Designation: A 645/A 645M – 05

Standard Specification for Pressure Vessel Plates, 5 % and 5 ½ % Nickel Alloy Steels, Specially Heat Treated[1]

This standard is issued under the fixed designation A 645/A 645M; 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.

1. Scope*

1.1 This specification[2] covers specially heat treated 5 % and 5 ½ % nickel alloy steel plates intended primarily for welded pressure vessels for service at low or cryogenic temperatures.

1.2 The maximum thickness of plates which can be supplied under this specification is limited only by the capacity of the material to meet the specified requirements.

1.3 This material is susceptible to magnetization. Use of magnets in handling after heat treatment should be avoided if residual magnetism would be detrimental to subsequent fabrication or service.

1.4 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

3. General Requirements and Ordering Information

3.1 Plates supplied to this product specification shall conform to Specification A 20/A 20M, which outlines the testing and retesting methods and procedures, permissible variations in dimensions and mass, quality and repair of defects, marking, loading, and so forth.

3.2 Specification A 20/A 20M also establishes the rules for the ordering information that should be complied with when purchasing plates 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.

3.4 The purchaser is referred to the listed supplementary requirements in this specification and to the detailed supplementary 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. Materials and Manufacture

4.1 *Steelmaking Practice*—The steel shall be killed and shall conform to the fine austenitic grain size requirements of Specification A 20/A 20M.

5. Heat Treatment

5.1 Grade A plates shall be heat treated in accordance with 5.2. Grade B plates shall be heat treated in accordance with 5.3. Shell plates and other parts, including heads and reinforcing pads that are heated above 1125°F [605°C] for forming, shall be heat treated after forming,

5.2 *Grade A, Procedure and Sequence*:

5.2.1 *Hardening*—The plates shall be heated to a temperature within the range from 1575 to 1675°F [855 to 915°C], held within that temperature range for a minimum of 1 h/in. [2.4 min/mm] of thickness, but in no case less than 15 min, and then water-quenched to below 300°F [150°C].

5.2.2 *Intermediate Heat Treatment*—The plates shall be reheated to a temperature within the range from 1275 to 1400°F [690 to 760°C], held within that temperature range for a minimum of 1 h/in. [2.4 min/mm] of thickness, but in no case less than 15 min, and then water-quenched to below 300°F [150°C].

5.2.3 *Tempering*—The plates shall be reheated to a temperature within the range from 1150 to 1225°F [620 to 665°C], held within that temperature range for a minimum of 1 h/in. [2.4 min/mm] of thickness, but in no case less than 15 min, and then water-quenched or air cooled to below 300°F [150°C].

5.3 *Grade B, Procedure and Sequence*:

5.3.1 *Hardening*—The plates shall be heated to a temperature within the range from 1470 to 1600°F [800 to 870°C], held within that temperature range for a sufficient time to obtain

[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 for Boilers and Pressure Vessels.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Specification SA-645 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.

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

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uniform temperature throughout the plate thickness, and then quenched in a liquid medium.

5.3.2 *Intermediate Heat Treatment*—The plates shall be reheated to a temperature within the range from 1200 to 1330°F [650 to 720°C], held within that temperature range for a minimum of 1 h/in. [2.4 min/mm] of thickness, but in no case less than 15 min, and then water-quenched to below 300°F [150°C] for nominal plate thicknesses over ⅝ in. [16 mm], or cooled in air or water-quenched to below 300°F [150°C] for nominal plate thicknesses of ⅝ in. [16 mm] and under.

5.3.3 *Tempering*—The plates shall be reheated to a temperature within the range from 1020 to 1150°F [550 to 620°C], held within that temperature range for a minimum of 30 min/in. [1.2 min/mm] of thickness, but in no case less than 15 min, and then water-quenched to below 300°F [150°C].

6. Chemical Requirements

6.1 The steel shall conform to the chemical requirements given in Table 1 unless otherwise modified in accordance with Supplementary Requirement S17, Vacuum Carbon-Deoxidized Steel, in Specification A 20/A 20M.

7. Mechanical Requirements

7.1 *Tension Tests*—The plates as represented by the tension test specimens shall conform to the requirements given in Table 2.

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

7.2 *Impact Tests*:

7.2.1 Charpy V-notch tests shall be made in accordance with the general requirements of Specification A 20/A 20M.

7.2.2 The longitudinal axis of the test specimens shall be transverse to the final direction of rolling of the plate.

7.2.3 Unless otherwise agreed, the plates shall be impact tested at the following temperatures:

7.2.3.1 Grade A: –220°F [–140°C].

7.2.3.2 Grade B: –320°F [–195°C].

7.2.4 Each specimen shall have a lateral expansion opposite the notch of not less than 0.015 in. [0.38 mm].

TABLE 1 Chemical Requirements

Element	Composition, %	
	Grade A	Grade B
Carbon, max		
Heat Analysis	0.13	0.13
Produce Analysis	0.15	0.15
Manganese		
Heat Analysis	0.30–0.60	0.90–1.50
Product Analysis	0.25–0.66	0.84–1.59
Phosphorus, max		
Heat Analysis	0.025	0.020
Product Analysis	0.035	0.025
Sulfur, max		
Heat Analysis	0.025	0.010
Product Analysis	0.035	0.015
Silicon		
Heat Analysis	0.20–0.40	0.15–0.30[A]
Product Analysis	0.18–0.45	0.13–0.33[A]
Nickel		
Heat Analysis	4.8–5.2	5.0–6.0
Product Analysis	4.7–5.3	4.9–6.1
Chromium		
Heat Analysis	...	0.10–1.00
Product Analysis	...	0.06–1.05
Molybdenum		
Heat Analysis	0.20–0.35	0.10–0.30
Product Analysis	0.17–0.38	0.09–0.33
Aluminum, total		
Heat Analysis	0.02–0.12	0.02–0.05
Product Analysis	0.01–0.16	0.015–0.06
Nitrogen, max		
Heat Analysis	0.020	0.010
Product Analysis	0.025	0.010

