



Designation: A 841/A 841M – 03

Standard Specification for Steel Plates for Pressure Vessels, Produced by Thermo- Mechanical Control Process (TMCP)¹

This standard is issued under the fixed designation A 841/A 841M; 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 specification² covers steel plates produced by the thermo-mechanical control process (TMCP). The plates are intended primarily for use in welded pressure vessels.

1.2 The TMCP method consists of rolling-reduction and cooling rate controls that result in mechanical properties in the finished plate that are equivalent to those attained using conventional rolling and heat treating processes, which entail reheating after rolling. A description of the TMCP method is given in Appendix X1.

1.3 Due to the inherent characteristics of the TMCP method, the plates cannot be formed at elevated temperatures without sustaining significant losses in strength and toughness. The plates may be formed and post-weld heat-treated at temperatures not exceeding 1200°F [650°C], providing the requirements of 6.1 are met.

1.4 The maximum permitted nominal thickness of plates furnished to this specification is 4 in. [100 mm] for Grades A, B, and C; and 1.5 in. [40 mm] for Grades D³, E, and F.

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.

2. Referenced Documents

2.1 ASTM Standards:

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.

Current edition approved April 10, 2003. Published June 2003. Originally approved in 1985. Last previous edition approved in 2001 as A 841/A 841M – 01.

² For ASME Boiler and Pressure Vessel Code applications, see related Specification SA-841/SA-841M in Section II of that Code.

³ ExxonMobil Upstream Research Company has patents pending concerning the use of chemistry ranges in ASTM A 841 Grade D, in combination with specific TMCP routes and/or specific microstructural features. Interested parties are invited to submit information regarding identification of alternatives to these patented items to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

A 20/A 20M Specification for General Requirements for Steel Plates for Pressure Vessels⁴

A 435/A 435M Specification for Straight-Beam Ultrasonic Examination of Steel Plates⁴

A 577/A 577M Specification for Ultrasonic Angle-Beam Examination of Steel Plates⁴

A 578/A 578M Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications⁴

3. General Requirements and Ordering Information

3.1 Plates supplied to this product specification shall conform to Specification A 20/A 20M, which outlines the testing and retesting methods and procedures, permissible variations in dimensions, quality and repair of defects, marking, loading, etc.

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

3.2.1 If the plates are to be subjected to warm forming or post-weld heat treatment, the order must indicate the temperatures and times-at-temperature that will be utilized in such operations. (See 6.1 and Specification A 20/A 20M, Supplementary Requirement S3.)

3.3 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:

3.3.1 Vacuum treatment,

3.3.2 Additional or special tension testing,

3.3.3 Additional or special impact testing, and

3.3.4 Nondestructive examination.

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

3.5 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.

⁴ Annual Book of ASTM Standards, Vol 01.04.

***A Summary of Changes section appears at the end of this standard.**

 **A 841/A 841M – 03**

4. Manufacture

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

4.2 The plates shall be produced by the thermo-mechanical control process.

5. Chemical Composition

5.1 The chemical composition on heat analysis shall conform to the requirements given in Table 1, except as otherwise provided in Supplementary Requirement S17 of Specification A 20/A 20M when that requirement is involved.

5.2 If a product analysis is made on a sample taken from the standard location (see Specification A 20/A 20M), the results of the analysis shall not deviate from the limits for the heat analysis by more than the values given in Table 2.

6. Mechanical Requirements

6.1 If the plates are to be subjected to warm forming or post-weld heat treatment, the test coupons shall be subjected to heat treatment to simulate such fabrication operations. (See 3.2.1 and Specification A 20/A 20M, Supplementary Requirement S3.)

6.2 *Tension Test Requirements*—The plates as represented by the tension-test specimens shall conform to the requirements given in Table 3.

6.2.1 *Number and Location of Test Coupons*—Two tension tests shall be made from each plate-as-rolled. One test coupon shall be taken from a corner of the plate on each end.

6.3 *Notch Toughness Test Requirements:*

6.3.1 Longitudinal Charpy V-notch tests shall be made in accordance with Specification A 20/A 20M.

6.3.2 For Grades A, B and C, unless the test temperature and absorbed energy requirements are specified in the purchase order, the tests shall be conducted at –40°F [–40°C] and the average absorbed energy for each set of three full size specimens shall be 15 ft-lb [20J] or more.

6.3.3 For Grade D, unless the test temperature and the lateral expansion requirements are specified in the purchase order, the tests shall be conducted at –40°F [–40°C] and the lateral expansion for each specimen shall be 0.015 in. [0.4 mm] or more.

6.3.4 For Grades E and F, unless the test temperature and absorbed energy requirements are specified in the purchase order, the tests shall be conducted at –40°F [–40°C] and the

TABLE 1 Chemical Requirements

Element	Composition %					
	Grade A	Grade B	Grade C	Grade D	Grade E	Grade F
Carbon, max	0.20	0.15	0.10	0.09	0.07	0.10 ^A
Manganese						
t ≤ 1.5 in. [40 mm]	0.70–1.35 ^B	0.70–1.35 ^B	0.70–1.60	1.00–2.00	0.70–1.60	1.10–1.70 ^A
t > 1.5 in. [40 mm]	1.00–1.60	1.00–1.60	1.00–1.60	^C	^C	^C
Phosphorus, max	0.030	0.030	0.030	0.010	0.015	0.020
Sulfur, max	0.030	0.025	0.015	0.005	0.005	0.008
Silicon	0.15–0.50	0.15–0.50	0.15–0.50	0.05–0.25	0.05–0.30	0.10–0.45
Copper, max	0.35	0.35	0.35	0.50	0.35	0.40
Nickel	0.25 max	0.60 max	0.25 max	1.0–5.0	0.60 max	0.85 max
Chromium, max	0.25	0.25	0.25	0.30	0.30	0.30
Molybdenum, max	0.08	0.30	0.08	0.40	0.30	0.50
Columbium, max	0.03	0.03	0.06	0.05	0.08	0.10
Vanadium, max	0.06	0.06	0.06	0.02	0.06	0.09
Titanium	^D	^D	0.006–0.02	0.006–0.03	^D	^E
Boron	...	...	...	0.0005–0.002	0.0007 max	0.0007 max
Aluminum, min	0.020 total or 0.015 acid soluble ^D	0.020 total or 0.015 acid soluble ^D	...	...	0.020 total or 0.015 acid soluble ^D	0.020 total or 0.015 acid soluble ^E

