SPECIFICATION FOR PRESSURE VESSEL PLATES, ALLOY STEEL, CHROMIUM-MOLYBDENUM-VANADIUM

SA-832/SA-832M

(Identical with ASTM Specification A832/A832M-17.)

Standard Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum-Vanadium

1. Scope

1.1 This specification covers chromium-molybdenum-vanadium alloy steel plates intended primarily for the fabrication of welded pressure vessels.

1.2 The plates furnished under this specification are required to be normalized-and-tempered. Specification A542/A542M includes coverage of the material in the quenched-and-tempered condition.

1.3 The maximum thickness of plates furnished to this specification is limited only by the capacity of the composition to meet the specified property requirements.

1.4 The material is intended to be suitable for fusion welding. Welding technique is of fundamental importance and it is presupposed that welding procedures will be in accordance with approved methods.

1.5 This specification is expressed in both inch-pound units and in SI units. However, unless the order specifies the applicable "M" specification designation (SI units), the material shall be furnished to inch-pound units.

1.6 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 must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*

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

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

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

A542/A542M Specification for Pressure Vessel Plates, Alloy Steel, Quenched-and-Tempered, Chromium-Molybdenum, and Chromium-Molybdenum-Vanadium

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, permissible variations in dimensions, 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. Manufacture

4.1 *Steelmaking Process*—The steel shall be made by one of the processes permitted in Specification A20/A20M.

TABLE 1 Tensile Requirements

Tensile strength, ksi, [MPa]	85–110 [585–760]
Yield strength, min, ksi, [MPa]	60 [415]
Elongation in 2 in. [50 mm], min, %[A]	18
Reduction of area, min, %	45[B] 40[C]

[A] See Specification A20/A20M for elongation adjustments.
[B] Measured on round specimen.
[C] Measured on flat specimen.

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

5. Heat Treatment

5.1 All plates shall be normalized and tempered except as allowed by 5.2. The minimum normalizing temperature for Grade 22V shall be 1650°F [900°C]. The minimum normalizing temperature for Grade 23V shall be 1850°F [1010°C]. The minimum tempering temperature shall be 1250°F [675°C].

5.2 Plates ordered without the heat treatment required by 5.1 shall be furnished in either the stress-relieved or the annealed condition. Heat treatment of plates so ordered, to conform to 5.1 and to Table 1, shall be the responsibility of the purchaser.

6. Chemical Composition

6.1 The steel shall conform to the requirements as to chemical composition shown in Table 2.

7. Mechanical Properties

7.1 *Tension Test Requirements:*

7.1.1 The material as represented by the tension test specimens shall conform to the requirements of Table 1.

7.2 *Notch Toughness Requirements:*

7.2.1 A transverse Charpy V-notch test from each plate as heat-treated shall have a minimum energy absorption value of 40 ft·lbf [54 J] average of three specimens and 35 ft·lbf [48 J] for one specimen only in the set.

7.2.2 The notch toughness test temperature shall be 0°F [−18°C].

8. Keywords

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

TABLE 2 Chemical Requirements

NOTE 1—Where ". . ." appears there is no requirement.

Element	Composition, %		
	Grade 21V	Grade 22V	Grade 23V
Carbon			
Heat analysis	0.10–0.15	0.11–0.15	0.10–0.15
Product analysis	0.08–0.18	0.09–0.18	0.08–0.18
Manganese			
Heat analysis	0.30–0.60	0.30–0.60	0.30–0.60
Product analysis	0.25–0.66	0.25–0.66	0.25–0.66
Phosphorus, max	0.025[A]		0.025[A]
Heat analysis	...	0.015	...
Product analysis	...	0.020	...
Sulfur, max	0.025[A]		0.010[A]
Heat analysis	...	0.010	...
Product analysis	...	0.015	...
Silicon, max			
Heat analysis	0.10	0.10	0.10
Product analysis	0.13	0.13	0.13
Chromium			
Heat analysis	2.75–3.25	2.00–2.50	2.75–3.25
Product analysis	2.63–3.37	1.88–2.62	2.63–3.37
Molybdenum			
Heat analysis	0.90–1.10	0.90–1.10	0.90–1.10
Product analysis	0.85–1.15	0.85–1.15	0.85–1.15
Vanadium			
Heat analysis	0.20–0.30	0.25–0.35	0.20–0.30
Product analysis	0.18–0.33	0.23–0.37	0.18–0.33
Titanium			
Heat analysis	0.015–0.035	0.030, max	...
Product analysis	0.005–0.045	0.035, max	...
Boron			
Heat analysis	0.001–0.003	0.0020, max	...
Product analysis	NA[B]	NA[B]	...
Copper, max			
Heat analysis	...	0.20	...
Product analysis	...	0.23	...
Nickel, max			
Heat analysis	...	0.25	...
Product analysis	...	0.28	...
Columbium (Niobium),[C] max			
Heat analysis	...	0.07	0.015–0.070
Product analysis	...	0.08	0.010–0.075
Calcium, max[D]			
Heat analysis	...	0.015	0.0005–0.0150
Product analysis	...	0.020	NA[B]

[A] Applies to both heat analysis and product analysis.
[B] NA = Not Applicable.
[C] Columbium and niobium are interchangeable names for the same element and both names are acceptable for use in A01 specifications.
[D] Rare earth metals (REM) may be added in place of calcium, subject to agreement between the producer and the purchaser. In that case, the total amount of REM shall be determined and reported.

