

**SPECIFICATION FOR PRESSURE VESSEL PLATES,
ALLOY STEEL, QUENCHED AND TEMPERED,
MANGANESE-MOLYBDENUM AND MANGANESE-
MOLYBDENUM-NICKEL**



SA-533/SA-533M



(Identical with ASTM Specification A533/A533M-16.)

Standard Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered, Manganese-Molybdenum and Manganese- Molybdenum-Nickel

1. Scope

1.1 This specification covers one type of manganese-molybdenum and four types of manganese-molybdenum-nickel alloy steel plates for use in the quenched and tempered condition for the construction of welded pressure vessels.

1.2 Material under this specification is available in five types, designated “A”, “B”, “C”, “D”, and “E”. The material is also available in three classes having the following strength levels.

Class	Tensile Strength, ksi [MPa]
1	80–100 [550 to 690]
2	90–115 [620 to 795]
3	100–125 [690 to 860]

1.3 The maximum thickness of Class 1 and Class 2 plates is limited only by the capacity of the composition to meet the specified mechanical property requirements; however, current practice normally limits the maximum thickness to 12 in. [300 mm] for Types A through D and to 7 in. [180 mm] for Type E.

1.4 The maximum thickness of Class 3 plates is 2½ in. [65 mm] for Types A through D and 2 in. [50 mm] for Type E.

1.5 The minimum nominal thickness of plates of all classes is 0.25 in. [6.5 mm].

1.6 These alloy steel plates in the as-rolled condition are sensitive to cracking during transit and handling, particularly in thicknesses over about 1 or 2 in. [25 or 50 mm]. They should be shipped in the as-rolled conditions only by mutual agreement of manufacturer and the purchaser.

1.7 Plates covered by this specification are often used in the beltline region of nuclear reactor vessels where the material

properties may be affected by high levels of radiation. Appendix X1 provides some information pertinent to this usage.

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

2. Referenced Documents

2.1 ASTM Standards:

A20/A20M Specification for General Requirements for Steel Plates for Pressure Vessels

A435/A435M Specification for Straight-Beam Ultrasonic Examination of Steel Plates

A577/A577M Specification for Ultrasonic Angle-Beam Examination of Steel Plates

A578/A578M Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications

3. General Requirements and Ordering Information

3.1 Material supplied to this material specification shall conform to Specification A20/A20M. These requirements outline the testing and retesting methods and procedures, permitted variations in dimensions, and mass, quality and repair of defects, marking, loading, and ordering information.

3.2 In addition to the basic requirements of this specification, certain supplementary requirements are available when additional control, testing, or examination is required to meet end use requirements. The purchaser is referred to the listed supplementary requirements in this specification and to the detailed requirements in Specification A20/A20M.

TABLE 1 Chemical Requirements

NOTE 1—Where “...” appears there is no requirement.

	Composition, %				
	Type A	Type B	Type C	Type D	Type E
Carbon, max ^A	0.25	0.25	0.25	0.25	0.20
Manganese: ^B					
Heat analysis	1.15–1.50	1.15–1.50	1.15–1.50	1.15–1.50	1.15–1.70
Product analysis	1.07–1.62	1.07–1.62	1.07–1.62	1.07–1.62	1.04–1.84
Phosphorus, max ^A	0.025	0.025	0.025	0.025	0.020
Sulfur, max ^A	0.025	0.025	0.025	0.025	0.015
Silicon:					
Heat analysis	0.15–0.40	0.15–0.40	0.15–0.40	0.15–0.40	0.15–0.40
Product analysis	0.13–0.45	0.13–0.45	0.13–0.45	0.13–0.45	0.13–0.45
Molybdenum:					
Heat analysis	0.45–0.60	0.45–0.60	0.45–0.60	0.45–0.60	0.25–0.60
Product analysis	0.41–0.64	0.41–0.64	0.41–0.64	0.41–0.64	0.21–0.64
Nickel:					
Heat analysis	...	0.40–0.70	0.70–1.00	0.20–0.40	0.60–1.00
Product analysis	...	0.37–0.73	0.67–1.03	0.17–0.43	0.57–1.03
Chromium, max:					
Heat analysis	...	...	...	...	0.60
Product analysis	...	...	...	...	0.64

^A Applies to both heat and product analyses.

^B For Types A, B, C, and D, the maximum manganese content may be increased to 1.60 % on heat analysis and 1.65 % on product analysis when Class 2 or Class 3 properties are specified and when Supplementary Requirement S3 (see Specification A20/A20M) is specified with a total holding time of more than 1 h/in. [2.4 min/mm] of thickness.

