

Specification for Carbon Manganese Steel Plate with Improved Toughness for Offshore Structures

API SPECIFICATION 2MT1 (SPEC 2MT1)
SECOND EDITION, SEPTEMBER 2001

EFFECTIVE DATE: MARCH 2002



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Upstream Segment

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FOREWORD

This specification is under the jurisdiction of the API Subcommittee on Standardization of Offshore Structures.

The purpose of this specification is to provide standards for the purchase of as rolled steel plate with improved toughness suitable for use in selected applications on offshore platforms.

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CONTENTS

	Page
1 SCOPE	1
1.1 Coverage	1
1.2 Primary Application	1
2 REFERENCES	1
3 GENERAL REQUIREMENTS FOR DELIVERY	1
3.1 Applicable Reference Specifications	1
3.2 Visual Examination	1
3.3 Mill Test Certificates	1
4 MANUFACTURING	1
4.1 Delivery Conditions	1
4.2 Plate Retreatment	1
4.3 Manufacturing Procedure Specification	1
5 CHEMICAL REQUIREMENTS	2
5.1 Chemical Composition	2
5.2 Carbon Equivalent	2
5.3 Reporting Additional Elements	2
5.4 Restricted Elements	2
5.5 Additional Marking	2
6 MECHANICAL REQUIREMENTS	2
6.1 Tensile Requirements	2
6.2 Test Frequency	2
6.3 Retesting Options	2
6.4 Heat Requalification	3
6.5 Retesting of Rejected Material	3
6.6 Retreatment	3
7 NOTCH TOUGHNESS REQUIREMENTS	3
7.1 Charpy V-notch Impact Tests	3
7.2 Retest Conditions	3
7.3 Heat Requalification	3
7.4 Retesting of Rejected Material	3
7.5 Retreatment	3
8 MARKING	3
8.1 Plate Marking	3
Tables	
1 Chemical Requirements, Heat Analysis	2
2 Tensile Requirements	2
3 Notch Toughness Requirements Charpy V-Notch Testing	3
APPENDIX A SUGGESTIONS FOR ORDERING API 2MT1 STEEL PLATE	5

Specification for Carbon Manganese Steel Plate with Improved Toughness for Offshore Structures

1 Scope

1.1 COVERAGE

This specification covers one grade of intermediate strength steel plates, though 2¹/₂ in. thick, for use in welded construction of offshore structures. These steels are intended for fabrication primarily by cold forming and welding as per API Spec 2B. The welding procedure is of fundamental importance, and it is presumed that procedures will be suitable for the steels and their intended service. Conversely, the steel should be amendable to fabrication and welding under shipyard and offshore conditions. These steels are suitable for use in selected portions of offshore structures, which must resist impact and plastic fatigue loading. When hot or warm forming or PWHT above 1100°F is anticipated for accelerated cooling (AC) or quenched and tempered (QC) plates, S9 should be invoked, (*italics added per ASTM A913*).

1.2 PRIMARY APPLICATION

The primary use of these steels is for Class “B” applications as defined in API RP 2A. API Specs 2H, 2W, and 2Y cover other steels providing improved mechanical properties and toughness for Class “A” applications and should be used where substantial z-direction stresses are expected.

2 References

The applicable editions of standards referenced herein are as follows:

API

Spec 2B *Fabrication of Structural Steel Pipe*

ASTM¹

A6/A6M-01 *Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling*

A370-97a *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

A578/
A578M-96 *Standard Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications*

A673/
A673M-95 *Standard Specification for Sampling Procedure for Impact Testing of Structural Steel*

¹ASTM, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428.

E23-00

Standard Test Method for Notched Bar Impact Testing of Metallic Materials

3 General Requirements for Delivery

3.1 APPLICABLE REFERENCE SPECIFICATIONS

Material furnished to this specification shall conform to ASTM A6/A6M-01 and shall be marked as specified in Section 8 of this specification.

If a conflict occurs between ASTM A6 and API Spec 2MT1, API Spec 2MT1 shall take precedence.

3.2 VISUAL EXAMINATION

Visual examination for defects shall be performed on all surfaces (ASTM A6/A6M-01 Section 9).

