



Standard Specification for Pressure Vessel Plates, Alloy Steel, Chromium- Molybdenum¹

This standard is issued under the fixed designation A387/A387M; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification² covers chromium-molybdenum alloy steel plates intended primarily for welded boilers and pressure vessels designed for elevated temperature service.

1.2 Plates are available under this specification in several grades having different alloy contents as follows:

Grade	Nominal Chromium Content, %	Nominal Molybdenum Content, %
2	0.50	0.50
12	1.00	0.50
11	1.25	0.50
22, 22L	2.25	1.00
<u>22</u>	<u>2.25</u>	<u>1.00</u>
21, 21L	3.00	1.00
<u>21</u>	<u>3.00</u>	<u>1.00</u>
5	5.00	0.50
9	9.00	1.00
91	9.00	1.00

1.3 Each grade except Grades ~~21L, 22L,~~ and Grade 91 is available in two classes of tensile strength levels as defined in the Tensile Requirements tables. ~~Grades 21L and 22L are available only as Class 1. Grade 91 is available only as Class 2. Grade 91 is available only as Class 2.~~ Grade 91 consists of two types, with Type 2 differentiated from Type 1 by requiring restricted composition for the enhancement of creep resistance.

NOTE 1—Grade 911, previously covered by this specification, is now covered by Specification **A1017/A1017M**.

1.4 The maximum thickness of plates is limited only by the capacity of the composition to meet the specified mechanical property requirements.

1.5 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 this specification.

1.6 *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:*³

[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](#)

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 Plates for Boilers and Pressure Vessels.

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² For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-387/SA-387M 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

[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

[A1017/A1017M](#) Specification for Pressure Vessel Plates, Alloy Steel, Chromium-Molybdenum-Tungsten

2.2 *AWS Specifications*.⁴

[A5.5/A5.5M](#) Low-Alloy Steel Electrodes for Shielded Metal Arc Welding

[A5.23/A5.23M](#) Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding

[A5.28/A5.28M](#) Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding

[A5.29/A5.29M](#) Low-Alloy Steel Electrodes for Flux Cored Arc Welding

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 and weight, 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 Practice*—The steel shall be killed.

5. Heat Treatment

5.1 Except for Grade 91, all plates shall be thermally treated either by annealing, normalizing and tempering, or, when permitted by the purchaser, accelerated cooling from the austenitizing temperature by air blasting or liquid quenching, followed by tempering. Minimum tempering temperatures shall be as follows:

Grade	Temperature, °F [°C]
2, 12, and 11	1150 [620]
22, 22L, 21, 21L, and 9	1250 [675]
22, 21, and 9	1250 [675]
5	1300 [705]

5.1.1 Grade 91 plates shall be thermally treated, either by normalizing and tempering or by accelerated cooling from the austenitizing temperature by air blasting or liquid quenching, followed by tempering. Grade 91 plates shall be austenitized at 1900 to 1975°F [1040 to 1080°C] and shall be tempered at 1350 to 1470°F [730 to 800°C].

5.2 Grade 5, 9, 21, 21H, 22, 22L, and 91 plates ordered without the heat treatment required by 5.1 shall be furnished in either the stress relieved or the annealed condition.

5.3 For plates ordered without the heat treatment required by 5.1, heat treatment of the plates to conform to 5.1 and to [Table 2](#) or [Table 3](#), as applicable, shall be the responsibility of the purchaser.

6. Chemical Requirements

6.1 The steel shall conform to the requirements as to chemical composition shown in [Table 1](#) unless otherwise modified in accordance with Supplementary Requirement S17, Vacuum Carbon-Deoxidized Steel, in Specification [A20/A20M](#) for grades other than Grade 11.

7. Metallurgical Structure

7.1 *Austenitic Grain Size*—Grade 2 material shall have a coarse austenitic grain size.

8. Mechanical Requirements

8.1 *Tension Test Requirements*:

8.1.1 The material as represented by the tension test specimens shall conform to the applicable requirements of [Table 2](#) or [Table 3](#), as specified on the order.

8.1.2 Adjustment of the percentage elongation requirements is permitted in accordance with Specification [A20/A20M](#) for plates up to ¾ in. [20 mm] inclusive, in thickness when an 8-in. [200-mm] gage length is used.

⁴ Available from American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126, <http://www.aws.org>.