[A] The specified minimum limit does not apply if the total aluminum is 0.030 % or more, ore if the acid soluble aluminum content is 0.025 % or more.

TABLE 2 Tensile Requirements

	Grade A	Grade B
Yield strength, min, ksi [MPa][A]	65 [450]	85 [590]
Tensile strength, ksi [MPa]	95–115 [655 to 795]	100–120 [690–830]
Elongation in 2 in. [50 mm], min, %[B]	20.0	20

[A] At 0.2 % offset, or, if agreed between the purchaser and the manufacturer, at 0.5 % extension under load.

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

7.2.5 The values of energy absorption in foot-pounds-force [joules] and the fracture appearance in percent shear shall be recorded and reported for information.

8. Keywords

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

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SUPPLEMENTARY REQUIREMENTS

A list of standardized supplementary requirements for use at the option of the purchaser is included in Specification A 20/A 20M. Supplementary requirements shall not apply unless specified in the order. Those which are considered suitable for use with this specification are listed below by title. Others enumerated in Specification A 20/A 20M may be used with this specification subject to agreement by the supplier.

S1. Vacuum Treatment,
S2. Product Analysis,
S6. Drop-Weight Test (for Material 0.625 in. [16 mm] and over in Thickness),
S8. Ultrasonic Examination in accordance with Specification A 435/A 435M,
S11. Ultrasonic Examination in accordance with Specification A 577/A 577M,
S12. Ultrasonic Examination in accordance with Specification A 578/A 578M, and
S17. Vacuum Carbon-Deoxidized Steel.

ADDITIONAL SUPPLEMENTARY REQUIREMENTS

Also listed below are additional supplementary requirements which are considered suitable for use with this specification.

S64. Longitudinal Charpy Impact Energy Absorption Requirement

S64.1 When required, the purchaser may specify longitudinal Charpy V-notch impact testing to energy-absorption acceptance criteria.

S64.2 Tests shall be conducted in accordance with the general requirements of Specification A 20/A 20M.

S64.3 The longitudinal Charpy V-notch impact properties shall not be less than those shown in Table S1.

S64.4 The impact values obtained on subsize specimens shall not be less than the values listed in Table S1.

TABLE S1 Charpy Impact Requirements for Longitudinal Specimens

Size of Specimen, mm	Charpy V-notch Impact Value Required for Acceptance (Average of Three Specimens), ft·lbf [J]	Minimum Charpy V-notch Impact Value Without Requiring Retest (One Specimen Only of a Set), ft·lbf [J]
10 by 10	25 [34]	20 [27]
10 by 7.5	19 [26]	16 [22]
10 by 6.67	17 [23]	13 [18]
10 by 5.0	13 [18]	10 [14]
10 by 3.33	8 [11]	7 [10]
10 by 2.50	6 [8]	5 [7]

S65. Transverse Charpy Impact Energy Absorption Requirement

S65.1 When required, the purchaser may specify transverse Charpy V-notch impact testing to energy-absorption acceptance criteria.

S65.2 Tests shall be conducted in accordance with the general requirements of Specification A 20/A 20M.

S65.3 The transverse Charpy V-notch impact properties shall not be less than those shown in Table S2.

S65.4 The impact values obtained on subsize specimens shall not be less than the values listed in Table S2.

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TABLE S2 Charpy Impact Requirements for Transverse Specimens

Size of Specimen, mm	Charpy V-notch Impact Value Required for Acceptance (Average of Three Specimens), ft·lbf [J]	Minimum Charpy V-notch Impact Value Without Requiring Retest (One Specimen Only of a Set), ft·lbf [J]
10 by 10	20 [27]	16 [22]
10 by 7.5	15 [20]	12 [16]
10 by 6.6	13 [18]	10 [14]
10 by 5.0	10 [14]	8 [11]
10 by 3.33	7 [10]	5 [7]
10 by 2.50	5 [7]	4 [5]

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A 645/A 645 – 99a) that may impact the use of this standard.

(1) The title of this specification was revised.
(2) 5 % Ni steel was redesignated as Grade A.
(3) A new Grade B, 5½ % Ni steel, was added.
(4) Section 3, Terminology, was deleted and subsequent sections were renumbered.
(5) The names of the heat treatments in sections 5.2.2 and 5.2.3 were revised.
(6) The impact test temperature for Grade A was changed from –275°F [–170°C] to –220°F [–140°C].
(7) Keywords were revised.
(8) Supplementary Requirement S14, Bend Test, was deleted.

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