



Designation: A 693 – 93 (Reapproved 1999)

Standard Specification for Precipitation-Hardening Stainless and Heat-Resisting Steel Plate, Sheet, and Strip¹

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 specification² 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:

A 480/A 480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip³

E 527 Practice for Numbering Metals and Alloys (UNS)⁴

2.2 SAE Standard:

SAE J 1086 Recommended Practice for Numbering Metals and Alloys (UNS)⁵

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:

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

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

³ Annual Book of ASTM Standards, Vol 01.03.

⁴ Annual Book of ASTM Standards, Vol 01.01.

⁵ Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

3.1.1 Definitions,

3.1.2 General requirements for delivery.

3.1.3 *Ordering Information:*

3.1.3.1 In addition to the requirements of A 480/A 480M, the heat treatment (see Section 6) must be specified on the purchase order.

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.

6. Heat Treatment of Product

6.1 Material shall be furnished in the solution-annealed condition as noted in Table 2 and Table 3 unless otherwise specified by the purchaser on the purchase order.

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.

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 | 15.00–17.50 | 3.00–5.00 | ... | ... | ... | 3.00–5.00 | D |
| S 17700 | 631 | 0.09 | 1.00 | 0.040 | 0.030 | 1.00 | 16.00–18.00 | 6.50–7.75 | 0.75–1.50 | ... | ... | ... | ... |
| S 15700 | 632 | 0.09 | 1.00 | 0.040 | 0.030 | 1.00 | 14.00–16.00 | 6.50–7.75 | 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 | 16.00–17.00 | 4.00–5.00 | ... | 2.50–3.25 | ... | ... | E |
| S 35500 | 634 | 0.10–0.15 | 0.50–1.25 | 0.040 | 0.030 | 0.50 | 15.00–16.00 | 4.00–5.00 | ... | 2.50–3.25 | ... | ... | F |
| S 17600 | 635 | 0.08 | 1.00 | 0.040 | 0.030 | 1.00 | 16.00–17.50 | 6.00–7.50 | 0.40 | ... | 0.40–1.20 | ... | ... |
| S 36200 | XM-9 | 0.05 | 0.50 | 0.030 | 0.030 | 0.30 | 14.00–14.50 | 6.25–7.00 | 0.10 | 0.30 | 0.60–0.90 | ... | ... |
| S 15500 | XM-12 | 0.07 | 1.00 | 0.040 | 0.030 | 1.00 | 14.00–15.50 | 3.50–5.50 | ... | ... | ... | 2.50–4.50 | D |
| S 13800 | XM-13 | 0.05 | 0.20 | 0.010 | 0.008 | 0.10 | 12.25–13.25 | 7.50–8.50 | 0.90–1.35 | 2.00–2.50 | ... | ... | G |
| S 45500 | XM-16 | 0.05 | 0.50 | 0.040 | 0.030 | 0.50 | 11.00–12.50 | 7.50–9.50 | ... | 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 | 14.00–16.00 | 5.00–7.00 | ... | 0.50–1.00 | ... | 1.25–1.75 | H |

^ALimits are in percent maximum unless shown as a range or stated otherwise.

^BNew designation established in accordance with Practice E 527 and SAE J1086.

^CThe terms Columbium (Cb) and Niobium (Nb) both relate to the same element.

^DColumbium plus tantalum 0.15–0.45.

^ENitrogen 0.07–0.13.

^FColumbium plus tantalum 0.10–0.50.

^GNitrogen 0.01.

^HColumbium 8 times carbon minimum.

iTeh Standards
(<https://standards.itih.ai>)

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) | 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. |
| <i>Alternative Treatment:</i> | | | |
| | | 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. | |
| 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. 900 ± 10°F, 8 h, air cool. |
| S36200 | XM-9 | 1550 ± 25°F (air cool) | Same as Type 630 |
| S15500 | XM-12 | 1900 ± 25°F (cool as required) | 950 ± 10°F, 4 h, air cool. |
| S13800 | XM-13 | 1700 ± 25°F (cool as required to below 60°F) | 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. |

^ATimes refer to time material is at temperature.

^BEqualization 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.

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. |
| <i>Alternative Treatment</i> | | | |
| | | 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. |

^ATimes refer to time material is at temperature.

^BEqualization 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.

[ASTM A693-93\(1999\)](https://standards.iteh.ai/catalog/standards/sist/d1f8ad08-0ef4-4fa6-a988-98a145ea9384/astm-a693-931999)
<https://standards.iteh.ai/catalog/standards/sist/d1f8ad08-0ef4-4fa6-a988-98a145ea9384/astm-a693-931999>
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) | 185 | 1255 | 160 | 1105 | 3 | 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 |

^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 |
|-----|-----|----|-----|---|-----|-----|