

Steel Plates Produced by Thermo-Mechanically Controlled Processing for Offshore Structures

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Steel Plates Produced by Thermo-Mechanically Controlled Processing for Offshore Structures

1 Scope

1.1 Coverage

This specification covers four grades of steel plates that are to be produced by thermo-mechanically controlled processing (TMCP) for use in welded construction of offshore structures.

1.2 Application of the API Monogram

If the product is manufactured at a facility licensed by API and is intended to be supplied bearing the API Monogram, the requirements of Annex A apply.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda or errata) applies.

API Recommended Practice 2Z, *Preproduction Qualification for Steel Plates for Offshore Structures*

ASTM¹ A6/A6M, *Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling*

ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A578/A578M, *Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications*

ASTM A673, *Standard Terminology Relating to Surface Analysis*

ASTM E10, *Standard Test Method for Brinell Hardness of Metallic Materials*

ASTM E23, *Standard Test Methods for Notched Bar Impact Testing of Metallic Materials*

ASTM E208, *Standard Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels*

3 Abbreviations

ACC accelerated cooling

CP conventional preheat

CR controlled rolling

¹ American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959, www.astm.org.

CTOD	crack tip opening displacement
CTS	controlled thermal severity
MP	modified preheat
SMYS	specified minimum yield strength
SR	supplementary requirement
TMCP	thermo-mechanically controlled processing
TMR	thermo-mechanical rolling

4 Manufacturing

4.1 Steelmaking Practice

The steel shall be made by the basic oxygen or electric furnace process.

4.2 Rolling

4.2.1 The plates shall be produced by TMCP. A general description of the TMCP method is given in Annex B.

4.2.2 One of the following processes used to manufacture the plate shall be identified on the mill certificates:

- a) thermo-mechanical rolling (TMR) alone (but may also include CR);
- b) TMR combined with accelerated cooling (ACC);
- c) TMR combined with tempering or aging; or
- d) TMR combined with both ACC and tempering or aging.

The manufacturer's process shall be identified with a code number or designation for ready reference, sufficient to provide traceability of process variables; it is not the intent to require the disclosure of confidential information.

When SR 9 is required, the addition or deletion of tempering or aging shall be considered a major essential variable (reference API 2Z table on *Tolerances for Minor and Major Changes in Melting, Casing, and Processing Variables Other Than Chemistry*). If SR 9 is not required, addition or deletion of tempering or aging shall be at the discretion of the manufacturer. When tempering or aging is performed, the tempering or aging temperature shall be included on the mill certificates.

4.3 Post-manufacturing Heating

Plates manufactured to this specification shall not be warm formed or post-weld heat treated at temperatures:

- a) above 1100 °F (595 °C); or
- b) more than 50 °F (38 °C) below the original manufacturing tempering or aging temperature (if applicable) due to risk of sustaining irreversible and significant losses in strength and toughness.

Post-weld heat treatment or warm-forming temperatures between 400 °F (205 °C) and either of the above shall require testing to SR 7 in Annex C. Verification or simulation is not necessary for heating at temperatures below 400 °F (205 °C).

4.4 Preproduction Qualification

The SR 9 supplement in Annex C shall require testing in accordance with the plate preproduction qualification requirements of API 2Z. These tests evaluate HAZ hydrogen cracking resistance and CTOD HAZ toughness that may be desirable for demonstrating superior service performance. The SR 9 supplement shall require contractual specification prior to steel production. For Grades 50 and 60, SR 9 is optional. For Grades 70 and 80, SR 9 shall be required.

4.5 General Requirements for Delivery

Material furnished to this specification shall conform to the applicable requirements of ASTM A6/A6M, as modified herein. See Annex D for suggestions when ordering API 2W steel plates.

5 Chemical Requirements

5.1 The steels shall conform to the requirements for chemical composition, as determined by heat analysis, prescribed in Table 1 and to the requirements of 5.2 through 5.5. All elements intentionally added, and any element listed in 5.2 or Table 1, shall be included in the heat analysis for the steel.

Table 1—Chemical Requirements (Heat Analysis, %)

Element	Grades 50	Grade 60	Grades 70	Grade 80
Carbon, max	0.12	0.12	0.10	0.10
Manganese	1.15–1.60 ^a	1.15–1.60 ^a	2.0 max	2.0 max
Phosphorus, max	0.020	0.020	0.020	0.020
Sulfur, max	0.010	0.010	0.010	0.010
Silicon	0.05–0.50 ^b	0.05–0.50 ^b	0.50 max	0.50 max
Nickel, max	0.75	1.0	1.50	1.50
Chromium, max	0.25	0.25	0.60	0.60
Molybdenum, max	0.08 ^c	0.15 ^c	0.50	0.50
Copper, max	0.5	0.5	0.70	1.1
Titanium				
N ≤ 0.005	0.003–0.02	0.003–0.02	0.003–0.02	0.003–0.02
N > 0.005	0.007–0.02	0.007–0.02	0.007–0.02	0.007–0.02
Columbium (Niobium), max	0.04	0.04	0.050	0.050
Nitrogen, max	0.009 ^d	0.009 ^d	0.009	0.009
Boron, max	0.0005	0.0005	0.0005	0.0005
Aluminum ^e				
Acid soluble or	0.015–0.055	0.015–0.055	0.015–0.055	0.015–0.055
total	0.02–0.06	0.02–0.06	0.02–0.06	0.02–0.06

^a With the API 2Z preproduction qualification report, the max Mn value can be increased up to 2.00 %.

^b Silicon may be less than 0.05% if included in the SR 9 preproduction qualification.

^c For Grades 50 and 60, when $P_{cm} \leq$ Table 2 and C is $\leq$ 0.10 %, with the API 2Z preproduction qualification report, the max Mo value can be 0.21 %.

^d For Grades 50 and 60, nitrogen may be 0.013 % max if titanium is 0.010–0.02 %.

^e When non-Al deoxidation elements are used in accordance with this table, the minimum Al value is not applicable when the SR 9 preproduction qualification has been performed.