

PART

**2**

**Rules for Testing and Certification of Materials**

CHAPTER **3 Materials for Machinery, Boilers,  
Pressure Vessels and Piping**

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PART

**2**

CHAPTER

**3 Materials for Machinery, Boilers,  
Pressure Vessels, and Piping**

SECTION

**1 General Requirements**

**1 Testing and Inspection**

**1.1 General (2007)**

All materials subject to test and inspection, intended for use in boilers, pressure vessels, piping and machinery of vessels classed or proposed for classification, are to be verified by the Surveyor in accordance with the following requirements or their equivalent. Materials, test specimens, and testing procedures having characteristics differing from those prescribed herein require special approval for each application of such materials and the physical tests may be modified to suit conditions as approved in connection with the design.

**1.3 Test and Test Data**

**1.3.1 Witnessed Tests**

The designation (W) indicates that the Surveyor is to witness the testing unless the plant and product is approved under the Bureau's Quality Assurance Program.

**1.3.2 Manufacturer's Data**

The designation (M) indicated that test data is to be provided by the manufacturer without verification by a Surveyor of the procedures used or the results obtained.

**1.3.3 Other Tests**

The designation (A) indicates those tests for which test data is to be provided by the supplier and audited by the Surveyor to verify that the procedures used and random tests witnessed are in compliance with Rule requirements.

See Part 2, Appendix 1 for the complete listing of indicated designations for the various tests called out by Part 2, Chapter 3.

**1.5 Rejection of Previously Accepted Material**

In the event of any material proving unsatisfactory in the process of being worked, it is to be rejected, notwithstanding any previous certificate of satisfactory testing.

## 1.7 Calibrated Testing Machines (2005)

The Surveyor is to be satisfied that the testing machines are maintained in a satisfactory and accurate condition and is to keep a record of the dates and by whom the machines were rechecked or calibrated. All tests are to be carried out to a recognized national or international Standard by competent personnel.

## 1.9 ASTM References

For identification of ASTM references, see 2-1-1/1.13.

## 3 Defects

All materials are to be free from cracks, injurious surface flaws, injurious laminations and similar defects. Except as indicated for specific materials, welding or dressing for the purpose of remedying defects is not permitted unless and until sanctioned by the Surveyor. In such cases, where sanction is required for materials to be so treated, the Surveyor may prescribe further probing and necessary heat treatment; then, if found satisfactory, the part treated is to be stamped with the Surveyor's identification mark and surrounded by a ring of paint.

## 5 Identification of Materials

The manufacturer is to adopt a system of marking ingots, slabs, finished plates, shapes, castings and forgings which will enable the material to be traced to its original heat; and the Surveyor is to be given every facility for so tracing material.

## 7 Manufacturer's Certificates

### 7.1 Form of Certificate

Unless requested otherwise, four copies of the certified mill test reports and shipping information (may be separate or combined documents) of all accepted material indicating the grade of steel, heat identification numbers, test results and weight shipped are to be furnished to the Surveyor. One copy of the mill test report is to be endorsed by the Surveyor and forwarded to the Purchaser, and three are to be retained for the use of the Bureau. Before the certified mill test reports and shipping information are distributed to the local Bureau office, the manufacturer is to furnish the Surveyor with a certificate stating that the material has been made by an approved process and that it has satisfactorily withstood the prescribed tests. The following form of certificate will be accepted if printed on each certified mill test report with the name of the firm and initialed by the authorized representative of the manufacturer:

"We hereby certify that the material described herein has been made to the applicable specification by the \_\_\_\_\_ process (state process) and tested in accordance with the requirements of \_\_\_\_\_ (the American Bureau of Shipping Rules or state other specification) with satisfactory results."

At the request of manufacturers, consideration may be given to modifications in the form of the certificate, provided it correspondingly indicates compliance with the requirements of the Rules to no less degree than indicated in the foregoing statement.

### 7.3 Other Certificates

Where steel is not produced in the works at which it is rolled or forged, a certificate is to be supplied to the Surveyor stating the process by which it was manufactured, the name of the manufacturer who supplied it and the number of the heat from which it was made. The number of the heat is to be marked on each plate or bar for the purpose of identification.

## 9 Marking and Retests

### 9.1 Identification of Test Specimens

Where test specimens are required to be selected by the Surveyor, they are not to be detached until stamped with his identification mark; but in no case, except as otherwise specified, are they to be detached until the material has received its final treatment. Satisfactory Bureau-tested material is to be stamped **AB**, or as specified for a particular material, to indicate compliance with the requirements.

### 9.3 Defects in Specimens

If any test specimen shows defective machining or develops defects, it may be discarded and another specimen substituted, except that for forgings, a retest is not allowed if a defect develops during testing which is caused by rupture, cracks, or flakes in the steel.

### 9.5 Retests (2005)

The elongation value is, in principle, valid only if the distance between the fracture and the nearest gauge mark is not less than one-third of the original gauge length. However, the result is valid irrespective of the location of the fracture if the percentage elongation after fracture is equal to or greater than the required value.

Generally, elongation,  $A_5$ , is determined on a proportional gauge length,  $5.65\sqrt{S_0} = 5d$ , but may also be given for other specified gauge lengths.

If the material is a ferritic steel of low or medium strength and not cold worked, and the elongation is measured on a non-proportional gauge length, the required elongation,  $A_0$ , on that gauge length,  $L_0$ , may after agreement be calculated from the following formula:

$$A_0 = 2A_5 \left( \frac{\sqrt{S_0}}{L_0} \right)^{0.40}$$

### 9.7 Rejected Material

In the event that any set of test specimens fails to meet the requirements, the material from which such specimens have been taken are to be rejected and the required markings withheld or obliterated.

## 11 Standard Test Specimens

### 11.1 General

Test specimens are to be taken longitudinally and of the full thickness or section of material as rolled, except as otherwise specified.

### 11.3 Test Specimens (2005)

Test specimens are to receive no other preparation than that prescribed and are to similarly and simultaneously receive all of the treatment given the material from which they are cut, except as otherwise specified. Straightening of specimens distorted by shearing is to be carried out while the piece is cold. The accuracy of the tensile test machines is to be within  $\pm 1\%$  of the load.