3.3 MILL TEST CERTIFICATES

Mill test certificates are required for all API Spec 2MT1 steel plate. See paragraphs 5.2, 5.3, 5.4, 6.1 and 7.1.

4 Manufacturing

4.1 DELIVERY CONDITIONS

All plates shall be delivered in the as-rolled (hot rolled or controlled rolled), TMCP, normalized, or quenched and tempered condition except as noted in 4.2 below.

4.2 PLATE RETREATMENT

Plates that fail to meet the minimum specified mechanical requirements in the as-rolled condition may be heat treated either by normalizing or quenching and tempering treatments. For quenched and tempered treatment, the plate shall be heated to a temperature between 1550°F (845°C) and 1700°F (925°C) to produce an austenitic structure, held a sufficient time to obtain uniform structure throughout, quenched in a suitable medium, then tempered in the range of 1050°F to 1250°F (565°C to 675°C) for a suitable time to obtain the specified mechanical properties.

4.3 MANUFACTURING PROCEDURE SPECIFICATION

The manufacturer shall provide the purchaser with the proposed manufacturing approach (i.e., thermal treatment), and, when requested, with the Manufacturing Procedure Specification (MPS). If additional detail for MPS is required, see S-15.

Table 1—Chemical Requirements, Heat Analysis

REQUIREMENT, WT. %		REQUIREMENT, WT. %	
Element	Grade 2MT1	Element	Grade 2MT1
Carbon, max.	0.12	Titanium, max.	0.020 ^a
Manganese	1.15 – 1.60	Aluminum, total ^c	0.020 – 0.060
		Aluminum, soluble ^c	0.015 – 0.055
Phosphorous, max.	0.030	Nitrogen, max.	0.012 ^b
Sulfur, max.	0.010	Vanadium, max.	0.080 ^a
Silicon	0.10 – 0.40	Zirconium ^c	
		Boron, max.	0.0005 ^b
Niobium	0.010 – 0.040	Cerium, max. ^d	0.010

^a Minimum values, if any, shall be as agreed upon and states on the order.

^b Shall not be intentionally added.

^c Shall not be intentionally added without the specific approval of the purchaser, in which case the limiting values for heat and product analyses shall be as agreed upon and stated on the order.

^d Shall not be intentionally added without specific approval of the purchaser. Analysis not required if cerium or “rare earths” not intentionally added.

^e Analyze for either total OR soluble aluminum.

5 Chemical Requirements

5.1 CHEMICAL COMPOSITION

The steel shall conform to the requirements for chemical composition as prescribed in Table 1 and to the additional requirements of 5.2.

5.2 CARBON EQUIVALENT

5.2.1 The Carbon Equivalent (CE_{IIW}) and P_{cm} shall be calculated and reported based on heat analysis. The CE_{IIW} shall be determined by the following formula:

$$CE_{IIW} = C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$$

The P_{cm} shall be determined by the following formula:

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn + Cu + Cr}{20} + \frac{Ni}{60} + \frac{Mo}{5} + \frac{V}{10} + 5B$$

5.2.2 The maximum CE_{IIW} and P_{cm} shall be as follows:

Grade	Thickness	$CE_{IIW} \max$	$P_{cm} \max$
2MT1	to 2 in. incl.	0.43	0.24
	over 2 in. to 2 1/2 in. incl.	0.45	0.25

Lower CE_{IIW} or P_{cm} may be specified by agreement between purchaser and manufacturer.

5.3 REPORTING ADDITIONAL ELEMENTS

Any element intentionally added and all elements in the CE_{IIW} and P_{cm} formulas shall be reported.

5.4 RESTRICTED ELEMENTS

Boron, zirconium, cerium and other rare earth metals shall not be intentionally added without the specific approval of the purchaser.

5.5 ADDITIONAL MARKING

If any of the elements listed in 5.4 are added, the plate must be given additional markings, per Section 8.1.d.

6 Mechanical Requirements

6.1 TENSILE REQUIREMENTS

The material, as represented by the test specimens, shall conform to the tensile requirements given in Table 2. Testing shall be according to ASTM A370.

6.2 TEST FREQUENCY

Tensile testing frequency shall be defined in paragraph 11.4 of ASTM A6.