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 is included in Specification A20/A20M. Some of those considered suitable for use with this specification are listed below by title.

S1. Vacuum Treatment,
S2. Product Analysis,
S3. Simulated Post-Weld Heat Treatment of Mechanical Test Coupons,
S4. Additional Tension 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, and
S19. Restricted Chemical Requirements.

ADDITIONAL SUPPLEMENTARY REQUIREMENTS

HIGH TEMPERATURE HYDROGEN SERVICE

In addition, the following supplementary requirements are suitable for this application.

S62. Temper Embrittlement Factor

S62.1 The composition of the steel, based on heat analysis, shall be restricted in accordance with the following equations:

$$J = (\mathrm{Si}+\mathrm{Mn}) \times (\mathrm{P}+\mathrm{Sn}) \times 10^4 \le 150 \quad (\text{Si, Mn, P and Sn in wt \%})$$
$$\mathrm{Cu} \le 0.20\,\%$$
$$\mathrm{Ni} \le 0.30\,\%$$

S62.1.1 Lower values of J, Cu, and Ni can be specified by agreement between purchaser and the supplier.

S62.1.2 When so specified by the purchaser, the maximum value of J shall not exceed 100.

S62.1.3 The values of J shall be reported.

S62.1.4 If the plates are repaired by welding, the composition of the weld deposit shall be restricted in accordance with the following equations:

$$X = (10\mathrm{P}+5\mathrm{Sb}+4\mathrm{Sn}+\mathrm{As})/100 \le 15 \quad (\text{P, Sb, Sn and As in ppm})$$
$$\mathrm{Cu} \le 0.20\,\%$$
$$\mathrm{Ni} \le 0.30\,\%$$

S62.1.5 The values of X shall be reported.

S63. Impact Properties After Step Cooling

S63.1 The Charpy V-notch impact properties shall be determined as follows:

S63.1.1 A sufficient amount of Charpy V-notch test specimens shall be taken from the same location from a plate from each heat of steel to construct two transition temperature curves.

S63.1.2 The test specimens for one transition temperature curve shall be given the minimum post-weld heat treatment (PWHT) cycle specified by the purchaser.

S63.2 The test specimens for the other transition temperature curve shall be given the PWHT cycle specified in S63.1.2 plus the following step cooling heat treatment:

Hold at 1100°F (593°C) for 1 h, then cool at 10°F (5.6°C)/h to 1000°F (538°C).

Hold at 1000°F (538°C) for 15 h, then cool at 10°F (5.6°C)/h to 975°F (524°C).

Hold at 975°F (524°C) for 24 h, then cool at 10°F (5.6°C)/h to 925°F (496°C).

Hold at 925°F (496°C) for 60 h, then cool at 5°F (2.8°C)/h to 875°F (468°C).

Hold at 875°F (468°C) for 100 h, then cool at 50°F (27.8°C)/h to 600°F (315°C).

Cool in still air.

S63.3 Test the Charpy V-notch test specimens in accordance with Test Methods and Definitions A370 to determine the 40-ft-lbs (55 J) transition temperature from each transition temperature curve using a set of three test specimens at each test temperature. The test temperatures shall include tests on the upper and lower shelves and a minimum of four intermediate temperatures.

S63.4 The following requirements shall be met:

$$\mathrm{vTr40} + 2.5\,\Delta\mathrm{vTr40} \le 50°F$$
$$\mathrm{vTr55} + 2.5\,\Delta\mathrm{vTr55} \le 10°C$$

where:

vTr40 (vTR55) = the 40-ft-lbs (55 J) transition temperature of the material subjected to the minimum PWHT specified by the purchaser.

ΔvTr40 (ΔvTr55) = the shift of the 40-ft-lbs (55 J) transition temperature the of the step cooled material. (The 40-ft-lbs (55 J) transition temperature the of the step cooled material minus that of the material subjected to the minimum PWHT only).

S63.5 The 40-ft-lbs (55 J) transition temperatures for the two material conditions shall be reported. (Fig. S1.1)

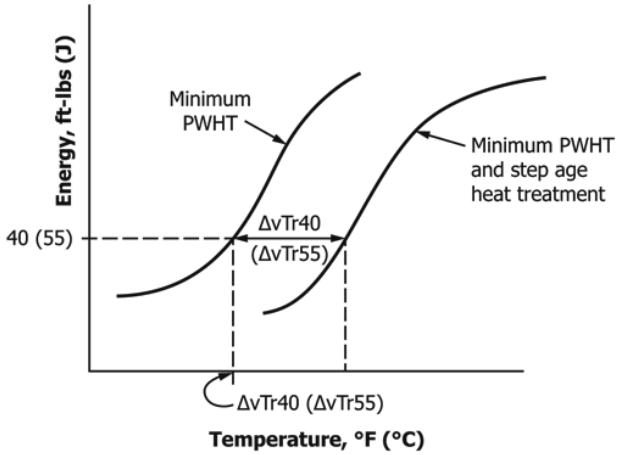

FIG. S1.1 Transition Temperature Curves Before and After Step Cool Heat Treatment

INTENTIONALLY LEFT BLANK