## **11.5 Tension Test Specimens for Plates and Shapes**

Tension test specimens for rolled plates, shapes and flats are to be cut from the finished material and machined to the form and dimensions shown in 2-3-1/Figure 1, or they may be prepared with both edges parallel throughout their length. Alternatives to the foregoing are indicated under specific materials.

## **11.7 Tension Test Specimens for Castings (Other than Gray Cast Iron) and Forgings (2006)**

Tension test specimens for castings (other than gray cast iron) and forgings are to be machined to the form and dimensions shown for the round specimen alternative C in 2-3-1/Figure 1 or in accordance with 2-3-1/Figure 2.

## **11.9 Tension Test Specimens (for Gray Cast Iron) (2006)**

Tension test specimens for gray cast iron are, unless otherwise approved, to be machined to the form and dimensions shown in 2-3-1/Figure 3 from test bars cast separately from the casting represented. Such test bars are to be poured from ladles of iron used to pour the castings and under the same sand conditions, and they are to receive the same thermal treatment as the castings they represent.

## **11.11 Transverse or Flexure Test Specimens for Gray Cast Iron (2006)**

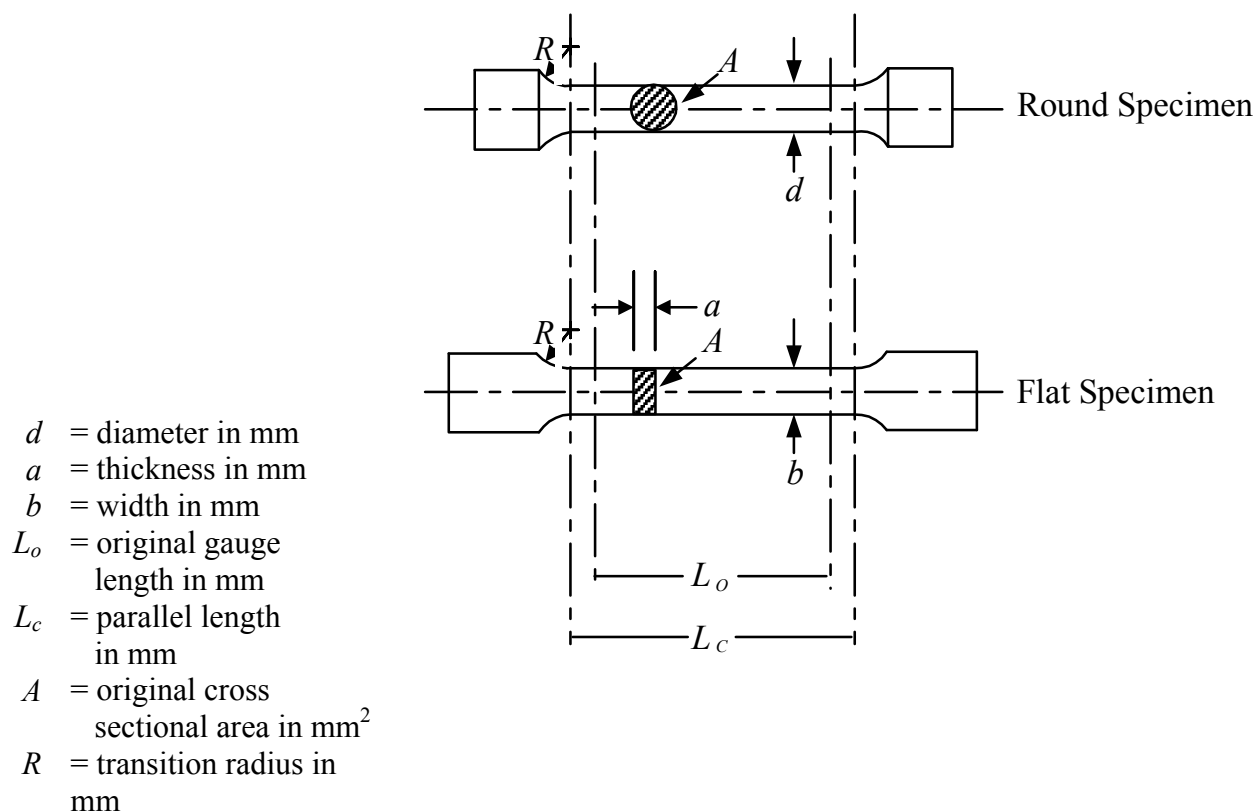
Transverse or flexure test specimens for gray cast iron are, unless otherwise approved, to be a test bar as cast with a 50 mm (2 in.) diameter and 700 mm (27 in.) length. Such test bars are to be cast under the same conditions as described in 2-3-1/11.9.

## **11.13 Bend Test Specimens for Steel Castings and Forgings (2005)**

When required, bend test specimens for steel castings and forgings may be machined to 25 mm × 20 mm (1 in. × 0.790 in.) in section. The length is unimportant, provided that it is enough to perform the bending operation.

The edges on the tensile side of the bend test specimens may have the corners rounded to a radius of 1–2 mm (0.040–0.080 in.).

**FIGURE 1**  
**Standard Tension Test Specimen<sup>(1)</sup> (2006)**

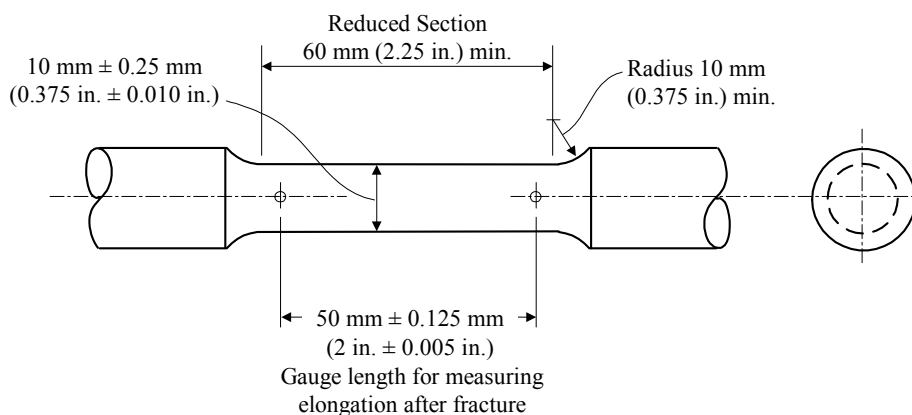


	$d$	$a$	$b$	$L_o$	$L_c$	$R$
Flat specimen Alternative A	—	$t^{(2)}$	25	$5.65 \sqrt{A}$	$L_o + 2 \sqrt{A}$	25
Flat specimen Alternative B	—	$t^{(2)}$	25	200	225	25
Round specimen Alternative C	14	—	—	70	85	10

*Notes:*

- Standard specimen in accordance with ASTM E8/E8M or A370 will also be acceptable in conjunction with the corresponding elongation requirements in 2-1-2/Table 2 or 2-1-3/Table 2.
- $t$  is the full thickness of the material as produced. If the capacity of the testing machine does not allow full thickness specimens to be broken, the thickness may be reduced by machining one surface only.
- $L_o$ , the proportional gauge length, is to be greater than 20 mm.

