RULES CHANGE NOTICE No.1 April 2022

Part 1 Seagoing Ships

Volume V

RULES FOR MATERIALS

Consolidated Edition 2022

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Foreword

This Rules Change Notices (RCN) No. 1 provide amendment and corrigenda to the Rules for Materials (Pt.1, Vol.V) 2022 edition along with effective date from which these changes are applicable.

Amendments to the preceding edition are marked by strikethrough, red color, and expanded text. These new additions and amendments are to be read in conjunction with the requirements given in the 2022 Edition of the Rules.

The summary of current amendments for each section including the implementation date are indicated in *Table 1 - Amendments Incorporates in This Notice*.

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Any quires or comments concerning these Rules are welcomed through communication with BKI Head Office.

Rules Changes Notice No. 1 – April 2022

Table 1 – Amendments Incorporates in This Notice

These amendments will come into force for ship contracted for construction on or after 1 January 2023 unless otherwise specified in table.

Paragraph	Title/Subject	Status/Remark
Section 2 – Mechanical and Technological Test		
2.B.	**Testing Machines and Personnel**	
2.B.2.	-	To add the edition of the standard, refer to IACS UR W2
2.B.3.	-	To add the edition of the standard, refer to IACS UR W2
Table 2.1	Indication errors and calibration periods for tensile testing machines	To add the edition of the standard, refer to IACS UR W2
2.C.	**Sampling and Specimen Preparation**	
2.C.4.	Removal and dimensions of test specimens	To add the edition of the standards, refer to IACS UR W2
2.D.	**Tensile Tests**	
2.D.1.2	Dimensional tolerances	To add the edition of the standard, refer to IACS UR W2
2.D.1.3.2	-	To add the edition of the standard, refer to IACS UR W2
2.D.1.3.4	-	To add the edition of the standard, refer to IACS UR W2
2.D.1.4	Tolerances	To add the edition of the standards, refer to IACS UR W2
2.D.2	Performance of tests	To add the edition of the standard, refer to IACS UR W2
2.D.3.4	Elongation A	To add the edition of the standards, refer to IACS UR W2
2.E.	**Notched Bar Impact Tests**	
2.E.1.1	-	To revise the reference standard
2.E.5.2	-	To revise the reference standard
2.F.	**Technological Tests on Pipes**	
2.F.1.2	-	To add the edition of the standard, refer to IACS UR W2
2.F.2.1	-	To add the edition of the standard, refer to IACS UR W2
2.F.3.2	-	To add the edition of the standard, refer to IACS UR W2
2.F.4.2	-	To add the edition of the standard, refer to IACS UR W2
2.F.5.2	-	To add the edition of the standard, refer to IACS UR W2
2.G.	**Instructions for the Bend Test, Hardness Test and Drop Weight Test**	
2.G.1.3	-	To add the edition of the standard
2.G.2.1	-	To revise the reference standards
2.G.3.1	-	To add the edition of the standard, refer to IACS UR W2

Paragraph	Title/Subject	Status/Remark
Section 4 – Steel Plates, Strips, Section, and Bars		
4.A.	**General Rules**	
4.A.5.2	-	To add the edition of the standard
Table 4.1	Permitted minus tolerances for the thickness of plates and wide flats	To add the edition of the standard, refer to IACS UR W13
4.A.6.3	-	To add the edition of the standard
4.A.8.6.1	-	To add the edition of the standard, refer to IACS UR W14 and to add new standard as an example
4.B.	**Normal and Higher Strength Hull Structural Steels**	
4.B.7.1.1	-	To add the edition of the standard
4.C.	**Unalloyed Steels for Welded Structures**	
4.C.2.1	-	To add the edition of the standard
4.C.2.2	-	To add the edition of the standard
4.D.	**High-Strength Steels for Welded Structures**	
4.D.3.1.1	Note	To add the edition of the standard
4.D.4.6.2	-	To add the edition of the standard, refer to IACS UR W14
4.D.4.6.2	-	To add the edition of the standard
4.D.4.6.3.1	-	To add the edition of the standard
4.D.4.6.3.2	-	To add the edition of the standard
4.E.	**Steels for Steam Boilers and Pressure Vessels**	
4.E.2.1	-	To add the edition of the standard
4.E.2.2	-	To add the edition of the standard
4.E.2.4	-	To add the edition of the standard
4.E.5.4.1	-	To add the edition of the standard
4.E.7.1	-	To add the edition of the standard
4.F.	**Steels for Cargo Tanks Vessels**	
4.F.2.1	-	To add the edition of the standard
4.F.2.2	-	To add the edition of the standard
4.F.2.3	-	To add the edition of the standard
4.F.2.4	-	To add the edition of the standard
Table 4.17	Minimum design temperatures for steels used in the fabrication of cargo tanks	To add the edition of the standards
4.F.9.7.2	-	To add the edition of the standards, refer to IACS UR W14
4.G.	**Stainless Steels**	

Paragraph	Title/Subject	Status/Remark
4.G.2.3	-	To add the edition of the standard
4.G.7.2	-	To add the edition of the standard
4.I.	**Steels with Through Thickness Properties**	
4.I.2.2	-	To add the edition of the standards, refer to IACS UR W14
4.I.3.1.3	Note	To add the edition of the standard
4.M.	**High Manganese Austenitic Steel for Cryogenic Service**	To add the requirements according to IACS Rec. 169
Section 10 – Aluminium Alloys		
10.A.	**Wrought Aluminium Alloys**	
10.A.1.5	-	To add the edition of the standards, refer to IACS UR W25
10.A.4.2	-	To add the edition of the standard
10.A.9.5.1	-	To add the edition of the standards, refer to IACS UR W25
10.A.9.5.2	-	To add the edition of the standards, refer to IACS UR W25 and to revise term “Classification Society” with “BKI
10.A.9.5.3	-	To add the edition of the standards, refer to IACS UR W25
10.B.	**Aluminium Casting Alloys**	
10.B.3.1	-	To add the edition of the standard, refer to IACS UR W25
10.B.3.3	-	To add the edition of the standard, refer to IACS UR W25
Section 13 – Chain Cables and Accessories		
13.A.	**Anchor Chain Cables and Accessories Chain**	
13.A.3.2	-	To add the edition of the standard, refer to IACS UR W18
Table 13.4	Heat treatment of chain cables and accessories	Redaction correction
13.C.	**Offshore Mooring Chain**	
13.C.1.1.4	-	Redaction correction
13.C.1.3.3	-	To revise reference standard and to add the edition of the standard
13.C.1.5.2	-	Redaction correction
13.C.1.6.6	-	To add the edition of the standards
13.C.1.6.7	-	To add the edition of the standards
13.C.2.2.1	Steel manufacture	To add the edition of the standards
13.C.2.2.3	Mechanical tests	To replace the reference
Table 13.11	Notes	Redaction correction
13.C.2.2.5.1	-	To add the edition of the standards
13.C.2.3.1	Manufacture	To add the edition of the standards
13.C.2.3.5	Mechanical tests	To replace the reference