6.3 RETESTING OPTIONS

If one of more of the initial tension tests fail to meet the retest conditions as shown in ASTM A6 paragraph 15 or purchase order requirements, all plates of the same thickness as the original failed test are considered rejected and all plates from the heat are rejected except as may be requalified by 6.4.

Table 2—Tensile Requirements

Property	Grade 2MT1
Yield Strength, ksi, (MPa), min. t ≤ 2.5 in.	50 (345)
Tensile Strength, ksi (MPa)	65 – 90 (448 – 620)
Elongation, %, min in 2 in. or 50 mm	23
in 8 in. or 200 mm	18

6.4 HEAT REQUALIFICATION

Plates from a rejected heat may be requalified by testing the next thickest plate gage or as described in 6.5 and 6.6.

6.5 RETESTING OF REJECTED MATERIAL

At the option of the manufacturer or processor, retests may be made on rejected material. In this case, each plate as-rolled must be tested. Acceptance or rejection of each plate as-rolled shall be on the basis of the result of its own test results.

6.6 RETREATMENT

At the option of the manufacturer or processor, plates within lots or individually tested plates that fail to meet test requirements in the as-rolled condition may be heat treated after which each plate in the as-heat-treated condition shall be tested. Marking shall be according to Section 8.

7 Notch Toughness Requirements

7.1 CHARPY V-NOTCH IMPACT TESTS

Impact tests shall be Charpy V-Notch tests. The location of the impact specimens shall be adjacent to the thinnest and thickest tension test piece representing each heat, except that in heats from which less than 50 tons is furnished, one test will suffice.

Three transverse specimens shall be tested in accordance with ASTM A673 Frequency (H). Specimen size, test temperature, and energy requirements are shown in Table 3. Testing shall be per ASTM A370.

7.2 RETEST CONDITIONS

If the average energy value for three specimens is below the average values specified, or if the energy value of one specimen is less than the minimum energy value specified for a single specimen, retests may be made as follows:

7.2.1 Retest three additional specimens, each of which must equal or exceed the minimum average energy value specified.

7.2.2 If the required energy values are not obtained upon retest, all plates of the same thickness as the failed test shall be considered rejected and the heat shall not be qualified except as may be requalified by 7.3.

Table 3—Notch Toughness Requirements
Charpy V-Notch Testing

Grade	Specimen Size	Minimum Avg. Energy ft-lb (<i>J</i>)	Minimum Single Value ft-lb (<i>J</i>)	Test Temp. °F (°C)
2MT1	10 × 10 mm	30 (41)	25 (34)	9 (-18)

7.3 HEAT REQUALIFICATION

Plates from a rejected heat may be requalified by testing the next thickest plate gage or as described in 7.4 and 7.5.

7.4 RETESTING OF REJECTED MATERIAL

At the option of the manufacturer or processor, retests may be made on rejected material in this case each plate as-rolled must be tested. Acceptance or rejection of each plate as-rolled shall be on the basis of the result of its own test results.

7.5 RETREATMENT

At the option of the manufacturer or processor, plates within lots or individually tested plates that fail to meet test requirements in the as-rolled condition may be heat treated after which each plate in the as-heat-treated condition shall be tested. Marking shall be according to Section 8.

8 Marking

8.1 PLATE MARKING

Plate furnished to this specification be marked the plate manufacturer in accordance with Sections 12 and 19 of ASTM A6/A6M, with the addition of the following:

- The API monogram may be applied to products complying with the requirements of the specification and only by authorized manufacturers. Grade 2MT1 shall be marked API 2MT1.
- Plates furnished in the *as-rolled* condition require no additional marking; plates furnished normalized shall be marked with the suffix “N”; quenched and tempered plates shall be marked with the suffix “QT”; plates produced with accelerated cooling form of TMCP shall be marked with the suffix “AC”; e.g., a normalized Grade 2MT1 plate would be marked “API 2MT1-N”.
- If any elements previously referenced in Section 5.4 are added to the plate, the plate shall be marked with a “C” adjacent to the 2MT1 in the markings listed in Section 8.1.b (e.g., API C-2MT1).

