

Specification for Carbon Manganese Steel Plate for Offshore Structures

API SPECIFICATION 2H
NINTH EDITION, JULY 2006

EFFECTIVE DATE: JANUARY 2007



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Upstream Segment

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FOREWORD

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

The purpose of this specification is to provide standards for the purchase of interchangeable steel plate suitable for use in selected welded tubular joints on offshore platforms.

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 this experience and by the service for which the plate is intended.

The following definitions apply:

Shall: As used in a standard, “shall” denotes a minimum requirement in order to conform to the specification.

Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the specification.

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Specification for Carbon Manganese Steel Plate for Offshore Structures

1 Scope

1.1 This specification covers two grades of intermediate strength steel plates up to 4 in. thick for use in welded construction of offshore structures, in selected critical portions which must resist impact, plastic fatigue loading, and lamellar tearing. 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 steels should be amenable to fabrication and welding under shipyard and offshore conditions. API Specifications 2W and 2Y cover companion steels providing similar mechanical properties but with the advantage of potentially lower preheats, and the availability of API RP 2Z prequalification of HAZ toughness. This improvement results from a reduction in the maximum allowed chemical composition and is made possible by changes in the method of heat treatment and/or processing.

1.2 The primary use of these steels is in tubular joints, stiffened plate construction, and other intersections where portions of the plates will be subjected to tension in the thickness direction (Z-direction). Supplementary Requirement S4 provides for through-thickness (Z-direction) testing of the plates by the material manufacturer and specified limits for acceptance. Supplementary Requirement S1 provides for ultrasonic examination of the plates by the material manufacturer and specifies limits for acceptance. For applications where through-thickness properties are desirable but the expense of extra testing is not considered necessary, Supplementary Requirement S5 provides a low-sulfur chemistry intended to reduce the size and number of sulfide inclusions in the plate. Supplementary requirement S5 is neither a substitute for S4 Through-Thickness Testing nor a guarantee of a minimum level of through-thickness ductility. Experience indicates, however, that tests of low-sulfur carbon-manganese steels would usually show at least 20% reduction-of-area in a Z-direction tension test. Even without S5, API Spec 2H provides a reduced sulfur level, compared to other common structural steels.

1.3 The notch toughness requirements specified in Section 7 or S12 are suitable for application below water or above water in areas of temperate climate [14°F (–10°C) minimum service temperature]. Cold-formed materials have less toughness due to straining than that of the original flat plate, especially in those areas aged by the attachment welding of stubs or braces. The requirements for plates in Section 7 include a moderate adjustment for losses in toughness due to straining and aging; however, differences in composition or fabrication practices may result in significantly greater degradation than that included. Supplementary Requirements S7 and S8 deal with the strain-aging problem, and consideration should be given to invoking S7 and/or S8 when the strain exceeds 5% or when (Nitrogen x % strain) exceeds 0.040. Supplementary Requirement S8 provides for testing at the specific temperatures and strain levels of interest and is recommended for all material purchases which exceed the purchaser's experience base.

For applications with lower service temperatures, lower test temperatures should be considered. Supplementary Requirement S2 provides for impact tests at temperatures other than those specified in Section 6 or S12. S2.1 provides for Drop Weight or Charpy V-notch testing at –76°F (–60°C). S2.2 provides for such testing at temperatures less than –40°F (–40°C) but other than –76°F (–60°C).

2 References

The standards referenced herein are as follows:

API

Spec 2B *Fabrication of Structural Steel Pipe*

ASTM¹

A6/A6M	<i>Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling</i>
A20/A20M	<i>Standard Specification for General Requirements for Steel Plates for Pressure Vessels</i>
A370	<i>Standard Test Methods and Definitions for Mechanical Testing of Steel Products</i>
A578/578M	<i>Standard Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications</i>

¹ASTM International, 100 Bar Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org

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

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

3 General Requirements for Delivery

3.1 Material furnished to this specification shall conform to ASTM A6/A6M and shall be marked as specified in Section 8. In the event of conflict, this specification shall prevail.