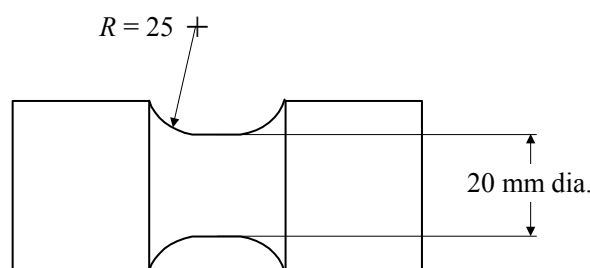
**FIGURE 2**  
**Standard Round Tension Test Specimen**  
**with 50 mm (2 in.) Gauge Length (2008)**



*Note:*

(2008) The gauge length and fillets are to be as shown, but the ends may be of any shape to fit the holders of the testing machine in such a way that the load is to be axial. The reduced section may have a gradual taper from the ends towards the center, with the ends not more than 0.13 mm (0.005 in.) larger in diameter than the center.

**FIGURE 3**  
**Tension Test Specimen Machined from Transverse**  
**or Flexure Test Bars for Gray Cast Iron (2006)**



## 13 Definition and Determination of Yield Point and Yield Strength

### 13.1 Yield Point (2005)

The yield point is the first stress in a material, less than the maximum obtainable stress, at which an increase in strain occurs without an increase in stress. The value of stress is measured at the commencement of plastic deformation at yield, or the value of stress measured at the first peak obtained during yielding even when that peak is equal to or less than any subsequent peaks observed during plastic deformation at yield. Yield point may be determined by the halt of the pointer or autographic diagram. The 0.5% total extension under load method will also be considered acceptable.

The test is to be carried out with an elastic stress within the following limits:

Modulus of Elasticity of the Material ( $E$ ), $N/mm^2$	Rate of Stressing, $N/mm^2 \cdot s^{-1}$	
	Min.	Max.
$< 150,000$	2	20
$\geq 150,000$	6	60

### 13.3 Yield Strength (2005)

The yield strength is the stress at which a material exhibits a specified limiting deviation from the proportionality of stress to strain. When no well-defined yield phenomenon exists, yield strength is to be determined by the 0.2% ( $R_p 0.2$ ) offset method. Alternatively, for material whose stress-strain characteristics are well known from previous tests in which stress-strain diagrams were plotted, the 0.5% extension under load method may be used. When agreed upon between the supplier and purchaser for austenitic and duplex stainless steel products, the 1% proof stress ( $R_p 1$ ) may be determined in addition to  $R_p 0.2$ .

The rate of loading is to be as stated in the limits above:

### 13.5 Tensile Strength (2005)

After reaching the yield or proof load, for ductile material, the machine speed during the tensile test is not to exceed that corresponding to a strain rate of  $0.008 s^{-1}$ . For brittle materials, such as gray cast iron, the elastic stress rate is not to exceed  $10 N/mm^2$  per second.

## 15 Permissible Variations in Dimensions (1994)

### 15.1 Scope

The under tolerance specified below represents the minimum material certification requirements and is to be considered as the lower limit of usual range of variations (plus/minus) from the specified dimension.

The responsibility for meeting the specified tolerances rests with the manufacturer who is to maintain a procedure acceptable to the Surveyor.

### 15.3 Plates (1996)

The maximum permissible under thickness tolerance for plates and wide flats for construction of machinery, excluding boilers, pressure vessels and independent tanks for liquefied gases and chemicals (see 2-3-2/1.15), is to be in accordance with the following:

Nominal Thickness, $t$ , in mm (in.)	Under Thickness Tolerance in mm. (in.)
$5 \leq t < 8$ mm (0.20 $\leq t < 0.32$ in.)	0.4 mm (0.016 in.)
$8 \leq t < 15$ mm (0.32 $\leq t < 0.59$ in.)	0.5 mm (0.02 in.)
$15 \leq t < 25$ mm (0.59 $\leq t < 0.98$ in.)	0.6 mm (0.024 in.)
$25 \leq t < 40$ mm (0.98 $\leq t < 1.57$ in.)	0.8 mm (0.032 in.)
$t \geq 40$ mm ( $t \geq 1.57$ in.)	1.0 mm (0.04 in.)

The thickness is to be measured at a distance of 10 mm (0.375 in.) or more from the edge.

The under thickness tolerance for plates and wide flats less than 5 mm (0.20 in.) in thickness will be specially considered.

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## PART

# 2

## CHAPTER 3 Materials for Machinery, Boilers, Pressure Vessels, and Piping

### SECTION 2 Steel Plates for Machinery, Boilers and Pressure Vessels

#### 1 General Requirements for All Grades of Steel Plates for Machinery, Boilers, and Pressure Vessels

##### 1.1 General

###### 1.1.1 Examination at Mills (2008)

The grades of steel covered in 2-3-2/3, 2-3-2/5 and 2-3-2/7 are rolled plates intended for use in machinery, boilers and other pressure vessels. All tests are to be conducted in the presence of the Surveyor at the place of manufacture prior to shipping, unless the plant is approved under the Bureau's Quality Assurance Program for Rolled Products. The material **surfaces** will be **examined** by the Surveyor when specially requested by the purchaser. Plates are to be free from defects and have a workmanlike finish, subject to the conditions given under 2-3-2/1.17.

