

W2 Test specimens and mechanical testing procedures for materials

(Rev.1
1995)

(Rev.2
July 2003)

(Rev.3
Sep 2021)

W2.1 Scope

W2.1.1 This document gives the requirements for test specimens when testing ferrous and non-ferrous metals.

W2.1.2 The corresponding testing procedures generally are to follow established practice as laid down in international and national standards. Some testing procedures are given in this document.

W2.1.3 Alternative specimens, such as those complying with recognized national standards, may be accepted subject to special approval by the Classification Society. The same applies to the given testing procedures.

W2.2 General

W2.2.1 Test samples from which test specimens are cut are to have undergone the same treatment as the material from which they have been taken (e.g. heat treatment).

W2.2.2 If test samples are cut from material by flame cutting or shearing, a reasonable margin is required to enable sufficient material to be removed from the cut edges during final machining.

W2.2.3 The preparation of test specimens is to be done in such a manner that test specimens are not subjected to any significant straining or heating.

W2.2.4 Any of the test specimens referred to as 'alternative' may be used except as otherwise stated or agreed.

Note:

1. Changes introduced in Rev.3 are to be uniformly implemented by IACS Societies on ships contracted for construction on or after 1 January 2023 and when the application for certification of steel plates is dated on or after 1 January 2023.
2. The "contracted for construction" date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. For further details regarding the date of "contract for construction", refer to IACS Procedural Requirement (PR) No. 29.

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W2.3 Testing machines

W 2.3.1 All tests are to be carried out by competent personnel. Testing machines are to be maintained in a satisfactory and accurate condition and are to be recalibrated at approximately annual intervals. This calibration is to be traced to a nationally recognised authority and is to be to the satisfaction of the Classification Society.

Impact testing machines are to be calibrated in accordance with ISO 148-2:2016 or other recognised standard.

The accuracy of tensile test machines is to be within \pm one per cent.

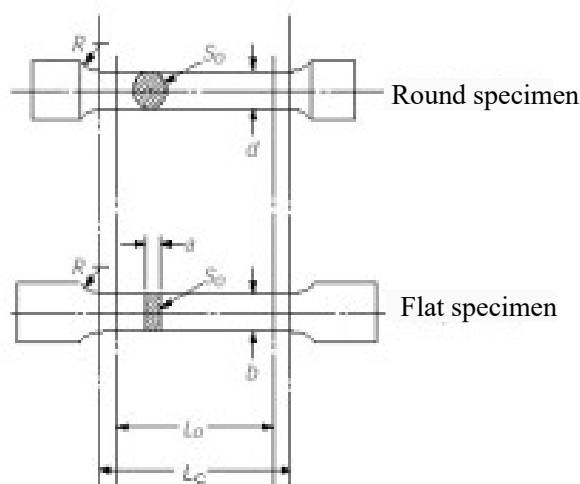
Tension/compression testing machines are to be calibrated in accordance with ISO 7500-1:2018 or other recognised standard.

W2.4 Tensile test specimens

W2.4.1 Designations

The following designations are used:

d	=	diameter
a	=	thickness
b	=	width
L_0	=	original gauge length
L_c	=	parallel length
S_0	=	original cross sectional area
R	=	transition radius
D	=	external tube diameter
t	=	plate thickness



W2.4.2 Dimensions

W2.4.2.1 General

Proportional test specimens with a gauge length $L_0 = 5,65 \sqrt{S_0}$

or $= 5 d$ should preferably be used as the minimum percentage elongation values specified in the W Unified Requirements refer to this gauge length, L_0 should preferably be greater than 20mm. The gauge length may be rounded off to the nearest 5 mm provided that the difference between this length and L_0 is less than 10% of L_0 .