3.2 Visual examination for defects shall be performed on all surfaces.

4 Manufacturing

4.1 All plates shall be normalized, except as otherwise permitted in 4.2, by the material manufacturer. Alternately, the fabricator may normalize the material using procedures established by the manufacturer on test coupons in accordance with ASTM A6/A6M.

4.2 If approved by the purchaser, Grade 50 plates over 2¹/₂ in. in nominal thickness, may be quenched-and-tempered by heating to a temperature between 1500°F (815°C) and 1700°F (925°C) to produce an austenitic structure, holding a sufficient time to attain uniform heat throughout the material, quenching in a suitable medium, and tempering in the range from 1100°F to 1300°F (595°C to 705°C).

5 Chemical Requirements

5.1 The steel shall conform to the requirements for chemical composition as prescribed in Table 1, and to the additional requirements of the following subsections.

Table 1—Chemical Requirements

Element	Requirement, Wt. %		Element	Requirement, Wt. %	
	Grade 42	Grade 50		Grade 42	Grade 50
Carbon, max			Colombium		
Heat analysis	0.18	0.18	Heat analysis	0.04 max	0.01 – 0.04
Product analysis	0.22	0.22			
Manganese			Titanium	0.020 max ^b	0.020 max ^b
Heat analysis	0.90 – 1.35 ^a	1.15 – 1.60	Aluminum, total		
			Heat analysis	0.02 – 0.06	0.02 – 0.06
Phosphorus, max			Nitrogen, max		
Heat analysis	0.030	0.030	Heat analysis	0.012 ^c	0.012 ^c
Sulfur, max			Vanadium	d	d
Heat analysis	0.010	0.010			
Product analysis	0.015	0.015			
Silicon					
Heat analysis	0.05 – 0.40	0.05 – 0.40			
Product analysis	0.05 – 0.45	0.05 – 0.45			

Notes:

^aManganese up to 1.60 on heat analysis is permitted at the option of the material manufacturer.

^bMinimum values, if any, shall be as agreed upon and stated on the order.

^cShall not be intentionally added.

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

5.2 Carbon Equivalent (CE). The Carbon Equivalent (CE) of the heat analysis shall be calculated and reported. The CE shall be determined by the following formula:

$$CE = C + \frac{Mn}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Ni + Cu)}{15}$$

The maximum CE shall be as follows:

Grade	Thickness	CE Max
42	to 2 ¹ / ₂ in.	0.43
	over 2 ¹ / ₂ in.	0.45
50	to 2 in.	0.43
	over 2 in.	0.45

5.3 Any element intentionally added and all elements in the CE formula shall be reported.

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

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

6 Mechanical Requirements

The material, as represented by transverse test specimens, shall conform to the tensile requirements given in Table 2.

Table 2—Tensile Requirements(transverse tests)

Property	Grade 42	Grade 50
Yield Strength		
ksi (MPa), min.		
t ≤ 2.5 in.	42 (289)	50 (345)
t > 2.5 in.	42 (289)	47 (324)
Tensile strength		
ksi (MPa)	62–82 (427–565)	70–90 (483–620)
Elongation, %, min.		
in 2 in. (50 mm)	22	21
in 8 in. (200 mm)	18	16

7 Notch Toughness Requirements

7.1 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 (45 t) is furnished, one test will suffice. If more stringent requirements are desired, Supplements S2 and/or S12 may be specified.

Charpy V-Notch Impact Test. Three transverse specimens shall be tested in accordance with ASTM A370. Specimen size, test temperature, and energy requirements are shown in Table 3. Due to the low carbon and sulfur contents, the energy of full-size specimens will often exceed the limit of ASTM E23. To prevent this, the producer has the option of testing sub-size specimens to any of the combinations of specimen size, energy requirement, and test temperature of Table 3, as indicated in options A through E.

7.2 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:

- Retest three additional specimens, each of which must equal or exceed the minimum average energy value specified.
- If the required energy values are not obtained upon retest, the plate may be renormalized or quenched and tempered and retested.