###### 1.1.2 Alloy Steels or Special Carbon Steels

When alloy steels or carbon steels differing from those indicated herein are proposed for any purpose, the purchaser's specification is to be submitted for approval in connection with the approval of the design for which the material is proposed. Specifications such as ASTM A387 (Grade C or Grade D) or other steels suitable for the intended service will be considered.

##### 1.3 Marking

###### 1.3.1 Plates and Test Specimens

The name or brand of the manufacturer, the letter indicating the grade of steel, the manufacturer's identification numbers and the letters **PV** to indicate pressure-vessel quality are to be legibly stamped (except as specified in 2-3-2/1.3.4) on each finished plate in two places, not less than 300 mm (12 in.) from the edges. Plates, the maximum lengthwise and crosswise dimensions of which do not exceed 1800 mm (72 in.), are to have the marking stamped in one place approximately midway between the center and an edge. The manufacturer's test identification number is to be legibly stamped on each test specimen. All test specimens are to be ring-stamped, match-marked or otherwise suitably identified to the satisfaction of the attending Surveyor before being detached.

### 1.3.2 Heat-treatment Marking

When the heat treatment is to be carried out by the fabricator as covered in 2-3-2/5.5 and 2-3-2/7.5, the letter **G** is to also be stamped on each plate by the steel producer to indicate that the material is in the unheat-treated (green) condition. After heat treatment at the fabricator's plant, the letter **T** is to be stamped following the letter **G**.

### 1.3.3 Bureau Markings

The Bureau markings **AB**, indicating satisfactory compliance with the Rule requirements and other markings as furnished by the Surveyor, are to be stamped on all plates near the marking specified in 2-3-2/1.3.1 to signify that the material has satisfactorily complied with the test prescribed, and that certificates for the material will be furnished to the Surveyor in accordance with 2-3-1/7. For coiled steel which is certified for chemical analysis only, the marking **AB** without grade designation is to be marked on the outer wrap of each coil shipped.

### 1.3.4 Thin Plates

Plates under 6.4 mm (0.25 in.) in thickness are to be legibly stenciled with the markings specified in 2-3-2/1.3.1 and 2-3-2/1.3.2 instead of stamped.

### 1.3.5 Special Impact Testing

When steel is impact tested in accordance with 2-3-2/9, the grade marking is to be followed by the test temperature in degrees Celsius. A prefix "0" to the test temperature is to indicate a temperature colder than zero degrees Celsius.

## 1.5 Process of Manufacture

The steel is to be made by one or more of the following processes: open-hearth, basic-oxygen or electric-furnace. The steel may be cast in ingots or may be strand (continuous) cast. The ratio of reduction of thickness from strand (continuous) cast slab to finished plate is to be a minimum of 3 to 1 unless specially approved.

### 1.5.1 Plates Produced from Coils

For coiled plate, the manufacturer or processor is to submit supporting data for review and approval to indicate that the manufacturing, processing and testing will provide material which is in compliance with the Rules.

## 1.7 Chemical Composition

### 1.7.1 Ladle Analysis

An analysis of each heat of steel is to be made by the manufacturer to determine the percentage of the elements specified. This analysis is to be made from a test sample taken during pouring of the heat. The chemical composition thus determined is to be reported to the Surveyor and is to conform to the requirements as specified for each grade in 2-3-2/3.5, 2-3-2/5.7 or 2-3-2/7.7.

### 1.7.2 Check Analysis

The chemical composition determined by check analysis is to conform to the requirements as specified for each Grade in 2-3-2/3.5, 2-3-2/5.7, and 2-3-2/7.7.

## 1.9 Test Specimens

### 1.9.1 Selection of Specimens

One tension test specimen is to be taken from each plate as rolled in such manner that the longitudinal axis of the specimen is transverse to the final direction of rolling of the plate. The tension test specimen is to be taken from a corner of the plate. If the final rolling direction of the plate is parallel to the original longitudinal ingot axis, the tension test specimen is to be taken from the “bottom” end of the plate. If the final direction of rolling of the plate is transverse to the original longitudinal ingot axis, or if the relationship of final rolling direction and original ingot axis is unknown, the tension test specimen may be taken from either end. For plates produced from coils, two tension test specimens are to be made from each coil. One tension test specimen is to be obtained from a location immediately prior to the first plate produced and a second test specimen obtained from the approximate center lap. When required, impact tests are to be obtained adjacent to both tension test coupons and a third coupon is to be obtained immediately after the last plate produced to the qualifying grade or specification.

### 1.9.2 Specimens from Plates 19 mm (0.75 in.) and Under in Thickness

For plates 19 mm (0.75 in.) and under in thickness, tension test specimens are to be the full thickness of the material and are to be machined to the form and dimensions shown in 2-3-1/Figure 1 or with both edges parallel.

### 1.9.3 Specimens from Plates Over 19 mm (0.75 in.) Thickness

For plates over 19 mm (0.75 in.) in thickness, tension test specimens may be machined to the form and dimensions shown in 2-3-1/Figure 2, and the axis of each such specimen is to be located as nearly as practicable midway between the center and the surface of the plate, or for plates up to 101.6 mm (4 in.) inclusive in thickness, they may be the full thickness of the material and of the form shown in 2-3-1/Figure 1 when adequate testing-machine capacity is available.

### 1.9.4 Stress Relieving

When required, test specimens are to be stress-relieved by gradually and uniformly heating them to 590–650°C (1100–1200°F), holding at temperature for at least 1 hour per 25 mm (1 in.) thickness and cooling in still atmosphere to a temperature not exceeding 315°C (600°F). If applicable, in the case of plates which are to be heat-treated and subsequently stress-relieved, the test specimens for such plates are to, before testing, be stress-relieved following the heat treatment.

## 1.11 Tensile Properties

### 1.11.1 Tensile Requirements

The material is to conform to the tensile requirements as specified for each grade in 2-3-2/3.9, 2-3-2/5.11 or 2-3-2/7.11.

### 1.11.2 Elongation Deduction for Material Under 7.9 mm (0.313 in.) Thick

For material under 7.9 mm (0.313 in.) in thickness, a deduction from the specified percentage of elongation in 200 mm (8 in.) of 1.25% is to be made for each decrease of 0.8 mm (0.031 in.) of the specified thickness below 7.9 mm (0.313 in.).