W 2.4.2.2 Plates, strips and sections

Flat specimens are usually to be used with dimensions as specified below

a) Proportional flat specimen

$$\begin{aligned}
 a &= t \\
 b &= 25 \text{ mm} \\
 L_0 &= 5,65 \sqrt{S_0} \\
 L_c &= L_0 + 2 \sqrt{S_0} \\
 R &= 25 \text{ mm}
 \end{aligned}$$

W2 (cont)

- b) Non-proportional flat specimen

$$\begin{aligned} a &= t \\ b &= 25 \text{ mm} \\ L_o &= 200 \text{ mm} \\ L_c &\geq 212.5 \text{ mm} \\ R &= 25 \text{ mm} \end{aligned}$$

When the capacity of the available testing machine is insufficient to allow the use of test specimen of full thickness, this may be reduced by machining one of the rolled surfaces. Alternatively, for materials over about 40 mm thick, proportional round test specimens with dimensions as specified below, may be used.

- c) Round specimen

$$\begin{aligned} d &\geq 10 \text{ mm to } 20 \text{ mm, preferably } 14 \text{ mm} \\ L_o &= 5d \\ L_c &\geq L_o + \frac{d}{2} \end{aligned}$$

$$R = 10 \text{ mm (for nodular cast iron and materials with a specified elongation less than 10%, } R \geq 1,5 d)$$

The axes of the round test specimens are to be located at approximately one quarter of the thickness from one of the rolled surfaces.

W2.4.2.3 Aluminium Alloys

Flat tensile test specimens shall be used for specified thicknesses up to and including 12.5mm. The tensile test specimen shall be prepared so that both rolled surfaces are maintained. For thicknesses exceeding 12.5mm, round tensile test specimens will be used. For thicknesses up to and including 40mm, the longitudinal axis of the round tensile test specimen shall be located at a distance from the surface equal to half of the thickness. For thicknesses over 40mm, the longitudinal axis of the round tensile test specimen shall be located at a distance from one of the surfaces equal to one quarter of the thickness.

W2.4.2.4 Forgings, castings (excluding grey cast iron)

Proportional round test specimens with dimensions as specified above in W2.4.2.2.c) are usually to be used.

For small size bars and similar products the test specimens may consist of a suitable length of bar or other product tested in the full cross-section.

W2.4.2.5 Tubes

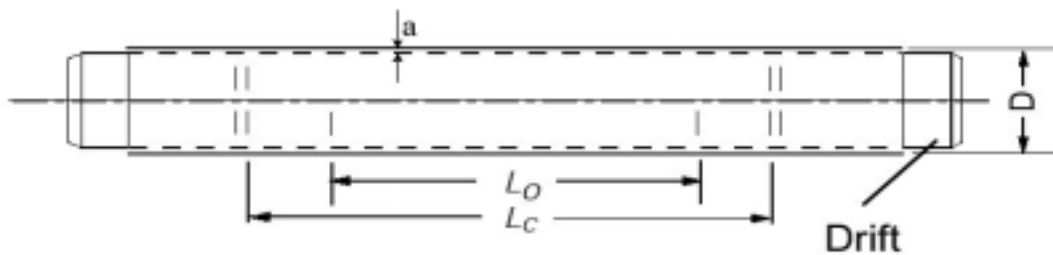
The test specimen shall conform with the following :

- a) full cross-section specimen with plugged ends :

$$L_o = 5,65 \sqrt{S_0}$$

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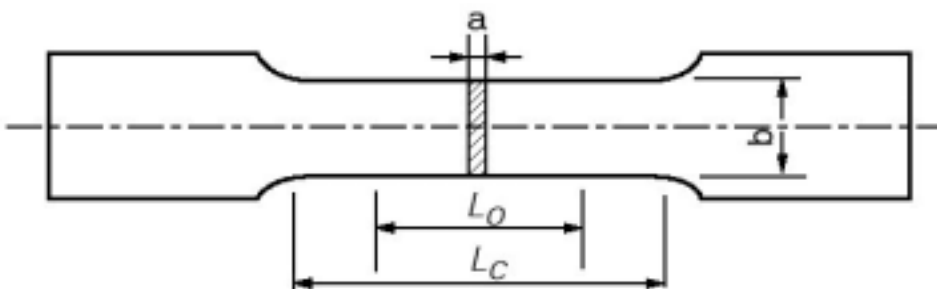
$L_c \geq 5,65 \sqrt{S_0} + \frac{D}{2}$ where L_c is the distance between the grips or the plugs, whichever is the smallest.



b) Strips cut longitudinally

$$\begin{aligned} a &= t \\ b &\geq 12 \text{ mm} \\ L_o &= 5,65 \sqrt{S_0} \\ L_c &= L_o + 2b \end{aligned}$$

The parallel test length is not to be flattened, but the enlarged ends may be flattened for gripping in the testing machine.