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APPENDIX A—SUGGESTIONS FOR ORDERING API 2MT1 STEEL PLATE

In placing orders for steel plate to be manufactured in accordance with API Spec 2MT1, the purchaser should specify the following on an inquiry and the purchase order:

Specification	API Spec 2MT1
Quantity/Size	As required
Grade	2MT1
Chemical Requirements (see Table 1, Footnotes b and d)	State whether use of boron and/or zirconium is permitted and, if permitted, state limits
Mill Inspection by Purchaser	State advance notice requirements
Delivery Date and Shipping Instructions	As required
Supplementary Requirements	State if required
Manufacturer's Procedure Specification (MPS)	

The purchaser should state on the purchase order the requirements concerning the following supplementary requirements which are optional with the *purchaser*:

S-1	ULTRASONIC EXAMINATION	<input type="checkbox"/>
S-9	SIMULATED POST-WELD HEAT TREATMENT	<input type="checkbox"/>
S-13	SURFACE QUALITY	<input type="checkbox"/>
S-14	THICKNESS TOLERANCE	<input type="checkbox"/>
S-15	MANUFACTURING PROCEDURE SPECIFICATION	<input type="checkbox"/>

Note: Nothing in this specification should be interpreted as indicating a preference for any material or process. In the selection of materials and processes, the purchaser must be guided by the purchaser's experience and by the service for which the plate is intended.

SUPPLEMENTARY REQUIREMENTS

These requirements shall not apply unless specified in the order in which case the manufacturer or processor shall perform the specified supplementary requirement before shipment of the material. Supplementary requirement S-1 provides for ultrasonic examination of the plates by the manufacturers and specifies limits for acceptance.

Supplementary Requirement S-9 provides for simulated post-weld heat treatment of test samples. The purchaser should specify on the purchase order the temperature range, time at temperature, and cooling rate.

Supplementary Requirement S-13 may be applied where surface quality is considered critical.

Supplementary Requirement S-14 may be applied to reduce the standard over thickness tolerance.

Supplementary Requirement S-15 may be applied if additional details of the manufacturing procedure or process are required by the purchaser.

By agreement between the purchaser and manufacturer, and when specified on the purchase order, the following Supplementary Requirements shall apply:

S-1 Ultrasonic Examination

S1.1 Pulse echo ultrasonic examination shall be performed on each plate in accordance with ASTM Specification A 578/A 578M. Acceptance Level II shall be used.

S1.2 Examination reports shall be furnished for each plate, and areas with more than 50% loss of back reflection shall be located on a sketch.

S-9 Simulation of Postweld Heat Treatment

A second test of test coupons shall be subjected to a simulated postweld heat treatment provided by the purchaser that is representative of the thermal treatment to which the material will be subjected during fabrication. The temperature range, time at temperature, and cooling rate shall be as specified on the order.

S-13 Surface Quality

For applications where surface quality is considered critical, plates are to be furnished in the blasted and inspected conditions. The depth of rolled-in scale or clusters of pits shall not exceed 0.015 in. and shall not result in an undergage condition. However, isolated individual pits not over 0.030 in. deep are acceptable provided plate thickness is not reduced below the specified minimum. Other surface imperfections such as tears, seams, snakes, blisters, scabs, etc., are not acceptable and must be conditioned without reducing the thickness below minimum. The surface imperfections may be removed by grinding provided each ground area is well fired and grinding does not reduce the thickness of the plate below minimum.

S-14 Thickness Tolerance

By agreement between purchaser and supplier, plates can be ordered to $1/2$ standard over tolerance for thickness shown in ASTM A6.

S-15 Manufacturing Procedure Specification (MPS)

Details of steel making refining, desulfurization deoxidation, continuous casting (if used), control of segregation, intermixing between heats, and slab cropping shall be addressed.

The sequence of deoxidizing, microalloying, and grain refining elements shall be shown. Slab quality control shall be included.

The MPS shall identify aim and range values for chemical composition, mechanical tests, and all major manufacturing

steps, including all examination and checkpoints. Process variables for steel plate rolling and cooling conditions shall be identified.

Details of welding repair and repair qualifications shall be shown.

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