### 1.11.3 Elongation Deduction for Material Over 88.9 mm (3.50 in.) Thick

For material over 88.9 mm (3.50 in.) in thickness, a deduction from the specified percentage of elongation in 50 mm (2 in.) of 0.50% is to be made for each increase of 12.7 mm (0.50 in.) of the specified thickness above 88.9 mm (3.50 in.). This deduction is not to exceed 3%.

## 1.13 Retests

### 1.13.1 For All Thicknesses

When the result of any of the physical tests specified for any of the material does not conform to the requirements, two additional specimens may, at the request of the manufacturer, be taken from the same plate and tested in the manner specified, but in such case, both of the specimens are to conform to the requirements (see 2-3-1/9.5).

### 1.13.2 For Heat-treated Material (2008)

If any heat-treated material fails to meet the mechanical requirements, the material may be reheat-treated, and all physical tests are to be repeated. Where plates are specially ordered requiring surface inspection, the Surveyor is to **reexamine** the plate surfaces following any additional heat treatment.

## 1.15 Thickness Variation

No plate is to vary more than 0.25 mm (0.01 in.) or 6% under the thickness specified, whichever is the lesser (See 4-4-1A1/1.7).

## 1.17 Finish

Except when ordered for riveted construction, plates may be conditioned by the manufacturer, for the removal of surface defects on either surface by grinding, provided the ground area is well faired and grinding does not reduce the thickness of the plate below the permissible minimum thickness.

## 1.19 Weldability

All of the grades covered in 2-3-2/3, 2-3-2/5 and 2-3-2/7 are intended for fusion welding, but welding technique is of fundamental importance and the welding procedure is to be in accordance with approved methods. See Part 2, Chapter 4.

# 3 Steel Plates for Intermediate-temperature Service

## 3.1 Scope

Three grades of low and intermediate-tensile-strength carbon-steel plates designated MA, MB, and MC are covered.

## 3.3 General

The various grades are in substantial agreement with ASTM designations as follows.

ASTM – A285 Grades A, B, C

ABS – Grades MA, MB, MC

The maximum thickness of these grades is to be 50.8 mm (2.0 in.).

### 3.5 Chemical Composition

The steel is to conform to the following requirements as to chemical composition.

	Grade MA	Grade MB	Grade MC
Carbon, max., %	0.17	0.22	0.28
Manganese, max., %	0.90	0.90	0.90
Phosphorus, max., %	0.035	0.035	0.035
Sulfur, max., %	0.045	0.045	0.045
Copper*, when Copper Steel is specified			
Ladle Analysis	0.20/0.35	0.20/0.35	0.20/0.35
Check Analysis	0.18/0.37	0.18/0.37	0.18/0.37

Note: See 2-3-2/1.7.

\* When specified, the maximum incidental copper content is to be 0.25%.

### 3.7 Specimen Preparation

Test specimens are to be prepared for testing from material in its rolled condition.

### 3.9 Tensile Properties

The material is to conform to the following requirements as to tensile properties.

	Grade MA	Grade MB	Grade MC
Tensile Strength N/mm <sup>2</sup> (kgf/mm <sup>2</sup> ) (psi)	310–450 (31.5–46) (45000–65000)	345–485 (35–49) (50000–70000)	380–515 (39–53) (55000–75000)
Yield Strength, min., N/mm <sup>2</sup> (kgf/mm <sup>2</sup> , psi)	165 (17, 24000)	185 (19, 27000)	205 (21, 30000)
Elongation in 200 mm (8 in.) min., %*	27	25	23
Elongation in 50 mm (2 in.) min., %	30	28	27

\* See 2-3-2/1.11.2 and 2-3-2/1.11.3.

## 5 Steel Plates for Intermediate- and Higher-temperature Service

### 5.1 Scope

Seven grades of steel plates designated MD, ME, MF, MG, H, I and J are covered. Grades MD, ME, MF and MG cover intermediate and higher-tensile-strength ranges in carbon-silicon steel plates; Grades H, I and J cover three high-tensile-strength ranges in carbon-molybdenum steel plates.

### 5.3 General

The various grades are in substantial agreement with ASTM designations as follows:

ASTM – A515 Grades 55, 60, 65, 70      ABS – Grades MD, ME, MF, MG

ASTM – A204 Grades A, B, C      ABS – Grades H, I, J

Plates are limited in thickness as follows: Grade MD to 304.8 mm (12.0 in.); Grades ME, MF and MG to 203.2 mm (8.0 in.); Grades H and I to 152.4 mm (6.0 in.) and Grade J to 101.6 mm (4 in.).

## 5.5 Heat Treatment

### 5.5.1 Treatment

Plates of Grades MD, ME, MF and MG over 50.8 mm (2.0 in.) and Grades H, I and J over 38.1 mm (1.5 in.) in thickness are to be treated either by normalizing or heating uniformly for hot forming. If the required treatment is to be obtained in conjunction with the hot-forming operation, the temperature to which the plates are heated for hot forming is to be equivalent to and is not to significantly exceed the normalizing temperature. If this treatment is not done at the rolling mill, the testing is to be carried out in accordance with 2-3-2/5.5.3.

### 5.5.2 Heat-treatment Instructions on Orders

Orders to the plate manufacturer or the fabricator are to specify when plates are to be heat-treated and any special requirement that the test specimens be stress-relieved, so that proper provision may be made for the heat treatment of the test specimens. The purchaser is to also indicate in the orders to the mill whether the rolling mill or the fabricator is to perform the required heat treatment of the plates.

### 5.5.3 Responsibility for Heat Treatment

When a fabricator is equipped and elects to perform the required normalizing or fabricates by hot forming as provided in 2-3-2/5.5.1, the plates are to be accepted on the basis of tests made at the plate manufacturer's plant on specimens heat-treated in accordance with the purchaser's order requirements. If the heat-treatment temperatures are not indicated on the purchase order, the plate manufacturer is to heat-treat the specimens under conditions considered appropriate to meet the test requirements. The plate manufacturer is to inform the fabricator of the procedure followed in treating the specimens at the mill for guidance in treating the plates. When the plates are to be normalized at the plate manufacturer's plant, the mechanical properties are to be determined on specimens simultaneously treated with the plates.

## 5.7 Chemical Composition

The steel is to conform to the requirements of 2-3-2/Table 1 as to chemical composition.