7.3 After renormalizing or quenching and tempering, specimens shall be obtained and qualified as prescribed in 7.1.

Table 3—Notch Toughness Requirements Charpy V-Notch Testing

Grade	Option	Specimen Size		Minimum Average Energy ft-lb (J)	Minimum Single Value ft-lb (J)	Test Temperature °F (°C)
		in.	mm			
42	A	0.394 x 0.394	10 x 10	25 (34)	20 (27)	−40 (−40)
	B	0.295 x 0.394	7.5 x 10	25 (34)	20 (27)	−40 (−40)
	C	0.197 x 0.394	5.0 x 10	25 (34)	20 (27)	−40 (−40)
	D	0.295 x 0.394	7.5 x 10	19 (26)	15 (20)	−50 (−46)
	E	0.197 x 0.394	5.0 x 10	13 (18)	10 (14)	−80 (−62)
50	A	0.394 x 0.394	10 x 10	30 (41)	25 (34)	−40 (−40)
	B	0.295 x 0.394	7.5 x 10	30 (41)	25 (34)	−40 (−40)
	C	0.197 x 0.394	5.0 x 10	30 (41)	25 (34)	−40 (−40)
	D	0.295 x 0.394	7.5 x 10	23 (31)	19 (26)	−50 (−46)
	E	0.197 x 0.394	5.0 x 10	15 (20)	13 (18)	−80 (−62)

8 Marking

8.1 Plate furnished to this specification shall be marked by the plate manufacturer in accordance with ASTM A6/A6M or ASTM A20/A20M if Supplementary Requirement S3 is ordered, with the addition of the following:

- The API Monogram may be applied to products complying with this specification, but only by authorized manufacturers (see Appendix C).
- Grade 42 shall be marked API 2H-42.
Grade 50 shall be marked API 2H-50.
- Plate furnished in the as-rolled (green) condition to be heat treated by the fabricator shall be marked with suffix “G”; plates furnished normalized shall be marked with the suffix “N”; quenched-and-tempered plates shall be marked with the suffix “QT”; e.g., a normalized Grade 50 plate would be marked “API 2H-50N”.
- 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 “H” in the markings listed in Section 8.1.b (e.g., API 2HC-50).

APPENDIX A—SUPPLEMENTARY REQUIREMENTS

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

S1 Ultrasonic Examination

S1.1 Pulse Echo ultrasonic examination shall be performed on each plate in accordance with ASTM A578/A578M. Acceptance Standard—Level A shall be used. Any area where one or more discontinuities produce a continuous total loss of backwall reflection accompanied by continuous indications on the same plane that cannot be encompassed within a circle whose diameter is 3 in. (75mm) shall be cause for rejection.

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

S2 Notch Toughness Test at Lower Temperature

S2.1 Notch toughness tests shall be made in accordance with the requirements of Section 7 or S12 and shall meet the requirements of Table S2-1 in lieu of the requirements of Table 3 or S12.2.

S2.2 Impact tests may be made at temperatures lower than those specified in Table 3 or S12.2 and other than those specified in Table S2-1. The testing temperature shall be specified by the purchaser and agreed to by the material manufacturer.

S2.3 If the design condition requires a higher energy value, energy values higher than those stated in Table S2-1 may be specified subject to agreement between the purchaser and the material manufacturer.

Table S2-1—Notch Toughness Requirements at Lower Temperatures Drop-Weight Testing—No-Break at -67°F (-55°C) Or Charpy Impact Testing

Grade	Specimen Size		Minimum Average Energy ft-lb (J)	Minimum Single Value ft-lb (J)	Test Temperature $^{\circ}\text{F} (^{\circ}\text{C})$
	in.	mm			
42	0.394 x 0.394	10 x 10	25 (34)	20 (27)	$-76 (-60)$
50	0.394 x 0.394	10 x 10	35 (48)	30 (41)	$-76 (-60)$

S3 Individual Plate Testing

The purchaser may specify either S3.1 or S3.2 or both.

S3.1 When mechanical testing of each plate is desired, steel may be ordered to conform to Section 11, Tension Tests, and Section 12, Notch Toughness Tests, of ASTM Specification A20/A20M.