^AFor each reduction of 0.01 percentage point below the specified maximum for carbon, an increase of 0.06 percentage points above the specified maximum for manganese is permitted, up to a maximum of 1.85 %.

^BManganese may exceed 1.35 % on heat analysis, up to a maximum of 1.60 %, provided that the carbon equivalent on heat analysis does not exceed 0.47 %, or the value specified in Supplementary Requirement S77 when that requirement is invoked, when based on the following formula:

$$CE = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15 \%$$

When this option is exercised, the manganese content on product analysis shall not exceed the heat analysis content by more than 0.12 percentage points.

^CNot applicable.

^DBy agreement, the steel may be produced with titanium, in which case the minimum aluminum content shall not apply. When this option is exercised, the titanium content, by heat analysis, shall be 0.006 % to 0.02 %, and the actual titanium content shall be reported on the test report.

^EBy agreement, the steel may be produced with titanium, in which case the minimum aluminum content shall not apply. When this option is exercised, the titanium content, by heat analysis, shall be 0.006 % to 0.03 %, and the actual titanium content shall be reported on the test report.

 **A 841/A 841M – 03**

TABLE 2 Product Analysis Tolerances

Element	Specified Limit, %	Tolerances, %	
		Under Minimum Limit	Over Maximum Limit
Carbon	to 0.15, incl	0.02	0.03
	over 0.15	0.03	0.04
Manganese	to 0.60, incl	0.05	0.06
	over 0.60 to 0.90, incl	0.06	0.08
	over 0.90 to 1.20, incl	0.08	0.10
	over 1.20 to 1.35, incl	0.09	0.11
	over 1.35 to 1.65, incl	0.09	0.12
Phosphorus	to 0.020, incl	...	0.005
	over 0.020	...	0.010
Sulfur	to 0.020, incl	...	0.005
	over 0.020	...	0.010
Silicon	to 0.30, incl	0.02	0.03
	over 0.30 to 0.40, incl	0.05	0.05
	over 0.40	0.06	0.06
Nickel	to 1.00, incl	0.03	0.03
	over 1.0 to 2.0, incl	0.05	0.05
	over 2.0 to 3.8, incl	0.07	0.07
	over 3.8	0.08	0.08
Chromium	to 0.90, incl	0.04	0.04
Molybdenum	to 0.20, incl	0.01	0.01
	over 0.20	0.03	0.03
Copper	to 1.00, incl	0.03	0.03
Vanadium	to 0.10, incl	0.01	0.01
Columbium	to 0.10, incl	0.01	0.01
Aluminum	to 0.15, incl	0.005	0.01
Titanium	to 0.010, incl	0.002	0.01
	over 0.010	0.01	0.01
Boron	any	^A	^A

^AProduct analysis is not applicable for this element.

average absorbed energy for each set of three full size specimens shall be 20 ft-lb [27 J] or more.

7. Marking

7.1 In addition to the marking required in Specification A 20/A 20M, each plate shall be legibly stamped with the letters “TMC” following the stamped specification designation.

8. Keywords

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

TABLE 3 Tensile Requirements

	Grades A, B, and C		Grade D	Grade E		Grade F		
	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8
Yield strength, min, ksi [MPa]								
to 1.5 in. [40 mm] incl	50 [345]	60 [415]	100 [690]	70 [485]	75 [515]	70 [485]	75 [515]	80 [550]
over 1.5 in. [40 mm] to 2.5 in. [to 65 mm]	50 [345]	60 [415]	^A	^A	^A	^A	^A	^A
over 2.5 in. [over 65 mm]	45 [310]	55 [380]	^A	^A	^A	^A	^A	^A
Tensile strength, ksi [MPa]								
to 1.5 in. [40 mm] incl	70–90 [480–620]	80–100 [550–690]	145–170 [1000–1170]	84–104 [580–715]	88–108 [605–745]	82–102 [565–705]	86–106 [590–730]	90–110 [620–760]
over 1.5 in. [40 mm] to 2.5 in. [to 65 mm]	70–90 [480–620]	80–100 [550–690]	^A	^A	^A	^A	^A	^A
over 2.5 in. [over 65 mm]	65–85 [450–585]	75–95 [515–655]	^A	^A	^A	^A	^A	^A
Elongation in 2 in. [50 mm], min, % ^B								
to 1.5 in. [40 mm] incl	22	22	13	20	19	20	19	18
over 1.5 in. [40 mm] to 2.5 in. [to 65 mm]	22	22	^A	^A	^A	^A	^A	^A
over 2.5 in. [over 65 mm]	22	22	^A	^A	^A	^A	^A	^A
Elongation in 8 in. [200 mm], min, % ^B								
to 1.5 in. [40 mm] incl	18	...	...	16	15	16	15	14
over 1.5 in. [40 mm] to 2.5 in. [to 65 mm]	18	...	^A	^A	^A	^A	^A	^A
over 2.5 in. [over 65 mm]	18	...	^A	^A	^A	^A	^A	^A

^A Not applicable.

^B See Specification A 20/A 20M for elongation requirement adjustments.