## 5.9 Test Specimens

### 5.9.1 Plates Not Requiring Heat Treatment

For plates not requiring heat treatment (see 2-3-2/5.5.1), the test specimens are to be prepared for testing from the material in its rolled condition. When Grades H, I and J plates are to be used in a boiler or pressure vessel which is to be stress-relieved, the test specimens for Grades H, I and J are to be stress-relieved. See 2-3-2/1.9.

### 5.9.2 Plates Requiring Heat Treatment

For plates requiring heat treatment (see 2-3-2/5.5.1), the test specimens are to be prepared from the material in its heat-treated condition, or from full-thickness samples similarly and simultaneously treated. When Grades H, I and J plates are to be used in a boiler or pressure vessel which is to be stress-relieved, the test specimens for Grades H, I and J are to be stress-relieved following the heat treatment. See 2-3-2/1.9 and 2-3-2/5.5.

## 5.11 Tensile Properties

The material is to conform to the requirements of 2-3-2/Table 2 as to tensile properties.

## 7 Steel Plates for Intermediate- and Lower-temperature Service

### 7.1 Scope

Four grades of carbon-manganese-silicon steel plates made to fine-grain practice in four tensile-strength ranges designated K, L, M, N are covered.

### 7.3 General

The various grades are in substantial agreement with ASTM designations, as follows.

ASTM – A516 Grades 55, 60, 65, 70

ABS – Grades K, L, M, N

Plates are limited in thickness, as follows: Grade K to 304.8 mm (12.0 in.); Grades L, M and N to 203.2 mm (8.0 in.).

Materials for Liquefied Gas Carriers are to comply with Section 5C-8-6.

### 7.5 Heat Treatment

#### 7.5.1 Grain Refinement

Plates over 38.1 mm (1.5 in.) are to be heat-treated to produce grain refinement either by normalizing or heating uniformly for hot forming. If the required treatment is to be obtained in conjunction with hot forming, the temperature to which the plates are heated for hot forming is to be equivalent to and is not to exceed significantly the normalizing temperature. If this treatment is not done at the rolling mill, the testing is to be carried out in accordance with 2-3-2/7.5.3. When improved notch toughness is required for plates 38 mm (1.5 in.) and under in thickness, heat treatment is to be specified as above.

#### 7.5.2 Heat-treatment Instructions on Orders

Orders to the plate manufacturer or the fabricator are to specify when plates are to be heat-treated for grain refinement, and any special requirements that the test specimens be stress-relieved, so that proper provision may be made for the heat treatment of the test specimens. The purchaser is also to indicate in the orders to the mill whether the rolling mill or the fabricator is to perform the required heat treatment of the plates.

#### 7.5.3 Responsibility for Heat Treatment

When a fabricator is equipped and elects to perform the required normalizing or fabricates by hot forming as provided in 2-3-2/7.5.1, the plates are to be accepted on the basis of tests made at the plate manufacturer's plant on specimens heat-treated in accordance with the purchaser's order requirements. If the heat-treatment temperatures are not indicated on the purchase order, the plate manufacturer is to heat-treat the specimens under conditions considered appropriate for grain refinement, and to meet the test requirements. The plate manufacturer is to inform the fabricator of the procedure followed in treating the specimens at the mill for guidance in treating the plates. When the plates are to be normalized at the plate manufacturer's plant, the mechanical properties are to be determined on specimens simultaneously treated with the plates.

### 7.7 Chemical Composition

The steel is to conform to the requirements of 2-3-2/Table 3 as to chemical composition.

## 7.9 Test Specimens

### 7.9.1 Plates 38.1 mm (1.5 in.) and Under in Thickness

For plates 38.1 mm (1.5 in.) and under in thickness, not requiring heat treatment, the test specimens are to be prepared for testing from the material in its rolled condition.

### 7.9.2 Plates Requiring Heat Treatment

For plates 38.1 mm (1.5 in.) and under in thickness, requiring heat treatment (see 2-3-2/7.5.1), or for plates over 38.1 mm (1.5 in.) in thickness, the test specimens are to be prepared from the material in its heat-treated condition, or from full-thickness samples similarly and simultaneously treated.

## 7.11 Tensile Properties

The material is to conform to the requirements of 2-3-2/Table 4 as to tensile properties.

## 9 Materials for Low Temperature Service [Below -18°C (0°F)]

Materials intended for service temperatures of below -18°C (0°F) may be provided in accordance with those requirements listed in 2-1-4/9. Other special low temperature materials, when the Charpy V-notch impact tests are conducted at 5°C (10°F) below minimum design temperature in accordance with 2-1-4/5.1 and meet the applicable requirements of 2-1-2/11 and 5C-8-6/Table 2 (ABS) may also be accepted. Such tests are not required for austenitic stainless steels or aluminum alloys such as type 5083.



**TABLE 1**  
**Chemical Composition for Plate Grades MD, ME, MF, MG, H, I, J**

Note See also 2-3-2/1.7

	MD	ME	MF	MG	H	I	J
Carbon, max., %:							
For plates 25.4 mm (1.0 in.) and under in thickness	0.20	0.24	0.28	0.31	0.18	0.20	0.23
For plates over 25.4 mm (1.0 in.) to 50.8 mm (2.0 in.) incl., in thickness	0.22	0.27	0.31	0.33	0.21	0.23	0.26
For plates over 50.8 mm (2.0 in.) to 101.6 mm (4.0 in.) incl., in thickness	0.24	0.29	0.33	0.35	0.23	0.25	0.28
For plates over 101.6 mm (4.0 in.) to 203.2 mm (8.0 in.) incl., in thickness	0.26	0.31	0.33	0.35	0.25	0.27	
For plates over 203.2 mm (8.0 in.) to 304.8 mm (12.0 in.) incl., in thickness	0.28						
Manganese, max., %	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Phosphorous max., %	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Sulphur, max., %	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Silicon, %:							
Ladle analysis	0.15-0.30	0.15-0.30	0.15-0.30	0.15-0.30	0.15-0.30	0.15-0.30	0.15-0.30
Check analysis	0.13-0.33	0.13-0.33	0.13-0.33	0.13-0.33	0.13-0.32	0.13-0.32	0.13-0.32
Molybdenum, %:							
Ladle analysis					0.45-0.60	0.45-0.60	0.45-0.60
Check analysis					0.41-0.64	0.41-0.64	0.41-0.64

**TABLE 2**  
**Tensile Properties for Plate Grades MD, ME, MF, MG, H, I, J**

A characteristic of certain types of alloy steels is a local, disproportionate increase in the degree of necking down or contraction of the specimens under tension tests, resulting in a decrease in the percentage of elongation as the gauge length is increased. The effect is not so pronounced in the thicker plates.