S3.2 When product analysis of each mother plate by the steel manufacturer is desired, steel may be ordered to conform to Supplement S2, Product Analysis, of ASTM Specification A20/A20M. Where limits for product analysis are not stated in the Chemistry Table of this specification, tolerances shall be in accordance with ASTM A751.

Note: When this supplement is not specified and subsequent product analysis is performed by the purchaser, the provisions of ASTM A6 would apply

S4 Through-Thickness (Z-Direction) Testing

S4.1 This Supplementary Requirement covers the procedure and acceptance standards for the determination of reduction-of-area using a tension test specimen whose axis is normal to the surfaces of steel plates $\frac{3}{4}$ in. (19 mm) and thicker. Definitions shall be in accordance with ASTM A370.

S4.2 *Number of Test Specimens.* Two tests shall be taken from each plate as rolled (parent plate).

S4.3 *Orientation of Test Specimens.* The longitudinal axis of the test specimens shall be perpendicular to the surface of the plate.

S4.4 *Location of Test Specimens.* One test specimen shall be taken at the ingot axis or cast slab longitudinal centerline at its intersection with each edge or end of the plate.

S4.5 *Preparation of Test Specimens.* Specimens shall be prepared as follows:

- a. Prolongations shall be joined to opposite surfaces of the plate being tested, with their axes coincident. The joining method used should be one which results in a minimal heat-affected-zone in the portion of the coupon being tested. Friction (inertia), stud, electron beam, or shielded metal-arc welding methods have proven to be suitable. Prolongation materials shall be selected so that failure shall occur in the plate portion of the specimen.
- b. Specimens shall be machined to the form and dimensions of the 0.500 in. (12.5 mm) round specimen of Figure 4 of ASTM A370, except for the plate thickness less than $1\frac{1}{4}$ in. (32 mm) where the 0.350 in. (8.75 mm) test specimen may be used.
- c. The full plate thickness shall be contained within the uniform section with no taper permitted. The length ("G" in Figure 4 of ASTM A370) of the cylindrical section of the test piece shall be adjusted as necessary to contain the plate thickness within a uniform diameter throughout the section.

S4.6 *Testing.* Tensile testing shall be conducted in accordance with the requirements of ASTM A370.

S4.7 *Acceptance Standards.* Standards for the acceptance of through-thickness testing shall be as follows:

- a. Each tension test specimen shall exhibit a minimum reduction-of-area of 30%. If one of the two specimens from a plate is below 30%, but not below 25%, a retest of two additional specimens from a location adjacent to the failed specimen shall be made, and both of these additional determinations shall equal or exceed 30%.
- b. Minimum reduction-of-area limits higher than stated in S4.7a may be specified subject to agreement between the material manufacturer and the purchaser.

S4.8 *Marking.* Plates accepted in accordance with this procedure for through-thickness testing shall be identified by stamping or stenciling "Z" adjacent to marking otherwise required (i.e., API 2H-50Z).

S5 Low Sulfur Steel For Improved Through-Thickness Properties

S5.1 *Intent.* The intent of this supplementary requirement is to provide, by chemical control, plates with low levels of sulfide inclusions and thereby a reduction of the potential for lamellar tearing of the plate in the area of attachment welds.

S5.2 *Chemistry.* The steels shall conform to the requirements for chemical composition prescribed in Table 4.1, except that the maximum content of sulfur on heat analysis shall be 0.006%.

S5.3 *Through-Thickness Testing.* Through-thickness (Z-direction) tensile testing is not required by this supplementary requirement.

S5.4 *Marking.* Plates accepted in accordance with this supplementary requirement shall be identified by stamping "LS" adjacent to marking otherwise required (i.e., API 2HXLs). Note: "X" refers to "G", "N", or "QT" as required by 8.1.c.

S7 Low Nitrogen Content For Improved Notch Toughness in Strain-Hardened Condition

S7.1 The nitrogen content shall be 0.009% maximum on heat analysis.