Paragraph	Title/Subject	Status/Remark
13.C.2.3.6	Non-destructive examination and repair	To replace the reference
13.C.2.4.1	Manufacture	To add the edition of the standards
13.C.2.4.6	Non-destructive examination and repair	To replace the reference
13.C.3.1.1	-	To add the edition of the standards, refer to IACS UR W18
13.C.3.2.5	Heat treatment of chain cable	To add the edition of the standards
13.C.3.2.9	Dimensions and dimensional tolerances	To add the edition of the standards, refer to IACS UR W18 & redaction correction
13.C.4.5	Non-destructive examination after proof load testing	To add the edition of the standards & redaction correction
13.C.5.5.2	-	To add the edition of the standards & redaction correction

Section 2 Mechanical and Technological Test

B. Testing Machines and Personnel

1. All tests shall be performed by trained personnel using calibrated testing machines. The testing machines shall be maintained by the owners in a good working condition and shall be calibrated at regular intervals by a testing authority acknowledged by BKI. The calibration records shall be kept available for inspection in the test laboratory.

2. Tensile testing machines are subject to the calibration periods and permitted indication errors shown in Table 2.1. Tensile testing machines shall be calibrated in accordance with ISO 7500-1:2018 or another commonly accepted standard.

3. For pendulum impact testing machines, the total friction with the full swing of the pendulum may not exceed 0,5 % of the available energy. On request, compliance with this value shall be demonstrated to the Surveyor before the machine is used. Pendulum impact testing machines shall be recalibrated at yearly intervals. The calibration of pendulum impact testing machines shall be performed in accordance with ISO 148-2:2016 or another commonly accepted standard.

4. Hardness testing equipment shall be calibrated at yearly intervals. It is to be verified that the acceptable tolerances for the equipment parameters and the indicating accuracy are complied with in accordance with the appropriate standards.

5. Compliance with the above requirements may also be evidenced by the testing laboratory's certificate of accreditation provided that the accreditation was granted by an accredited institution and the test methods in question are stated in the certificate of accreditation.

Table 2.1 Indication errors and calibration periods for tensile testing machines

Type of tensile testing machines	Test class (ISO 7500- 1:2018)	Permitted indication error, max.	Calibration period
Multi-purpose testing	1	1%	1 year
Testing machines for equipment components	3	3%	2 year

----------*end*----------

C. Sampling and Specimen Preparation

4. Removal and dimensions of test specimens

The longitudinal axes of test specimens are to be orientated in relation to the main direction of deformation in the manner prescribed in the following sections. Notwithstanding this, the manufacturer may, in order to save test material and after agreement with the Surveyor, take transverse instead of longitudinal test specimens, provided that corresponding requirements are specified for transverse test specimens or the requirements applicable to longitudinal specimens can be satisfied by this means.

The tolerances applicable to the specimen shall be in accordance with ISO 6892-1:2019, ISO 6892-2:2018 or another standard accepted by BKI.

----------*end*----------

D. Tensile Tests

1. Specimen shapes

The following notation is used to specify the dimensions of test specimens.

1.1 Notation

A = elongation determined in tensile test for gauge length L_o for short proportional test specimens [%]

A_r = elongation required due to conversion for other gauge lengths [%]

d_o = diameter of round specimen [mm]

a = thickness of flat specimen [mm]

b = width of flat specimen [mm]

L_o = initial gauge length [mm]

L_c = test length [mm]

S_o = initial cross-section within test length [mm^2]

S_u = smallest specimen cross section after fracture [mm^2]

r = shoulder radius at end of specimen [mm]

D = outside diameter of pipe [mm]

t = thickness of product [mm]

1.2 Dimensional tolerances

The dimensional tolerances shall be those specified in the relevant standards, e.g. or ISO 6892-1:2019.

1.3 Dimensions

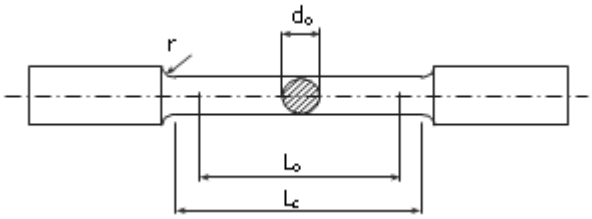
1.3.1 Use shall preferably be made of short proportional test specimens with an initial gauge length of $L_o = 5{,}65\sqrt{S_o}$ or $L_o = 5\ d_o$, respectively, as the requirements relating to elongation specified in the following Sections refer to this gauge length. The test length L_c shall be preferably 20 mm larger than L_o.

The gauge length L_o may be rounded to the nearest 5 mm provided that the difference between this gauge length and L_o is less than 10 % of L_o.

1.3.2 For forgings and castings, with the exception of grey cast iron, cylindrical specimens conforming to ISO 6892-1:2019 or as shown in Fig. 2.1 are to be used.