Round test specimens may also be used provided that the wall thickness is sufficient to allow the machining of such specimens to the dimensions given in W.2.4.2.2.c), with their axes located at the mid-wall thickness.

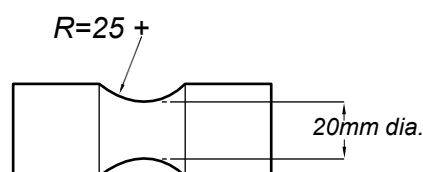
W2.4.2.6 Wires

Full cross-section test specimen with the following dimension is to be used:

$$\begin{aligned} L_o &= 200 \text{ mm} \\ L_c &= L_o + 50 \text{ mm} \end{aligned}$$

W2.4.2.7 Grey cast iron

Round non-cylindrical machined test specimen as shown below is to be used.



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W2.4.2.8 Weldments

a) Deposited metal tensile test

Round specimen with the following dimensions is to be used :

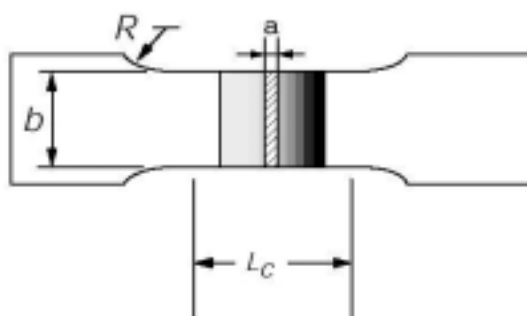
$$\begin{aligned} d &= 10 \text{ mm} \\ L_o &= 50 \text{ mm} \\ L_c &\geq 55 \text{ mm} \\ R &\geq 10 \text{ mm} \end{aligned}$$

For specially small or large dimensions other specimens may be used after agreement with the Classification Society, provided they conform with the geometrical relationship given in W2.4.2.2.c).

b) Butt weld tensile test

Flat specimen, the weld to be machined (or ground) flush with the surface of the plate, with the following dimensions is to be used :

$$\begin{aligned} a &= t \\ b &= 12 \text{ for } t < 2 \\ b &= 25 \text{ for } t > 2 \\ L_c &= \text{width of weld} + 60 \text{ mm} \\ R &> 25 \text{ mm} \end{aligned}$$



W2.4.2.9 Through thickness tensile test specimen

Round test specimens including built-up type by welding are to be prepared in accordance with a recognised standard.

W2.4.2.10 Tolerances

The tolerances on specimen dimensions are to be in accordance with ISO 6892-1:2019, ISO 6892-2:2018 or other recognised standards as appropriate.

W 2.4.3 Retest Procedure

When the tensile test fails to meet the requirements, two further tests may be made from the same piece. If both of these additional tests are satisfactory the item and/or batch (as applicable) is acceptable. If one or both of these tests fail the item and/or batch is to be rejected.

W2 (cont)

The additional tests detailed above are to be taken, preferably from material taken adjacent to the original tests, but alternatively from another test position or sample representative of the item/batch.

W2.5 Tensile properties at ambient temperature

W2.5.1 Yield stress (yield point)

The value of stress 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. 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 s ⁻¹	
	Min.	Max.
< 150 000	2	20
≥ 150 000	6	60

W2.5.2 Proof stress (yield strength)

When no well defined yield phenomenon exists, the 0.2% proof stress ($R_{p0.2}$) is to be determined according to the applicable specification. For austenitic and duplex stainless steel products, the 1% proof stress (R_{p1}) may be determined in addition to $R_{p0.2}$. The rate of loading shall be as stated in W2.5.1 above.