S8 Strain-Aged Charpy V-Notch Impact Tests

S8.1 Charpy V-notch impact test coupons representing the thickest and thinnest plate of each heat shall be uniformly strained 5%, or more if specified, in axial tension and aged at 480°F (250°C) for one hour at temperature prior to cutting the test specimens. The test results obtained from these specimens shall meet the requirements of Section 7.

S12 Notch Toughness Using Drop Weight

S12.1 Drop-Weight tests shall be conducted. One plate per 50 ton (45 t) lot or part thereof of the plates in each heat $\frac{5}{8}$ inch (16 mm) or more in thickness shall be tested. The plate tested shall be the thickest gage in each 50 ton (45 t) lot.

S12.2 Drop-Weight tests shall be in accordance with ASTM E208 on two P-3 specimens from the selected plate(s). The specimens shall be taken adjacent to the tensile test coupons and tested at -30°F (-35°C). Both specimens shall meet the "no break" criteria at the test temperature, and the results shall be reported.

S12.3 If one specimen fails (“Breaks”) on any plate tested, retests may be made as follows:

- a. Retest two additional specimens from each plate for which a specimen failed. Each of these two retest specimens must pass (“No Break”).
- b. If any of the specimens fail upon retest, the heat shall not be accepted without reheat treatment and repeating the tensile, Charpy V-notch impact, and drop-weight tests.

S13 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. (0.381 mm) and shall not result in an undergage condition. However, isolated individual pits not over 0.030 in. (0.762 mm) deep are acceptable provided that the 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 faired and grinding does not reduce the thickness of the plate below minimum.

S14 Thickness Tolerance

By agreement between purchaser and supplier, plates shall be furnished to $\frac{1}{2}$ standard over tolerance for thickness shown in ASTM A6/A6M.

APPENDIX B—SUGGESTIONS FOR ORDERING API 2H STEEL PLATE

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

Specification:	API Spec 2H
Quantity/Size:	As required
Grade:	42 or 50
Retreatment (see 4.2):	State whether retreatment per 4.2 is permitted
Chemical Requirements (see Table 4-1, Footnotes b & d):	State whether use of titanium, and/or vanadium, 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:	As required

The purchaser should state on the purchase order the requirements concerning the following Supplementary Requirements, which are optional with the purchaser.

- | | | |
|------|--|--------------------------|
| S1 | Ultrasonic Examination | <input type="checkbox"/> |
| S2 | Notch Toughness at Lower Temperatures | <input type="checkbox"/> |
| S2.1 | Notch Toughness at -76°F (-60°C) | <input type="checkbox"/> |
| S2.2 | Notch Toughness at Other than -40°F (-40°C) or -76°F (-60°C) | <input type="checkbox"/> |
| S2.3 | Higher Notch Toughness Energy Values | <input type="checkbox"/> |
| S3 | Individual Plate Testing | <input type="checkbox"/> |
| S4 | Through-Thickness (Z-Direction) Testing | <input type="checkbox"/> |
| S5 | Low Sulfur Steel for Improved Through-Thickness Properties | <input type="checkbox"/> |
| S7 | Low Nitrogen Content for Improved Notch Toughness in Strain-Aged Condition | <input type="checkbox"/> |
| S8 | Strain-Aged Charpy V-Notch Impact Tests | <input type="checkbox"/> |
| S9 | Simulated Post-Weld Heat Treatment | <input type="checkbox"/> |
| S12 | Notch Toughness Using Drop Weight | <input type="checkbox"/> |
| S13 | Surface Quality | <input type="checkbox"/> |
| S14 | Thickness Tolerance | <input type="checkbox"/> |

Note: Section 1 of this specification addresses the purpose/function of several of the supplementary requirements.

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Title: _____

Company: _____

Department: _____

Address: _____

City: _____

State/Province: _____

Zip/Postal Code: _____

Country: _____

Telephone: _____

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Title: _____

Company: _____

Department: _____

Address: _____

City: _____

State/Province: _____

Zip/Postal Code: _____

Country: _____

Telephone: _____

Fax: _____

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Quantity	Product Number	Title	SO★	Unit Price	Total

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