Specimen shape A should be preferred. If this is not possible, the alternative dimensions should be determined as specified for shape B with the specimen diameter do selected being between 10 and 20 mm.

1.3.3 For hot-rolled rods and products of similar shape, the specimen shapes prescribed in 1.3.2 are to be used. In the case of bars with a smaller section, suitable lengths may also be tested in their entirety, i.e. without machining the cross-section.

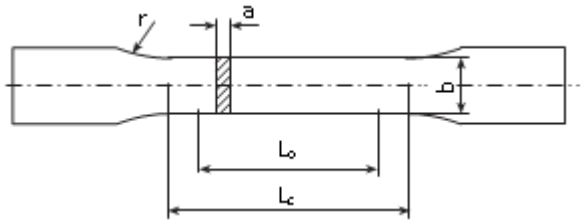


Dimension	Specimen shape A 14 mm round tensile specimen	Specimen shape B alternative specimen
d_o	14 mm	–
L_o	70 mm	5 d_o
L_c	85 mm	L_o + d_o
r	10 mm [1)]	10 mm [1)]

[1)] In the case of nodular graphite cast iron and all materials with a minimum elongation A ≤ 10 %, r = 20 mm (specimen shape A) or r = 1,5 d_o (specimen shape B)

Fig. 2.1 Round tensile specimens

1.3.4 For plates, strips and sections, flat tensile specimens conforming to ISO 6892-1:2019 or as shown in Fig. 2.2 are to be used by preference. In these cases the rolled surface of the metal shall be preserved. Where, in testing heavy plate thicknesses, the tensile loading capacity of the machine is insufficient, the thickness of the specimens may be reduced by machining one side to not less than ½ of the product thickness.



Dimension	Specimen shape C proportional test specimen	Specimen shape D 200 mm specimen
a	t	t
b	25 mm	≥ 25 mm
L_o	$5{,}65\sqrt{S_o}$	200 mm
L_c	$L_o + 2\sqrt{S_o}$	225 mm
r	25 mm	25 mm

Fig. 2.2 Flat tensile specimens

Otherwise round tensile specimens conforming to Fig. 2.1 are to be used, for which the following is to be observed:

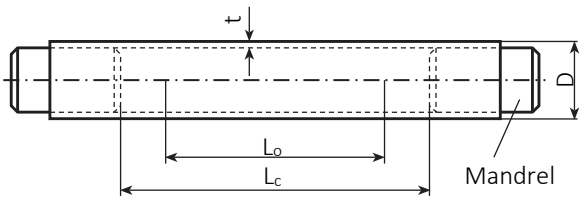
In the case of products with a thickness of > 40 mm, round tensile specimens as prescribed in 1.3.2 may also be used. The specimens shall then be taken from the sample in such a way that their axis is located at 1/4 of the product thickness measured from one face or as close as possible to this position.

1.3.5 In the case of pipes, the tensile test may be performed on a sufficiently long section of the entire pipe. To enable the specimen to be secured in the test machine, mandrels have to be inserted into the pipe

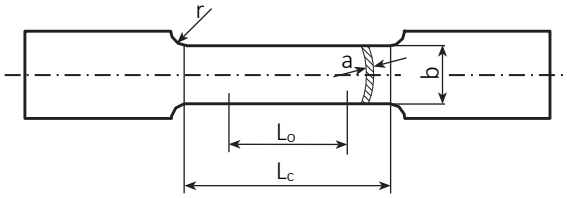
ends, see Fig. 2.3, specimen shape E, or the pipe ends have to be pressed flat. Where the pipe diameter precludes testing a length of the entire pipe, tensile specimens of shape F are to be taken from the pipe wall.

Where the wall thickness of the pipe is sufficient, cylindrical specimens as prescribed in 1.3.2 may also be used. The specimens shall then be taken from the sample in such a way that their axis is located at the mid-point of the wall thickness.

In the case of large pipe diameters, flat or cylindrical specimens perpendicular to the pipe axis may also be taken. To this end the test length may not be pressed flat, but the wider ends may be pressed flat to enable the specimen to be secured in the specimen device of the testing machine.



Shape E



Shape F

Dimension	Specimen shape E (with solid pipe section)	Specimen shape F (Flat specimen from pipe wall)
a	–	t
b	–	≥ 12 mm
L_o	$5{,}65\sqrt{S_o}$	$5{,}65\sqrt{S_o}$
L_c	$L_o + D$ [1)]	$L_o + 2b$
r	–	10 mm

[1)] This value also applies to the minimum distance between the grips of the test machine.

Fig. 2.3 Tensile specimens for pipes

1.3.6 For grey cast iron, test specimens as shown in Fig. 2.4 are to be used. These shall be taken from a separately cast cylindrical test bar with a casting diameter of 30 mm.

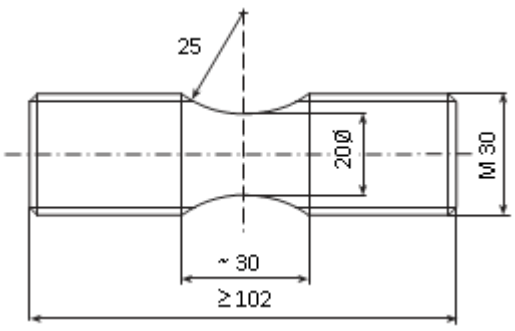


Fig. 2.4 Tensile specimen for grey cast iron

1.3.7 Tensile specimens which have their axes vertical to the product face (Z-specimens) are to be prepared as described in Section 4, I.3.

1.3.8 Aluminium alloys

For aluminium alloys with product thickness including 12,5 mm flat tensile specimens are to be used. The specimens shall be prepared in such a way that both rolled/pressed surfaces shall be preserved. For product thicknesses exceeding 12,5 mm round tensile specimens may be used. For product thicknesses up to and including 40 mm the longitudinal axis of the round tensile specimen shall be located at ½ of the product thickness measured from face. For product thickness measured from on face. For product thicknesses exceeding 40 mm the longitudinal axis of the round tensile specimen shall be located at ¼ of the product thickness measured from one face.