TABLE 2 Tensile Requirements

	Class 1	Class 2	Class 3
	ksi [MPa]	ksi [MPa]	ksi [MPa]
Tensile strength	80–100 [550–690]	90–115 [620–795]	100–125 [690–860]
Yield strength, min	50 [345]	70 [485]	83 [570]
Elongation in 2 in. [50 mm], min, % ^A	18	16	16

^ASee Specification A20/A20M for elongation adjustment.

3.3 If the requirements of this specification are in conflict with the requirements of Specification A20/A20M, the requirements of this specification shall prevail.

4. Manufacture

4.1 *Steelmaking Practice*—The steel shall be killed and shall conform to the fine austenitic grain requirement of Specification A20/A20M.

5. Heat Treatment

5.1 All plates shall be heat treated by heating to a suitable temperature within the range from 1550 to 1800°F [845 to 980°C], holding for a sufficient time to obtain uniform temperature throughout the plate thickness and then quenching, in water. Subsequently the plates shall be tempered at a suitable temperature to produce the specified properties, but not less than 1100°F [595°C] with a minimum holding time of ½ h/in. [1.2 min/mm] of thickness, but not less than ½ h.

5.2 When the plates are heat treated by the fabricator, it shall be his responsibility to apply the proper heat treatment and to conduct tests he deems necessary to assure that the specified properties are attained. Plates thicker than 2 in. [50 mm] shall be stress-relieved by the manufacturer prior to shipment at a temperature no lower than 1100°F [595°C].

6. Chemical Requirements

6.1 The steel shall conform to the chemical requirements shown in Table 1 unless otherwise modified in accordance with Supplementary Requirement S17, Vacuum Carbon-Deoxidized Steel, in Specification A20/A20M.

7. Mechanical Requirements

7.1 Tension Test Requirements:

7.1.1 The material as represented by the tension-test specimens shall conform to the requirements shown in Table 2.

7.1.2 For nominal plate thicknesses of ¾ in. [20 mm] and under, the 1½-in. [40 mm] wide rectangular specimen may be used, and the elongation may be determined in a 2-in. [50-mm] gage length that include the fracture and that shows the greatest elongation.

8. Keywords

8.1 alloy steel; alloy steel plate; pressure containing parts; pressure vessel steels; steel plates; steel plates for pressure vessels

SUPPLEMENTARY REQUIREMENTS

Supplementary requirements shall not apply unless specified in the order.

A list of standardized supplementary requirements for use at the option of the purchaser are included in Specification A20/A20M. Several of those considered suitable for use with this specification are listed below by title. Other tests may be performed by agreement between the supplier and the purchaser.

- S1. Vacuum Treatment,
- S2. Product Analysis,
- S3. Simulated Post-Weld Heat Treatment of Mechanical Test Coupons,
- S4.2 Additional Tension Test,
- S5. Charpy V-Notch Impact Test,

- S6. Drop Weight Test (for Material 0.625 in. [16 mm] and over in Thickness),
- S7. High-Temperature Tension Test,
- S8. Ultrasonic Examination in accordance with Specification A435/A435M,
- S9. Magnetic Particle Examination,

S11. Ultrasonic Examination in accordance with Specification A577/A577M,
 S12. Ultrasonic Examination in accordance with Specification A578/A578M,

S17. Vacuum Carbon-Deoxidized Steel, and
 S19. Restricted Chemical Requirements.

ADDITIONAL SUPPLEMENTARY REQUIREMENTS

Also listed below is additional optional Supplementary Requirements S53, which is suitable for this specification.

S53.

S53.1 When specified by the purchaser, the axis of the tensile and impact test specimens shall come from the mid-thickness of each plate tested, in lieu of midway between the center thickness and the top or bottom surface of the plate.

APPENDIX

(Nonmandatory Information)

X1. NUCLEAR REACTOR BELTLINE CONSIDERATIONS—RESIDUAL ELEMENTS

X1.1 Reactor design requires review and control of residual elements that affect the material properties. Copper and phosphorus are limited to levels determined by the total fluence to be encountered during plant life. Vanadium and sulfur can affect the upper energy shelf level. In the case of sulfur, control of this element or its morphology in the plate, or both, may offer alternative means of control. The limits required shall be specified in the ordering data. The following table itemizes

currently available commercial limits for the referenced elements:

Element	Heat Analysis, %	Product Analysis, %
Copper	0.10	0.12
Phosphorus	0.012	0.015
Sulfur	0.010	0.013
Vanadium	0.03	0.04