	MD	ME	MF	MG	H	I	J
Tensile Strength,							
N/mm <sup>2</sup>	380-515	415-550	450-585	485-620	450-585	485-620	515-655
kgf/mm <sup>2</sup>	39-53	42-56	46-60	49-63	46-60	49-63	53-67
psi	55000-75000	60000-80000	65000-85000	70000-90000	65000-85000	70000-90000	75000-95000
Yield Strength, min.,							
N/mm <sup>2</sup>	205	220	240	260	255	275	295
kgf/mm <sup>2</sup>	21	22.5	24.5	27	26	28	30.5
psi	30000	32000	35000	38000	37000	40000	43000
Elongation in 200 mm, (8 in.), min., %	23 <sup>(a)</sup>	21 <sup>(a)</sup>	19 <sup>(a)</sup>	17 <sup>(a)</sup>	19 <sup>(a,d)</sup>	17 <sup>(a,d)</sup>	16 <sup>(a,d)</sup>
Elongation in 50 mm, (2 in.) min., % <sup>(c)</sup>	27 <sup>(b)</sup>	25 <sup>(b)</sup>	23 <sup>(b)</sup>	21 <sup>(b)</sup>	23 <sup>(b)</sup>	21 <sup>(b)</sup>	20 <sup>(b)</sup>

Notes

- a See 2-3-2/1.11.2
- b See 2-3-2/1.11.3
- c When specimen shown in 2-3-1/Figure 2 is used.
- d For plates over 6.4 mm (0.25 in.) to 19.1 mm (0.75 in.) inclusive, in thickness, if the percentage of elongation of a 200 mm (8 in.) gauge-length test specimen falls not more than 3% below the amount specified, the elongation is to be considered satisfactory, provided the percentage of elongation in 50 mm (2 in.) across the break is not less than 25%.

**TABLE 3**  
**Chemical Composition for Plate Grades K, L, M, N**

Note See also 2-3-2/1.7

	<i>K</i>	<i>L</i>	<i>M</i>	<i>N</i>
Carbon, max., %:				
For plates 12.7 mm (0.50 in.) and under in thickness	0.18	0.21	0.24	0.27
Over 12.7 mm (0.50 in.) to 50.8 mm (2.0 in.) incl.	0.20	0.23	0.26	0.28
Over 50.8 mm (2.0 in.) to 101.6 mm (4.0 in.) incl.	0.22	0.25	0.28	0.30
Over 101.6 mm (4.0 in.) to 203.2 mm (8.0 in.) incl.	0.24	0.27	0.29	0.31
Over 203.2 mm (8.0 in.) to 304.8 mm (12.0 in.) incl.	0.26			
Manganese, %:				
For plates 12.7 mm (0.50 in.) and under in thickness				
Ladle	0.60/0.90	0.60/0.90	0.85/1.20	0.85/1.20
Check	0.56/0.94	0.56/0.94	0.80/1.25	0.80/1.25
Over 12.7 mm (0.50 in.) to 304.8 mm (12.0 in.) incl				
Ladle	0.60/1.20	0.85/1.20	0.85/1.20	0.85/1.20
Check	0.56/1.25	0.80/1.25	0.80/1.25	0.80/1.25
Phosphorus, max., %	0.035	0.035	0.035	0.035
Sulphur, max., %	0.04	0.04	0.04	0.04
Silicon, %:				
Ladle	0.15/0.30	0.15/0.30	0.15/0.30	0.15/0.30
Check	0.13/0.33	0.13/0.33	0.13/0.33	0.13/0.33

**TABLE 4**  
**Tensile Properties for Plate Grades K, L, M, N**

	<i>K</i>	<i>L</i>	<i>M</i>	<i>N</i>
Tensile Strength,				
N/mm <sup>2</sup>	380-515	415-550	450-585	485-620
kgf/mm <sup>2</sup>	39 to 53	42 to 56	46 to 60	49 to 63
psi	55000-75000	60000-80000	65000-85000	70000-90000
Yield Strength, min.,				
N/mm <sup>2</sup>	205	220	240	260
kgf/mm <sup>2</sup>	21	22.5	24.5	27
psi	30000	32000	35000	38000
Elongation in 200 mm, (8 in.), min., %	23 <sup>(a)</sup>	21 <sup>(a)</sup>	19 <sup>(a)</sup>	17 <sup>(a)</sup>
Elongation in 50 mm, (2 in.), min., % <sup>(c)</sup>	27 <sup>(b)</sup>	25 <sup>(b)</sup>	23 <sup>(b)</sup>	21 <sup>(b)</sup>

Notes:

- a See 2-3-2/1.11.2
- b See 2-3-2/1.11.3
- c When specimen shown in 2-3-1/Figure 2 is used.

PART

**2**

CHAPTER

**3 Materials for Machinery, Boilers,  
Pressure Vessels, and Piping**

SECTION

**3 Seamless Forged-steel Drums**

*Note:* In substantial agreement with ASTM A266 as to physical properties for Classes 1 and 3.

**1 Tests and Inspections**

In the event that any seamless forged-steel drums are presented for survey after special approval for each specific application, they are to be tested and surveyed in general accordance with the applicable procedures given for steel forgings. One tension test is to be taken from each end of the forging midway between the inner and outer surfaces of the wall in a tangential direction, the two specimens being taken from opposite sides of the drum. Grade A material is to have the following minimum properties, tensile strength 415 N/mm<sup>2</sup> (42 kgf/mm<sup>2</sup>, 60,000 psi), yield strength 205 N/mm<sup>2</sup> (21 kgf/mm<sup>2</sup>, 30,000 psi), elongation 23% in a 50 mm (2 in.) gauge length; Grade B material is to have the following minimum properties, tensile strength 515 N/mm<sup>2</sup> (53 kgf/mm<sup>2</sup>, 75,000 psi), yield strength 260 N/mm<sup>2</sup> (26.5 kgf/mm<sup>2</sup>, 37,500 psi), elongation 19% in a 50 mm (2 in.) gauge length.