1.3.9 Tensile specimens for wire ropes, single wires and strands are to be performed in accordance with Section 14, E.3. Specimens containing the entire section and the following dimensions are to be tested:

L_o = 200 mm

L_c = L_o + 50 mm

1.4 Tolerances

The manufacturing tolerances for specimens shall meet the requirements of ISO 6892-1:2019, ISO 6892-2:2018 or other recognized standard.

2. Performance of tests

Tests shall be performed in accordance with established standards. This category includes, for example ISO 6892-1:2019.

----------*end*----------

3. Determination of test results

3.4 Elongation A

If not otherwise stated, this relates to short proportional test specimens with $L_o = 5{,}65\sqrt{S_o}$ and then is named as A [%]. For test specimens whose gauge length bears a different relationship to the cross section of the test specimen, the required elongation Ar shall comply either with the minimum values specified for the products in question (e.g. for a gauge length L_o = 200 mm), or with the minimum value calculated by applying the following formula:

$$A_r = 2.A.\left(\frac{\sqrt{S_o}}{L_o}\right)^{2/5}$$

This conversion formula may only be used for ferritic steels with a strength of ≤ 700 N/mm^2 which have not been cold formed, see also ISO 2566-1:1984; ISO 2566-2:1984.

The value for the elongation is valid if the distance between the fracture and the nearest gauge mark is not less than L_o/3. However, the value is valid, irrespective of the position of the fracture, if the value for the elongation is equal to or greater than the specified value.

The result of the test shall be stated to an accuracy of 0,5%. If the elongation is not determined using short proportional test specimens, then the gauge length [mm] shall be stated in the test certificate, e.g. A_{200mm} = elongation for initial gauge length L_o = 200 mm.

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E. Notched Bar Impact Tests

1. General

1.1 As specified for the product in question, notched bar impact tests are to be performed either on Charpy V-notch specimens ~~to ISO 148-1~~ or on Charpy U-notch specimens to ISO ~~83~~ 148-1:2016), see Fig. 2.5 and Fig. 2.6.

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5. Determination of test results

5.1 Using the symbols shown below, the energy absorbed by the impact shall be normally stated in joules (J), accurately rounded to 1 J.

Where the test is conducted other than at room temperature, this shall also be stated.

5.2 If required, the crystalline proportion of the fracture surface and/or the lateral expansion at the point of fracture shall also be determined.

The crystalline proportion of the fracture surface shall then be estimated and expressed as a percentage of the total area of the fracture. The lateral expansion shall be measured to an accuracy of 0,01 mm on the side opposite the notch (see also ~~DIN 50115~~ ISO 148-1:2016 and ASTM A 370).

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F. Technological Tests on Pipes

1. Pipe flattening test

1.1 To perform this test, a section of pipe equal in length to 1,5 times the pipe diameter, but not less than 10 mm and not more than 100 mm, is flattened between two plates to the prescribed distance H see Section 5, A.8.5 or until fracture occurs, see Fig. 2.8. In the case of welded pipes, the specimen shall be placed in the press in such a manner that the seam is set at 90° to the direction of the pressure, unless agreed otherwise.

1.2 After the test, the specimens shall be thoroughly examined for defects with normal visual acuity. The test shall be satisfactory if the specimen, having been flattened to the prescribed distance, is free from cracks and did not fracture.

The dimensions of the pipe section, the distance H between the flattening plates as well as the position of the welding joint are to be stated.

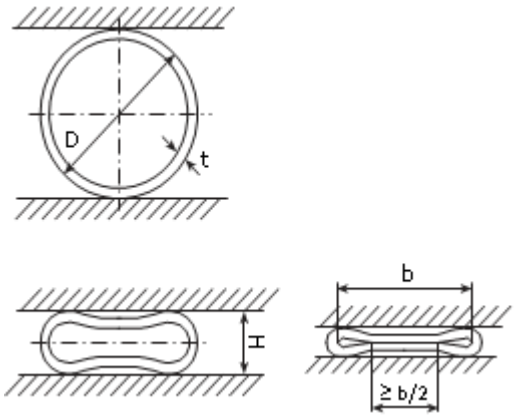
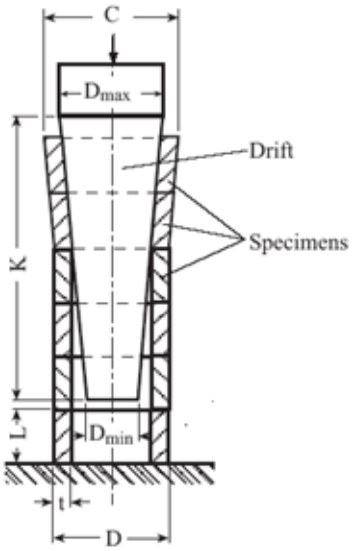


Fig. 2.8 Pipe flattening test

Examples of applicable standards: ISO 8492:2013 Pipe Flattening Test

2. Ring expanding test

2.1 To perform this test, sections of pipe measuring 10 to 16 mm in length L are expanded to the prescribed diameter C or until fracture occurs using a drift with a taper of about 1:5. Where necessary, more than one test shall be performed with drifts of increasing diameter. The superimposition of several specimens of the same size and steel grade is permitted, see Fig. 2.9.



$$\frac{D_{max} - D_{min}}{K} = 1:5$$

Fig. 2.9 Ring expanding test

The intrusion rate of the mandrel may not exceed 30 mm/s.

C = Diameter after the prescribed expansion

The dimensions of the pipe sections, the outer diameter C of the expanded part of the pipe section or the relative expansion [%], as well as the ratio of the taper (if not 1:5) are to be stated.

Examples of standards to be applied: ISO 8495:2013 Ring Expanding Test on Pipes

2.2 After the test, the specimens shall be thoroughly examined for defects with normal visual acuity, and the ductility of the pipes shall be assessed by reference to the expansion achieved and, where applicable, to the appearance of the fracture surface.