W2.5.3 Tensile strength (R_m)

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 0.008s⁻¹. For brittle materials, such as cast iron, the elastic stress rate is not to exceed 10 N/mm² per second.

W2.5.4 Fracture elongation (A)

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 expected value.

The elongation generally means elongation A_5 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 as 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:

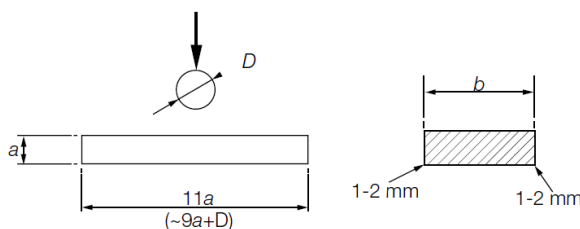
$$A_0 = 2A_5 \left(\frac{\sqrt{S_0}}{L_0} \right)^{0.40}$$

For tables and graphs see ISO 2566-1:1984; ISO 2566-2:1984.

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W2.6 Bend test specimen

W2.6.1 Flat bend test specimen, as given in the following, is to be used. Edges on tension side to be rounded to a radius of 1 to 2 mm.



W2.6.2 Forgings, castings and semi-finished products

$$a = 20 \text{ mm}$$

$$b = 25 \text{ mm}$$

W2.6.3 Plates, structural sections, sheets:

$$a = t$$

$$b = 30 \text{ mm}$$

W2.6.4 Butt welds, transverse specimen

a) face and root bend

$$a = t$$

$$b = 30 \text{ mm}$$

If the as rolled thickness t is greater than 25 mm, it may be reduced to 25mm by machining on the compression side of the bend specimen.

The surfaces of the weld are to be machined (ground) flush with the surface of the plate.

b) side bend

$$a = 10 \text{ mm}$$

$$b = t$$

If $t \geq 40$ mm, the side-bend specimen may be subdivided, each part being at least 20 mm wide.

W2.6.5 Butt weld, longitudinal specimens

The test specimens, for longitudinal face and root test, are to be in accordance with an appropriate recognised standard.

W2.7 Toughness testing

W2.7.1 Charpy V-notch impact specimens

The test specimens shall comply with the following dimensions:

Dimensions	Nominal	Tolerances
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Length	55 mm	± 0,60 mm
Width	-standard specimen	10 mm
	-subsize specimen	7,5 mm
	-subsize specimen	5 mm
Angle of notch	45°	± 2°
Thickness	10 mm	± 0,06 mm
Depth below notch	8 mm	± 0,06 mm
Root radius	0,25 mm	± 0,025 mm
Distance of notch from end of test specimen	27,5 mm	± 0,42 mm
Angle between plane of symmetry of notch and longitudinal axis of test specimen	90°	± 2°

W2.7.2 Sub size Charpy requirements

The testing and requirements for smaller than 5,0mm size specimens are to be in accordance with the general practice of the Classification Society. Minimum average values for subsized specimens are as follows:

Charpy V-notch specimen size	Minimum energy, average of 3 specimens
10 mm x 10 mm	E
10 mm x 7,5 mm	5E/6
10 mm x 5,0 mm	2E/3

E = the values of energy specified for full thickness 10 mm x 10 mm specimens

All other dimensions and tolerances are to be as specified in W2.7.1.

Only one individual value may be below the specified average value provided it is not less than 70% of that value.

In all cases, the largest size Charpy specimens possible for the material thickness shall be machined.

W2.7.3 Testing machines and temperature control in Charpy V-notch impact testing

All impact tests are to be carried out on Charpy machines complying with the requirements of ISO 148-2:2016 or other national and international recognised standards, and having a striking energy of not less than 150 J.

Where the test temperature is other than ambient the temperature of the test specimen at the moment of breaking shall be the specified temperature within $\pm 2^{\circ}\text{C}$.

