

# **SPECIFICATION FOR PRESSURE VESSEL PLATES, 5% AND 5½% NICKEL ALLOY STEELS, SPECIALLY HEAT TREATED**



**SA-645/SA-645M**



(Identical with ASTM Specification A645/A645M-10(2016).)

# Standard Specification for Pressure Vessel Plates, 5 % and 5½ % Nickel Alloy Steels, Specially Heat Treated

## 1. Scope

1.1 This specification 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.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 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 Plates 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.

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. Materials and Manufacture

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

## 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 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 5/8 in. [16 mm], or cooled in air or water-quenched to below 300°F [150°C] for nominal plate thicknesses of 5/8 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 A20/A20M.

## 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 3/4 in. [20 mm] and under, the 1 1/2 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 A20/A20M.

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:

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	0.025	0.025
Sulfur, max		
Heat Analysis	0.025	0.010
Product Analysis	0.025	0.015
Silicon		
Heat Analysis	0.20–0.40	0.15–0.30 <sup>A</sup>
Product Analysis	0.18–0.45	0.13–0.33 <sup>A</sup>
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

<sup>A</sup> The specified minimum limit does not apply if the total aluminum is 0.030 % or more, or if the acid soluble aluminum content is 0.025 % or more.

TABLE 2 Tensile Requirements

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

<sup>A</sup> At 0.2 % offset, or, if agreed between the purchaser and the manufacturer, at 0.5 % extension under load.

<sup>B</sup> See Specification A20/A20M for elongation adjustment.

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].

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

## SUPPLEMENTARY REQUIREMENTS

A list of standardized supplementary requirements for use at the option of the purchaser is included in Specification A20/A20M. 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 A20/A20M 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 A435/A435M,

- S11. Ultrasonic Examination in accordance with Specification A577/A577M,
- S12. Ultrasonic Examination in accordance with Specification A578/A578M, 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 A20/A20M.

S64.3 The longitudinal Charpy V-notch impact properties shall not be less than those shown in Table S1.1.

S64.4 The impact values obtained on subsize specimens shall not be less than the values listed in Table S1.1.

### 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 A20/A20M.

**TABLE S1.1 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]

S65.3 The transverse Charpy V-notch impact properties shall not be less than those shown in Table S2.1.

S65.4 The impact values obtained on subsize specimens shall not be less than the values listed in Table S2.1.

**TABLE S2.1 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]