The test shall be satisfactory if the specimen reveals no unacceptable defects such as scabs, laps, cracks, grooves or laminations and if the prescribed expansion has been reached.

3. Ring tensile test

3.1 The sections of pipe measuring about 15 mm in length shall have plane and smoothed ends and shall be at right angle to the pipe axis. To perform this test, the pipe sections are stretched in a tensile testing machine until fracture occurs using two pins with a diameter equal to at least three times the wall thickness of the pipe, see Fig. 2.10. In the case of welded pipes, the specimen shall be placed in the tensile testing device in such a way that the welded seam lies at 90° to the direction of the tensile load.

The rate of the pins may not exceed 5 mm/s.

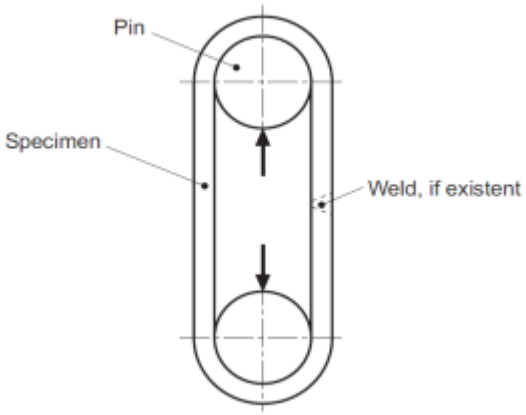


Fig. 2.10 Ring tensile test

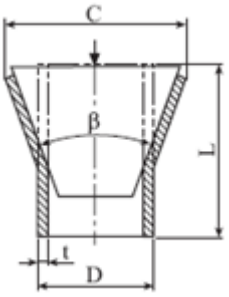
3.2 After the test, the specimens shall be thoroughly examined for defects with normal visual acuity. The test shall be satisfactory if the specimen reveals no unacceptable defects such as scabs, laps, cracks, grooves or laminations and if visible deformation has occurred at the point of fracture. The dimensions of the pipe sections are to be stated.

Example of standards to be applied: ISO 8496:2013 Ring Tensile Test on Pipes

4. Drift expanding test

4.1 To perform this test, a tapered drift is forced into the specimen until the outside diameter has increased to the prescribed value C for the product in question, see Fig. 2.11. The length of the specimen and the taper angle β of the drift shall be as shown in the following Table. The intrusion rate of the taper may not exceed 50 mm/s.

4.2 After the test, the specimens shall be thoroughly examined for defects with normal visual acuity. The test shall be satisfactory if the prescribed expansion has been effected without cracks.



Material	Length of specimen L	Taper angle β
Steel	≤ 2 D ≤ 1,5 D; min. 50 mm	30° 45°, 60° over 120°
Copper and Copper alloys	2 D	45°
Aluminium alloys	≥ 2 D , min 50 mm	60 °

Fig. 2.11 Drift expanding test

C = Diameter after the prescribed expansion

The dimensions of the pipe section, the outer diameter C of the expanded part of the pipe section or the relative expansion [%], as well as the taper angle are to be stated.

Examples of standards to be applied: ISO 8493:1998 Drift Expanding Test on Pipes.

5. Flanging test

5.1 To perform this test, a sample of pipe with a length L = 1,5 D is worked into a flange in the device shown in Fig. 2.12 until the outer diameter C of the flange attains the value prescribed for the product. The radius r shall match that prescribed for the product.

The intrusion rate of the tool may not exceed 50 mm/min.

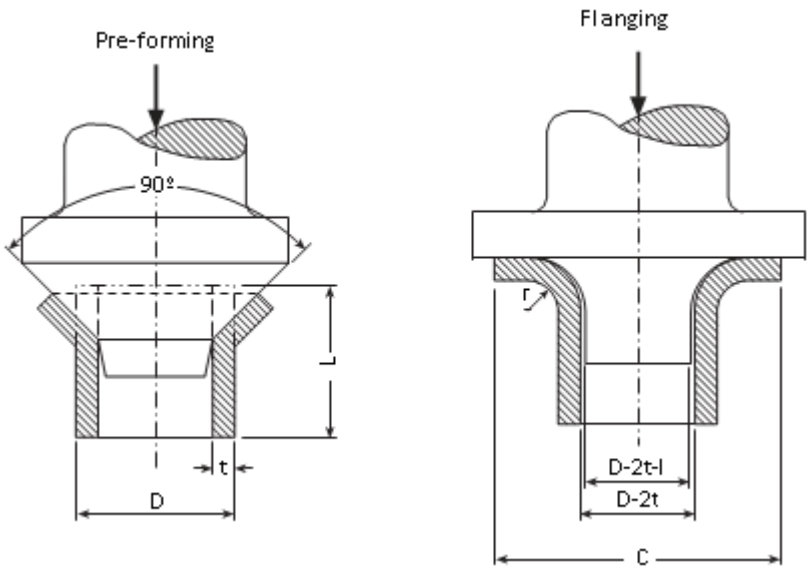


Fig. 2.12 Flanging test

5.2 The test shall be satisfactory if the flange has no apparent cracks. Minor defects on the edges can be disregarded. The dimensions of the pipe section, the outer diameter C of the expanded part of the pipe section or the relative expansion [%], as well as the edge radius of the forming tool are to be stated.

Examples of standards to be applied: ISO 8494:2013 Flanging Test on Pipes

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G. Instructions for the Bend Test, Hardness Test and Drop Weight Test

1. Technological bend test

1.1 For this test, specimens with thickness a and width b are to be prepared, the edges of which may be rounded on the tension side to a radius of 1 – 2 mm. For plates and sections the specimen thickness a is equal to the product thickness t. For product thicknesses t exceeding 25 mm the thickness may be reduced by machining the compression side of the bend specimen to not less than 25 mm.

For product widths smaller than or equal to 20 mm the specimen width b shall be equal to the product width. For product widths exceeding 20 mm the specimen width b = 20 – 50 mm.