W2.7.4 Charpy re-test procedure

Where specified the following Charpy re-test procedure will apply:

When the average value of the three initial Charpy V-notch impact specimens fails to meet the stated requirement, or the value for more than one specimen is below the required average value, or when the value of any one specimen is below 70% of the specified average value, three additional specimens from the same material may be tested and the results added to those previously obtained to form a new average. If this new average complies with the requirements and if not more than two individual results are lower than the required average and of these, not more than one result is below 70% of the specified average value the piece or batch (as specified for each product) may be accepted.

W2 (cont)

W2.7.5 Drop weight specimens

Drop weight specimens for determination of no-break performance according to ASTM E-208:2019 are to comply with this ASTM standard and have one of the following dimensions (mm):

Type P-1: 25 by 90 by 360

Type P-2: 19 by 50 by 130

Type P-3: 16 by 50 by 130

The following is to be noted if not otherwise specified:

the specimen sides shall be saw-cut or machined (minimum 25 mm to flame-cut surface)
the machining of the plate to prescribed specimen thickness shall be on one side only
the specimens may be of any orientation, but the orientation shall be the same for all specimens.

W2.8 Ductility tests for pipes and tubes

W2.8.1 Flattening test specimens

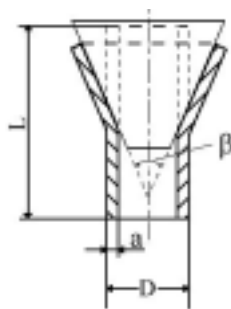
Length is to be from 10mm to 100mm. Plain and smoothed ends cut perpendicular to the tube axis. Reference is made to ISO 8492:2013.

W2.8.2 Drift expanding test

The lengths L of the drift expanding test specimens are to be as follows. Reference is made to ISO 8493:1998.

Metallic tubes: L equal to twice the external diameter D of the tube if the angle of the drift β is 30° , and L equal to $1.5D$ if the angle of the drift is 45° or 60° . The test piece may be shorter provided that after testing the remaining cylindrical portion is not less than $0.5D$.

The rate of penetration of the mandrel shall not exceed 50mm/min.

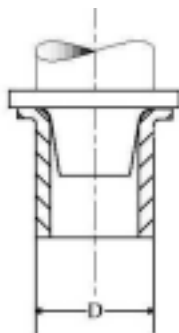


W2.8.3 Flanging test

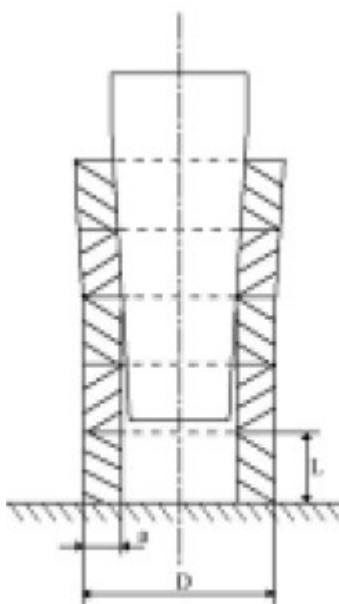
The flanging test specimen is to be of length L equal to approximately $1.5D$. The test piece may be shorter provided that after testing the remaining cylindrical portion is not less than $0.5D$.

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The rate of penetration of the forming tool shall not exceed 50mm/min. Reference is made to ISO 8494:2013.

**W2.8.4 Ring expanding test**

The test piece consists of a ring having a length of between 10 and 16mm. The rate of penetration of the mandrel shall not exceed 30mm/s. Reference is made to ISO 8495:2013.

**W2.8.5 Ring tensile test**

The ring shall have a length of about 15mm with plain and smoothed ends cut perpendicular to the tube axis.

The ring is to be drawn to fracture by means of two mandrels placed inside the ring and pulled in tensile testing machine. The rate shall not exceed 5mm/s.

Reference is made to ISO 8496:2013.

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