



# Standard Specification for Pressure Vessel Plates, Five Percent Nickel Alloy Steel, Specially Heat Treated<sup>1</sup>

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<sup>2</sup> covers austenitized, quenched, tempered, and reversion-annealed 5 % 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:

A 20/A 20M Specification for General Requirements for Steel Plates for Pressure Vessels<sup>3</sup>

## 3. Terminology

### 3.1 Definitions of Terms Specific to This Standard:

3.1.1 *reversion annealing*—heating to an optimum temperature above the  $A_{c1}$ , followed by quenching or air cooling to develop maximum toughness. This operation is performed subsequent to temperizing.

3.1.2 *temperizing*—heating to an optimum temperature and quenching to develop a microstructure containing some re-

tained austenite and characterized by a lamellar pattern of alternate acicular grains of martensite and ferrite. This operation is performed subsequent to an initial austenitizing and quenching.

## 4. General Requirements and Ordering Information

4.1 Material supplied to this material specification shall conform to Specification A 20/A 20M. These requirements outline the testing and retesting methods and procedures, permissible variations in dimensions and weight, quality and repair of defects, marking, loading, etc.

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

4.3 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:

- 4.3.1 Vacuum treatment,
- 4.3.2 Additional or special tension testing,
- 4.3.3 Impact testing, and
- 4.3.4 Nondestructive examination.

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

4.5 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.

## 5. Materials and Manufacture

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

## 6. Heat Treatment

6.1 All plates shall be heat treated in accordance with 6.2. Shell plates and other parts, including heads and reinforcing pads, which are heated above 1125°F [605°C] for forming, shall be heat treated after forming.

### 6.2 Procedure and Sequence:

#### 6.2.1 Hardening:

<sup>1</sup> 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 A01.11 on Steel for Boilers and Pressure Vessels.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SA-645 in Section II of that Code.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 01.04.



6.2.1.1 The plates shall be heated to a temperature of 1575 to 1675°F [855 to 915°C], held at this temperature 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].

#### 6.2.2 Tempering:

6.2.2.1 The plates shall be reheated to a temperature of 1275 to 1400°F [690 to 760°C], held at this temperature 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].

#### 6.2.3 Reversion Annealing:

6.2.3.1 The plates shall be reheated to a temperature of 1150 to 1225°F [620 to 665°C], held at this temperature 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].

## 7. Chemical Requirements

7.1 The steel shall conform to the requirements as to chemical composition prescribed 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**

Element	Composition, %	
	Heat Analysis	Product Analysis
Carbon, max	0.13	0.15
Manganese	0.30–0.60	0.25–0.66
Phosphorus, max	0.025	0.035
Sulfur, max	0.025	0.035
Silicon	0.20–0.40	0.18–0.45
Nickel	4.75–5.25	4.65–5.35
Molybdenum	0.20–0.35	0.17–0.38
Aluminum, total	0.02–0.12	0.01–0.16
Nitrogen, max	0.020	0.025

## 8. Mechanical Requirements

8.1 *Tension Tests*—The material as represented by tension test specimens shall conform to the requirements prescribed in Table 2.

8.1.1 For nominal plate thicknesses of  $\frac{3}{4}$  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.

#### 8.2 Impact Tests:

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

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

8.2.3 Unless otherwise agreed, tests shall be conducted at –275°F [–170°C].

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

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

## 9. Keywords

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

**TABLE 2 Tensile Requirements**

	ksi [MPa]
Yield strength, min <sup>A</sup>	65 [450]
Tensile strength	95–115 [655 to 795]
Elongation in 2 in. [50 mm], min, % <sup>B</sup>	20.0

<sup>A</sup> At 0.2 % offset. Upon agreement between the purchaser and the manufacturer, yield strength may be determined by the total extension-under-load method, using a total extension of 0.005 in./in. [0.005 mm/mm].

<sup>B</sup> See Specification A 20/A 20M for elongation adjustment.

## 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 Tests,  
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,  
S14. Bend Test, 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.

**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]

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