For forgings, castings and semi-finished products the specimen thickness shall be a = 20 mm and the specimen width b = 25 mm.

1.2 For butt-welded joints the bend specimens at right angle to the weld joint shall have the following dimensions for verification of the final pass and the root pass:

- a = t
- b = 30 – 50 mm

For side bend specimens the following dimensions do apply:

- a = 10 mm
- b = t

For t ≥ 40 mm the side bend specimen may be split, with the width of each part being at least 20 mm.

For bend specimens with longitudinal direction to the joint the dimensions shall be in accordance with generally accepted standards.

1.3 To perform this test, the test specimen is bent in a continuous operation as shown in Fig. 2.13 and using a mandrel of specified radius D/2 until the prescribed bending angle α is reached or the initial incipient fracture occurs. For normal strength steels D/2 = 2 · a, for higher strength steels D/2 = 3 · a. The test shall be satisfactory if the prescribed bending angle is achieved without incipient fracture. If, when the specimen is unclamped, it springs back, the bending operation need not be repeated.

Example of standard to be applied: ISO 7438:2020 Metallic materials - Bend Test

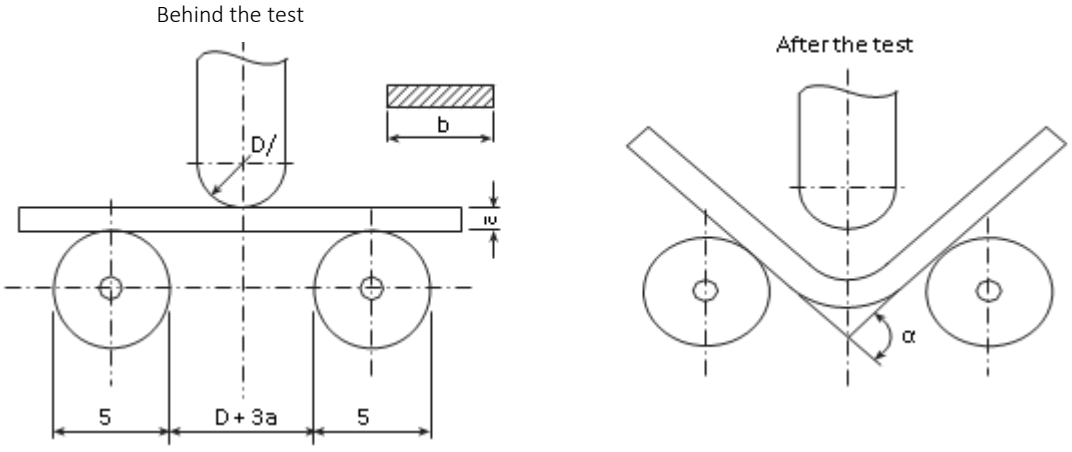

Fig. 2.13 Technological bend test

2. Hardness tests

2.1 The tests are to be performed, according to specification, to determine the Brinell, Vickers or Rockwell hardness using standardized methods, see for example:

- ISO 6506-1:2014 Brinell Hardness Test
- ISO 6507-1:2018 Vickers Hardness Test
- ISO 6508-1:2016 Rockwell Hardness Test

2.2 Hardness tests shall not be considered a substitute for the tensile test. Brinell hardness tests may, however, be permitted for the purpose of comparing mechanical properties provided that, of several products of the same shape, grade of material and heat treatment, at least one has been subjected to the tensile test.

3. Pellini drop weight test

3.1 This test shall be performed in accordance with ASTM E-208:2019 on steels with product thicknesses of ≥ 16 mm. The specimen shape will be chosen which most closely matches the product thickness accordingly to Table 2.4. The correct specimen thickness shall be achieved by machining one side.

The long sides of the test specimens shall be made with a saw cut or, in the case of specimens obtained by thermal cutting, shall be machined with a machining allowance of at least 25 mm.

Table 2.4 Specimen dimensions for drop weight test

Specimen shape	Dimensions [mm]
P1	360 × 90 × 25
P2	130 × 50 × 19
P3	130 × 50 × 16

end

Section 4 Steel Plates, Strips, Section, and Bars

A. General Rules

5. General characteristics of products

5.1 All products shall have a smooth rolled surface and shall be free from any defects liable to have more than an insignificantly adverse effect on their workability and intended use, e.g. laminations, cracks, blow holes, scabs and seams.

5.2 Unless otherwise stipulated by the purchaser or prescribed by BKI, hot-rolled plates, wide flats and sections shall be subject to the delivery conditions stipulated in EN 10163:2007.

5.3 Unless otherwise specified or agreed, surface defects may only be removed by grinding within the permitted tolerance on the minimum thickness. The depressions caused by grinding shall have a smooth transition to the surrounding surface of the product.

6. Dimensions, dimensional and geometrical tolerances

6.1 Plates, strips and wide flats may be delivered either with the minus tolerances shown in Table 4.1 or with no minus tolerance. Where no stipulations are made in the following individual rules, e.g. for shipbuilding steels in accordance with B., flat products made from high-strength steels in accordance with D., flat products for cargo tanks in accordance with F. and clad plates in accordance with H. the permitted minus tolerance is to be agreed when the order is placed.

Table 4.1 Permitted minus tolerances for the thickness of plates and wide flats

Nominal Thickness [mm]	Permitted minus tolerances [1] [mm] for class		
	A	B	C
3 ≤ t < 5	-0,3	-0,3	0
5 ≤ t < 8	-0,4	-0,3	0
8 ≤ t < 15	-0,5	-0,3	0
15 ≤ t < 25	-0,6	-0,3	0
25 ≤ t < 40	-0,7	-0,3	0
40 ≤ t < 80	-0,9	-0,3	0
80 ≤ t < 150	-1,1	-0,3	0
150 ≤ t < 250	-1,2	-0,3	0
t ≥ 250	-1,3	-0,3	0

[1] See also ISO 7452:2013

6.2 The thickness is to be measured at points located at least 25 mm from the edge of the product, if not stipulated otherwise in the individual rules, e.g. for shipbuilding steels in accordance with B. and flat products made from high-strength steels in accordance with D. Local depressions due to flaws and grinding marks arising from the remedying of defects are not taken into account, provided that they do not exceed the tolerances.

