Designation: A 533/A 533M – 93 (Reapproved 2004)ε1

Used in USDOE-NE Standards

Standard Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered, Manganese-Molybdenum and Manganese-Molybdenum-Nickel[1]

This standard is issued under the fixed designation A 533/A 533M; 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.

ε[1] NOTE—Supplementary Requirement S14, Bend Test, was editorially removed in September 2004.

1. Scope

1.1 This specification[2] covers manganese-molybdenum and manganese-molybdenum-nickel alloy steel plates for use in the quenched and tempered condition for the construction of welded pressure vessels.

1.2 This specification includes four types of chemical analysis and three classes of strength levels as follows:

Type	Nominal Molybdenum Content, %	Nominal Nickel Content, %
A	0.50	. . .
B	0.50	0.55
C	0.50	0.85
D	0.50	0.30

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].

1.4 The maximum thickness of Class 3 plates is 2½ in. [65 mm].

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 with the mutual agreement of manufacturer and fabricator.

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:* [3]

A 20/A 20M Specification for General Requirements for Steel Plates for Pressure Vessels

A 435/A 435M Specification for Straight-Beam Ultrasonic Examination of Steel Plates

A 577/A 577M Specification for Ultrasonic Angle-Beam Examination of Steel Plates

A 578/A 578M Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications

3. General Requirements and Ordering Information

3.1 Material supplied to this material specification shall conform to Specification A 20/A 20M. These requirements outline the testing and retesting methods and procedures,

[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 A01.11 on Steel Plates for Boilers and Pressure Vessels.

Current edition approved Sept. 1, 2004. Published September 2004. Originally approved in 1965. Last previous edition approved in 1999 as A 533/A 533M – 93 (1999).

[2] For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-533/SA-533M 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.

Copyright © ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States.

Copyright ASTM International
Provided by IHS under license with ASTM
No reproduction or networking permitted without license from IHS
Not for Resale

permissible variations in dimensions, and mass, quality and repair of defects, marking, loading, etc.

3.2 Specification A 20/A 20M also establishes the rules for the ordering information which should be complied with when purchasing material to this specification.

3.3 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. These include:

3.3.1 Vacuum treatment,

3.3.2 Additional or special tension testing,

3.3.3 Impact testing, and

3.3.4 Nondestructive examination.

3.4 The purchaser is referred to the listed supplementary requirements in this specification and to the detailed requirements in Specification A 20/A 20M.

3.5 If the requirements of this specification are in conflict with the requirements of Specification A 20/A 20M, 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 A 20/A 20M.

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.

6. *Chemical Requirements* 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 A 20/A 20M.

TABLE 1 Chemical Requirements

	Composition, %			
	Type A	Type B	Type C	Type D
Carbon, max[A]	0.25	0.25	0.25	0.25
Manganese[B]:				
Heat analysis	1.15–1.50	1.15–1.50	1.15–1.50	1.15–1.50
Product analysis	1.07–1.62	1.07–1.62	1.07–1.62	1.07–1.62
Phosphorus, max[A]	0.035	0.035	0.035	0.035
Sulfur, max[A]	0.035	0.035	0.035	0.035
Silicon:				
Heat analysis	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
Molybdenum:				
Heat analysis	0.45–0.60	0.45–0.60	0.45–0.60	0.45–0.60
Product analysis	0.41–0.64	0.41–0.64	0.41–0.64	0.41–0.64
Nickel:				
Heat analysis	. . .	0.40–0.70	0.70–1.00	0.20–0.40
Product analysis	. . .	0.37–0.73	0.67–1.03	0.17–0.43

[A] Applies to both heat and product analyses.

[B] 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 A 20/A 20M) is specified with a total holding time of more than 1 h/in. [2.4 min/mm] of thickness.

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.

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

[A] See Specification A 20/A 20M for elongation adjustment.

Copyright ASTM International
Provided by IHS under license with ASTM
No reproduction or networking permitted without license from IHS
Not for Resale

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 A 20/A 20M. 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 A 435/A 435M,

S9. Magnetic Particle Examination,

S11. Ultrasonic Examination in accordance with Specification A 577/A 577M,

S12. Ultrasonic Examination in accordance with Specification A 578/A 578M,

S17. Vacuum Carbon-Deoxidized Steel, and

S19. Restricted Chemical Requirements

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	0.015	0.018
Vanadium	0.05	0.06

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).

Copyright ASTM International
Provided by IHS under license with ASTM
No reproduction or networking permitted without license from IHS
Not for Resale