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## Standard Specification for Pressure Vessel Plates, Alloy Steel, Chromium- Molybdenum-Vanadium<sup>1</sup>

This standard is issued under the fixed designation A832/A832M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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<sup>ε1</sup> NOTE—Editorial information was added to Table 2 in September 2015.

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### 1. Scope\***Scope**

1.1 This specification<sup>2</sup> 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. However, the maximum thickness of plates normally furnished under this specification is 6 in. [150 mm].

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.

### 2. Referenced Documents

2.1 *ASTM Standards*:<sup>3</sup>

**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**.

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<sup>1</sup> 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.

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<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-832/SA-832M in Section II of that Code.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto: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

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**.

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

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**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, % <sup>A</sup>	18
Reduction of area, min, %	45 <sup>B</sup> 40 <sup>C</sup>

<sup>A</sup> See Specification **A20/A20M** for elongation adjustments.

<sup>B</sup> Measured on round specimen.

<sup>C</sup> Measured on flat specimen.

**TABLE 2 Chemical Requirements**

NOTE 1—Where “. . .” appears there is no requirement.†

Element	Composition, %		
	Grade 21V	Grade 22V	Grade 23V
	Grade-21V	Grade-22V	Grade-23V
<b>Carbon</b>			
—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
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
<b>Manganese</b>			
—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
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 <sup>A</sup>	...	0.025 <sup>A</sup>
—Heat analysis	...	0.015	...
—Product analysis	...	0.020	...
Phosphorus, max	0.025 <sup>A</sup>	...	0.025 <sup>A</sup>
Heat analysis	...	0.015	...
Product analysis	...	0.020	...
Sulfur, max	0.025 <sup>A</sup>	...	0.010 <sup>A</sup>
—Heat analysis	...	0.010	...
—Product analysis	...	0.015	...
Sulfur, max	0.025 <sup>A</sup>	...	0.010 <sup>A</sup>
Heat analysis	...	0.010	...
Product analysis	...	0.015	...
<b>Silicon, max</b>			
Heat analysis	0.10	0.10	0.10
Product analysis	0.13	0.13	0.13
<b>Chromium</b>			
—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
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
<b>Molybdenum</b>			
—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
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
<b>Vanadium</b>			
—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
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
<b>Titanium</b>			
—Heat analysis	0.015–0.035	0.030, max	...
—Product analysis	0.005–0.045	0.035, max	...
Heat analysis	0.015–0.035	0.030, max	...
Product analysis	0.005–0.045	0.035, max	...
<b>Boron</b>			
—Heat analysis	0.001–0.003	0.0020, max	...
—Product analysis	NA <sup>B</sup>	NA <sup>B</sup>	...
Heat analysis	0.001–0.003	0.0020, max	...
Product analysis	NA <sup>B</sup>	NA <sup>B</sup>	...
<b>Copper, max</b>			
—Heat analysis	...	0.20	...
—Product analysis	...	0.23	...
Copper, max	...	0.28	...
Heat analysis	...	0.20	...
Product analysis	...	0.23	...
<b>Nickel, max</b>			
—Heat analysis	...	0.25	...
—Product analysis	...	0.28	...
Nickel, max	...	0.28	...
Heat analysis	...	0.25	...
Product analysis	...	0.28	...
<b>Columbium, max</b>			
Heat analysis	...	0.07	0.015–0.070
Product analysis	...	0.08	0.010–0.075
<b>Calcium, max<sup>C</sup></b>			
Heat analysis	...	0.015	0.0005–0.0150