6.3 Unless otherwise agreed in the order, the provisions regarding form tolerances according to EN 10029:2011 apply.

----------*end*----------

8. General instructions for testing

8.6 Ultrasonic tests

8.6.1 The tests shall be performed in accordance with EN 10160:1999 or another standard accepted by BKI (e.g. ASTM A 578:2017). The testing staff shall be adequately qualified for this task and the Surveyor shall be furnished with proof thereof if he so requests. The Surveyor shall be permitted to take part in the tests at his request.

----------*end*----------

10. Certificates

10.3 Where the steels are not produced and rolled by the same manufacturer, a certificate issued by ~~the steelmaker~~ manufacturer specifying at least the heat numbers and the chemical compositions shall be handed to the Surveyor.

----------*end*----------

B. Normal and Higher Strength Hull Structural Steels

7. Freedom from defects and repair of surface defects

7.1 General characteristics

7.1.1 All products shall satisfy the requirements applicable to general characteristics set out in A.5.1. Unless otherwise agreed, the surface finish of the products shall be subject to standard EN 10163:2007, specifications relating to the surface finish of hot-rolled steel products (plate, steel wide flat and sections), Class A, or equivalent national or international standard, however, grinding of defects may only be carried out within the limits given in 7.2.

----------*end*----------

C. Unalloyed Steels for Welded Structures

2. Suitable steels

The following steels may be used with the requirements laid down in the relevant standards:

2.1 Steels conforming to EN 10025:2019, EN 10210:2019 and EN 10219:2019 grades as follows:

- S235: all grades

Note

The grades S235 JR and S235 JR G1 according to EN 10025: 1990 + A1: 1993 are excluded from application.

- S275: all grades
- S355: all grades

2.2 Weldable fine-grained structural steels conforming to EN 10025-3:2019, in the grades:

- S275 N, S 275 NL, S355 N, S355 NL (normalised or normalising rolled)

and conforming to EN 10025-4:2019 in the grades:

- S275 M, S275 ML, S355 M, S355 ML (thermo-mechanically rolled)

----------*end*----------

D. High-Strength Steels for Welded Structures

3. Requirements

3.1 Manufacturing process

3.1.1 The steels shall be manufactured in works approved by BKI by the basic oxygen process, in electric arc furnaces, or by another process approved by BKI. They shall be cast in fully killed condition and fine grain treated.

Note:

A fine grain structure has an equivalent index ≥ 6 determined by micrographic examination in accordance with ISO 643:2019 or alternative test method.

----------*end*----------

4. Testing

4.6 Non-destructive testing

4.6.1 Verification of internal soundness is the responsibility of the manufacturer. The acceptance by the BKI's Surveyor shall not absolve the manufacturer of this responsibility.

4.6.2 Where plates and wide flats are ordered with a certificate of ultrasonic examination, the tests are to be carried out according to a standard accepted by BKI, e.g. EN 10160:1999. The quality class is to be defined at the time of the order.

4.6.3 The seams of welded hollow sections of hull structural steel are to be subjected to non-destructive testing over their entire length.

4.6.3.1 Electrical welded hollow sections

The weld seam of hollow sections is to be examined according to one of the following European standards:

- ISO 10893-2:2011, acceptance category E4, except that the technique of rotating pipes or with rotating saddle coils is not permitted
- ISO 10893-3:2011, acceptance category F5, or ISO 10893-11:2011, acceptance category U5

4.6.3.2 Submerged-arc welded hollow sections

The weld seam of hollow sections is to be examined according to acceptance category U4 in accordance with ISO 10893-6:2019, image quality class R2.

Butt welds serving to connect strip or plate lengths by spiral submerged-arc welding have to be examined over their entire length according to the same test procedure and shall satisfy the same acceptance criteria as the main weld seam.

----------*end*----------

E. Steels for Steam Boilers and Pressure Vessels

1. Scope

These Rules apply to flat products made from ferritic steels, which are intended for the manufacture of steam boilers, pressure vessels, heat exchangers and other process equipment.

2. Approved steel grades

The materials listed below may be used:

2.1 Flat products made of steel used for pressure vessels conforming to EN 10028-2 :2017 "Alloyed and Unalloyed High Temperature Steels".

2.2 Flat products made of steel used for pressure vessels conforming to EN 10028-3:2017, "Weldable fine- grained structural steels, normalized".

2.3 Flat products made of KI-steels used for pressure vessels according to Table 4.14 and 4.15. For the 0,2 % proof stress at elevated temperatures, Table 4.16 applies.

2.4 Flat products made of other steels, provided that their suitability for the intended purpose and their properties have been proved to BKI. For this, the following requirements are to be satisfied:

2.4.1 The elongation (A) shall have the minimum values which characterize the grade of steel, as specified in the BKI report, but shall be not less than 16 %.

2.4.2 The impact energy shall meet or exceed the requirements of EN 10028-2 and -3 :2017 respectively for flat products of the same strength, see Table 4.14. In the case of plates to be used for shell rings and heads, the manufacturer and the steel user shall ensure that the values required for the final condition can be complied with.

Table 4.14 Mechanical and technological properties of flat products made of KI-steels used for pressure vessels

Steel grade	Normal delivery condition[1)]	Yield strength R_{eH} and $R_{p\,0,2}$ respectively [N/mm²] min.	Tensile strength R_m [N/mm²]	Elongation A [%] min.	Notched bar impact energy	
					Test temp. [ºC]	KV [J] min. transv.
KI-P235W	N	235	360 to 480	25	0	34
KI-P265W	N	265	410 to 530	23	0	34
KI-P295W	N	295	460 to 580	22	0	34
KI-P335W	N	355	510 to 650	21	0	34

[1)] N = normalized

end

5. Testing and scope of tests

5.4 Notched bar impact test

5.4.1 All products with thicknesses ≥ 6 mm shall be impact tested using Charpy V-notch specimens at the test temperature of 0°C. The specimens shall be taken from the products transverse to the direction of rolling. The number of sets (each of 3 specimens) required for this purpose shall be determined in the same way as the number of tensile test specimens prescribed in 5.2.