**3 Heat Treatment**

Except as specified herein, tests for acceptance are to be made after final treatment of the forgings. When the ends of drums are closed in by reforging after machining, the drums may be treated and tested prior to reforging. After reforging, the whole of the forging is to be simultaneously re-treated. If the original treatment was annealing, the re-anneal is to be above the transformation range, but not above the temperature of the first anneal. If the original treatment was normalizing and tempering, the re-treatment is to be identical with the original.

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## PART

# 2

## CHAPTER

### **3 Materials for Machinery, Boilers, Pressure Vessels, and Piping**

## SECTION

### **4 Seamless-steel Pressure Vessels**

#### **1 General**

The material for the manufacture of and the finished seamless pressure vessels are to be free from seams, cracks or other defects. Test specimens are to be cut from each cylinder before the necking-down process, stamped with the identification mark of the Surveyor and is to receive all heat treatments simultaneously with the cylinders.

#### **3 Tension Test**

A standard test specimen cut either longitudinally or circumferentially from each cylinder is to show the material to have a minimum tensile strength of  $415 \text{ N/mm}^2$  ( $42 \text{ kgf/mm}^2$ , 60,000 psi), maximum yield point of 70% of the tensile strength and a minimum elongation of 10% in 200 mm (8 in.).

#### **5 Flattening Test**

A ring 200 mm (8 in.) long is to be cut from each cylinder and is to stand being flattened without signs of fracture until the outside distance over the parallel sides is not greater than six times the thickness of the material.

#### **7 Hydrostatic Test**

Each cylinder is to be subjected to a hydrostatic pressure of not less than one and one-half times the working pressure while submerged in a water jacket for a period of at least thirty seconds. The permanent volumetric expansion is not to exceed 5% of the total volumetric expansion at the prescribed test pressure. This test is to be made without previously subjecting the cylinder to any pressure in excess of one-third of the working pressure.

#### **9 Inspection**

All cylinders are to be properly annealed and be free from dirt and scale. Before necking-down, the Surveyor is to examine the cylinders carefully for defects and gauge the cylinder walls to ascertain that the thickness of the material is in accordance with the approved plan.

## 11 Marking

Upon satisfactory compliance with the above requirements, the cylinders will be stamped **AB** with the identification mark of the Surveyor, the serial number, hydrostatic pressure and the date of acceptance.

## PART

# 2

## CHAPTER 3 Materials for Machinery, Boilers, Pressure Vessels, and Piping

### SECTION 5 Boiler and Superheater Tubes

#### 1 Scope (1998)

The following specifications cover thirteen grades of boiler and superheater tubes designated D, F, G, H, J, K, L, M, N, O, P, R, and S.

#### 3 General

##### 3.1 Grades D and F

Grades D and F cover electric-resistance-welded tubes made of carbon steel and intended for boiler tubes, boiler flues, superheater flues and safe ends. Grade F tubes are not suitable for safe-ending by forge-welding.

##### 3.3 Grade G

Grade G covers electric-resistance-welded, steel boiler and superheater tubes intended for high-pressure service.

##### 3.5 Grade H

Grade H covers seamless carbon-steel boiler tubes and superheater tubes intended for high-pressure service.

##### 3.7 Grade J

Grade J covers seamless medium carbon-steel boiler tubes and superheater tubes, boiler flues, including safe ends, arch and stay tubes. Grade J tubes are not suitable for safe-ending by forge-welding.

##### 3.9 Grades K, L and M

Grades K, L and M cover seamless carbon-molybdenum alloy-steel boiler and superheater tubes.

##### 3.11 Grades N, O and P

Grades N, O and P cover seamless chromium-molybdenum alloy-steel boiler and superheater tubes.

### 3.13 Grades R and S (1998)

Grades R and S cover seamless austenitic stainless steel superheater tubes.

### 3.15 ASTM Designation (1998)

The various Grades are in substantial agreement with ASTM, as follows:

<i>ABS Grade</i>	<i>ASTM Designation</i>
D	A178, Grade A
F	A178, Grade C
G	A226
H	A192
J	A210, Grade A-1
K	A209, Grade T1
L	A209, Grade T1a
M	A209, Grade T1b
N	A213, Grade T11
O	A213, Grade T12
P	A213, Grade T22
R	A213, Grade TP321
S	A213, Grade TP347

## 5 Process of Manufacture

### 5.1 Grades D, F, and G

The steel is to be made by one or more of the following processes: open-hearth, basic-oxygen or electric-furnace. Special consideration may be given to other processes, subject to such supplementary requirements or limits on application as will be specially determined in each case. Grade G is to be killed steel. All tubes of Grade D, F, and G are to be made by electric-resistance welding and are to be normalized at a temperature above the upper critical temperature.

### 5.3 Grades H, J, K, L, and M (1998)

The steel is to be killed steel made by one or more of the following processes: open hearth, electric furnace, or basic oxygen furnace. Tubes are to be made by the seamless process and are to be either hot-finished or cold-drawn. Cold-drawn tubes are to be heat-treated by isothermal annealing or by full annealing at a temperature of 650°C (1200°F) or higher. Cold-drawn tubes of Grades H, and J may also be heat-treated by normalizing. Cold-drawn tubes of Grades K, L, and M may also be heat-treated by normalizing and tempering at 650°C (1200°F) or higher. Hot-finished Grades H and J tubes need not be heat-treated. Hot-finished Grades K, L, and M tubes are to be heat-treated at a temperature of 650°C (1200°F) or higher.

### 5.5 Grades N, O, and P (1998)

The steel is to be made by the electric-furnace process or other approved process, except that Grade N may be made by the basic oxygen process and Grade O by basic oxygen or open hearth process. Tubes are to be made by the seamless process and are to be either hot-finished or cold-drawn. All material is to be furnished in the heat-treated condition. The heat treatment for Grades N and P is to consist of full annealing, isothermal annealing, or normalizing and tempering, as necessary to meet the requirements. The tempering temperature following normalizing is to be 650°C (1200°F) or higher for Grade N and 680°C (1250°F) or higher for Grade P. The hot-rolled or cold-drawn tubes Grade O, as a final heat treatment, are to be process annealed at 650°C (1200°F) to 730°C (1350°F).