)	0.140 (3.56) and under	235	1620	225	1550	3	...	C47	...	...	...
	1000 (538)	0.140 (3.56) and under	220	1515	210	1445	4	...	C45	...	...	...
	1050 (566)	0.140 (3.56) and under	200	1380	185	1275	5	...	C43	...	...	...
	1100 (593)	0.140 (3.56) and under	180	1240	145	1000	6	...	C39	...	...	...
S46910	Cold rolled at mill	0.00079 to 0.15 (0.020 to 3.8)	135	950	65	475	5	...	C29	...	...	...
	Cold rolled at mill +890 (475)	0.00079 to 0.15 (0.020 to 3.8)	180	1250	135	950	1	...	C38	...	...	...
	Cold rolled at mill	0.00059 to 0.091 (0.015 to 2.3)	160	1100	95	650	3	...	C33	...	...	...
	Cold rolled at mill +890 (475)	0.00059 to 0.091 (0.015 to 2.3)	240	1650	210	1450	1	...	C46	...	...	...
	Cold rolled at mill	0.00059 to 0.047 (0.015 to 1.2)	185	1300	160	1100	1	...	C38	...	...	...
	Cold rolled at mill +890 (475)	0.00059 to 0.047 (0.015 to 1.2)	280	1950	265	1850	...	...	C50	...	...	...
	Cold rolled at mill	0.00059 to 0.028 (0.015 to 0.70)	215	1500	195	1350	...	...	C42	...	...	...

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TABLE 5 *Continued*

Grade	Hardening or Precipitation Treatment or both, °F(°C)	Thickness, in. (mm)	Tensile Strength, min		Yield Strength, min		Elongation in 2 in. or 50 mm, min, %[A]	Reduction of Area, min, %[A]	Hardness, min		Impact Charpy V, min[B]	
			ksi	MPa	ksi	MPa			Rockwell, min/max	Brinell, min/max	ft·lbf	J
	Cold rolled at mill +890 (475)	0.00059 to 0.028 (0.015 to 0.70)	325	2250	310	2150	. . .	. . .	C54	. . .	. . .	. . .
	Cold rolled at mill	0.00059 to 0.0059 (0.015 to 0.15)	245	1700	220	1525	. . .	. . .	C45	. . .	. . .	. . .
	Cold rolled at mill +890 (475)	0.00059 to 0.0059 (0.015 to 0.15)	340	2350	325	2250	. . .	. . .	C55	. . .	. . .	. . .

[A] Applicable to tests in the long transverse direction. Transverse to the direction of rolling and parallel to the product surface.
[B] Impact test is not required unless specified on the purchase order.

TABLE 6 Bend Test Requirements in Solution-Treated Condition

Type	Size, in. (mm)	Cold Bend Degrees	Bend Test Mandrel
630			none required
631	0.187 (4.76) and under	180	1*T*[A]
	Over 0.187 to 0.275 (4.76 to 6.98)	180	3*T*
632	0.187 (4.76) and under	180	1*T*
	Over 0.187 to 0.275 (4.76 to 6.98)	180	3*T*
633	Under 0.1875 (4.762)	180	2*T*
634	0.187 to 0.249 (4.76 to 6.32)	130	3*T*
	Over 0.249 to 0.750 (6.32 to 19.08)	90	3*T*
635			none required
XM-9	0.109 (2.77) and under	180	9*T*
XM-12			none required
XM-13			none required
XM-16	Under 0.1875 (4.762)	180	6*T*
XM-25	Under 0.1875 (4.762)	180	6*T*
S46500	0.140 (3.56) and under	180	6*T*

[A] *T* = thickness of sheet being tested.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue, A 693 – 03, that may impact the use of this standard. (Approved March 1, 2006.)

(*1*) Added S46910 by revising 6.1, adding 6.2, and revising Tables 1-3 and Table 5.

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