TABLE 1 Chemical Requirements

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

Element	Composition, % Grade and UNS Number								
	Grade 2 S50460	Grade 12 K11757	Grade 11 K11789	Grade 22 K21590	Grade 22L K21590 Grade 21 K31545	Grade 21L K31545 Grade 5 S50200	Grade 9 K90941	Grade 91 K90901-Type 1 K90901	Grade 91 Type 2 K90901
Carbon:									
—Heat analysis	0.05–0.21	0.05–0.17	0.05–0.17	0.05–0.15 ^A	0.10 max 0.05–0.15 ^A	0.10 max	0.15 max	0.15 max	0.08–0.12
Heat analysis	0.05–0.21	0.05–0.17	0.05–0.17	0.05–0.15 ^A	0.05–0.15 ^A	0.15 max	0.15 max	0.08–0.12	0.08–0.12
—Product analysis	0.04–0.21	0.04–0.17	0.04–0.17	0.04–0.15 ^A	0.12 max 0.04–0.15 ^A	0.12 max	0.15 max	0.15 max	0.06–0.15
Product analysis	0.04–0.21	0.04–0.17	0.04–0.17	0.04–0.15 ^A	0.04–0.15 ^A	0.15 max	0.15 max	0.06–0.15	0.06–0.15
Manganese:									
—Heat analysis	0.55–0.80	0.40–0.65	0.40–0.65	0.30–0.60	0.30–0.60	0.30–0.60	0.30–0.60	0.30–0.60	0.30–0.60
Heat analysis	0.55–0.80	0.40–0.65	0.40–0.65	0.30–0.60	0.30–0.60	0.30–0.60	0.30–0.60	0.30–0.60	0.30–0.50
—Product analysis	0.50–0.88	0.35–0.73	0.35–0.73	0.25–0.66	0.25–0.66	0.25–0.66	0.25–0.66	0.25–0.66	0.25–0.66
Product analysis	0.50–0.88	0.35–0.73	0.35–0.73	0.25–0.66	0.25–0.66	0.25–0.66	0.25–0.66	0.25–0.66	0.30–0.50
Phosphorus, max:									
—Heat analysis	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Heat analysis	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.020	0.020
—Product analysis	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Product analysis	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.020
Sulfur, max:									
—Heat analysis	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Heat analysis	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.010
—Product analysis	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Product analysis	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.012	0.012
Silicon:									
—Heat analysis	0.15–0.40	0.15–0.40	0.50–0.80	0.50 max	0.50 max	0.50 max	0.50 max	0.20–0.50	0.20–0.40
Heat analysis	0.15–0.40	0.15–0.40	0.50–0.80	0.50 max	0.50 max	0.50 max	1.00 max	0.20–0.50	0.20–0.40
—Product analysis	0.13–0.45	0.13–0.45	0.44–0.86	0.50 max	0.50 max	0.50 max	1.05 max	0.18–0.56	0.20–0.40
Product analysis	0.13–0.45	0.13–0.45	0.44–0.86	0.50 max	0.50 max	0.55 max	1.05 max	0.18–0.56	0.20–0.40
Chromium:									
—Heat analysis	0.50–0.80	0.80–1.15	1.00–1.50	2.00–2.50	2.00–2.50	2.75–3.25	8.00–10.00	8.00–9.50	8.00–9.50
Heat analysis	0.50–0.80	0.80–1.15	1.00–1.50	2.00–2.50	2.75–3.25	4.00–6.00	8.00–10.00	8.00–9.50	8.00–9.50
—Product analysis	0.46–0.85	0.74–1.21	0.94–1.56	1.88–2.62	1.88–2.62	2.63–3.37	7.90–10.10	7.90–9.60	7.90–9.60
Product analysis	0.46–0.85	0.74–1.21	0.94–1.56	1.88–2.62	2.63–3.37	3.90–6.10	7.90–10.10	7.90–9.60	8.00–9.50
Molybdenum:									
—Heat analysis	0.45–0.60	0.45–0.60	0.45–0.65	0.90–1.10	0.90–1.10	0.90–1.10	0.90–1.10	0.85–1.05	0.85–1.05
Heat analysis	0.45–0.60	0.45–0.60	0.45–0.65	0.90–1.10	0.90–1.10	0.45–0.65	0.90–1.10	0.85–1.05	0.85–1.05
—Product analysis	0.40–0.65	0.40–0.65	0.40–0.70	0.85–1.15	0.85–1.15	0.85–1.15	0.85–1.15	0.80–1.10	0.80–1.10
Product analysis	0.40–0.65	0.40–0.65	0.40–0.70	0.85–1.15	0.85–1.15	0.40–0.70	0.85–1.15	0.80–1.10	0.80–1.05
Nickel, max:									
—Heat analysis	...	...	...	...	...	...	...	0.40	...
Heat analysis	...	...	...	...	...	...	...	0.40	0.20
—Product analysis	...	...	...	...	...	...	...	0.43	...
Product analysis	...	...	...	...	...	...	...	0.43	0.20
Vanadium:									
—Heat analysis	...	...	...	...	...	...	0.04 max	0.18–0.25	...
Heat analysis	...	...	...	...	...	...	0.04 max	0.18–0.25	0.18–0.25
—Product analysis	...	...	...	...	...	...	0.05 max	0.16–0.27	...

Element	Composition, % Grade and UNS Number							Grade 91 K90901-Type 1 K90901	Grade 91 Type 2 K90901
	Grade 2 S50460	Grade 12 K11757	Grade 11 K11789	Grade 22 K21590	Grade 22L K21590 Grade 21 K31545	Grade 21L K31545 Grade 5 S50200	Grade 9 K90941		
Product analysis	0.05 max	0.16-0.27	0.16-0.27
Columbium:									
Columbium (niobium): ^B									
—Heat analysis	0.06-0.10	...	...
Heat analysis	0.06-0.10	0.06-0.10
—Product analysis	0.05-0.11	...	...
Product analysis	0.05-0.11	0.05-0.11
Boron:									
—Heat analysis
Boron, max ^C	0.001
—Product analysis
Nitrogen:									
—Heat analysis	0.030-0.070	...
Heat analysis	0.030-0.070	0.035-0.070
—Product analysis	0.025-0.080	...
Product analysis	0.025-0.080	0.035-0.070
Aluminum, max:									
—Heat analysis
Nitrogen/aluminum	0.02	...
Aluminum, max ^C	≦ 4.0	...
—Product analysis	0.02	0.020
Titanium, max ^C	0.02	0.021
Titanium, max:								0.01	...
Zirconium, max ^C	0.01	0.01
—Heat analysis
Tungsten, max ^C	0.04	...
—Product analysis	0.05	...
Copper, max ^C	0.04	...
Zirconium, max:								0.10	...
Antimony, max ^C	0.003	...
—Heat analysis	0.04
Arsenic, max ^C	0.010	...
—Product analysis	0.04
Tin, max ^C	0.010	...

^A The carbon content for plates over 5 in. [125 mm] in thickness is 0.17 max on product analysis.
^B Columbium and niobium are interchangeable names for the same element and both names are acceptable for use in A01 specifications.
^C Applies to both heat and product analysis.

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