The test temperatures for flat products complying with EN 10025:2019 are given in the standard.

For other steels as per 2.4, the test temperature will be stipulated in the BKI approval.

----------*end*----------

7. Strength parameters for calculations

The strength parameters for calculations are:

7.1 For flat products conforming to EN 10028 Parts 2 and 3:2017, the values stated in these standards.

For flat products made of KI-steels used for pressure vessels according to 2.3, the values stated in Table 4.16.

----------*end*----------

F. Steels for Cargo Tanks Vessels

2. Approved steel grades

2.1 Weldable, fine-grained structural steels conforming to EN 10028-3:2017.

Note:

The use of steel grade P460 NH for tanks designed to carry pressure-liquefied ammonia at ambient temperatures is prohibited.

2.2 Fine-grained structural steels with nominal yield strengths above 355 N/mm^2 in accordance with EN 10028-3, -5 and -6:2017.

2.3 Nickel alloy steels which are tough at low temperatures, conforming to EN 10028-4:2017.

2.4 Stainless, austenitic steels conforming to EN 10028-7:2016, provided that they are suitable for the intended design temperature.

Table 4.17 Minimum design temperatures for steels used in the fabrication of cargo tanks

Steel designation	References to standards and rules	Minimum design temperature [ºC]
Fine-grained structural steels for ammonia which has been liquefied under pressure	For chemical composition, see Table 4.18	0
Normalized, TM rolled and fine- grained structural steels with nominal yield strengths above 355 N/mm^2	e.g. according to EN 10028-3, -5 or -6:2017	0
Other fine-grained structural steels with nominal yield strengths up to 355 N/mm^2	e.g. according to EN 10028-3, -5 or -6:2017	– 45 [1]
Nickel alloy steels containing 0,5 % Nickel	Steels according to EN 10028-4:2017 11MnNi5-3, 13MnNi6-3	– 55
1,5 % Nickel	15NiMn6	– 60 [2]
3,5 % Nickel	12Ni14	– 90 [2]
5 % Nickel	X12Ni5	– 105 [2]
9 % Nickel	X7Ni9, X8Ni9	– 165
Austenitic steels	e.g. steels according to EN 10028-7:2016 1.4306 (AISI 304 L)	– 165
	1.4404 (AISI 316 L)	
	1.4541 (AISI 321)	
	1.4550 (AISI 347)	

[1] BKI reserves the right to approve a lower design temperature (max. – 55°C) if suitable properties are demonstrated during approval testing.

[2] A lower design temperature may be approved for steels containing 1,5 %, 3,5 % and 5 % nickel if the steels are quenched and tempered. In these cases, the test temperatures will be specially stipulated by BKI.

----------*end*----------

9. Testing and scope of tests

9.7 Non-destructive tests

9.7.2 Ultrasonic testing is to be carried out according to EN 10160:1999 as follows :

Test grid ≤ 200 mm or in lines 100 mm apart.

	EN 10160:1999
Surface test	S_1
Marginal zone test	E_3

Zones for longitudinal, circumferential and connection welds over a width equal to the thickness of the plate, but not less than 50 mm in accordance with quality class E_3 according to EN 10160:1999.

Areas for the connection of supporting brackets, lifting lugs and floating securing devices 100 % in accordance with quality class S_3 according to EN 10160:1999.

----------*end*----------

G. Stainless Steels

2. Selection of steels

2.1 Steels shall be selected in accordance with the operator's list of cargoes, which provides information on the nature of the substances to be transported or stored.

2.2 Furthermore, steels shall be selected in such a way that also depending upon their further processing, e.g. by welding, the required chemical stability in relation to the respective cargo or operating fluid is ensured.

2.3 In the light of 2.1 and 2.2 above, suitable steels may be selected e.g. in accordance with EN 10088 :2014 relating to stainless steels, where the products are not required to be supplied in accordance with a specification which has been examined by BKI.

----------*end*----------

7. Testing and scope of tests

The following tests shall be performed:

7.1 Testing of chemical composition

The manufacturer shall determine the chemical composition of each heat and issue a relevant certificate.

7.2 Testing of resistance to intercrystalline corrosion

All products shall be tested for resistance to intercrystalline corrosion. For this purpose, at least 2 specimens shall be taken from each heat. The test is to be performed in accordance with ISO 3651:1998 on specimens in the following condition:

- stabilized steels and steels with a carbon content ≤ 0,03 %: sensitized (annealed at 700°C for 30 minutes and quenched in water)
- all other steels: in the condition in which they are supplied

----------*end*----------

I. Steels with Through Thickness Properties

2. Requirements

2.2 Freedom from defects

All products shall be free from defects liable to impair the required characteristics in the thickness direction, e.g. laminations, major non-metallic inclusions, flakes and segregations.

In addition, when subjected to ultrasonic testing flat products shall satisfy the Class 2 test requirements laid down in Stahl-Eisen-Lieferbedingung 072 (Iron and Steel Supply Conditions 072) or Class S2/E3 test requirements according to EN 10160:1999. For sections Class 1.2/23 test requirements according to EN 10306 :2002 apply.

Note

Iron and Steel Supply Conditions 072 specify the following Class 2 test requirements for the general ultrasonic test:

Minimum significant flaw size:	*0,5 cm^2*
Maximum permissible flaw size:	*1,0 cm^2*
Permissible incidence of flawsin relation to area:	
locally :	*up to 30 m^2*
in relation to total plate area :	*up to 15/m^2*
Maximum permissible length of significant flaws:	
parallel to edge (edge testing):	*4 cm*
Permissible incidence of flaws(edge testing):	*up to 5/m*

----------*end*----------

3. Testing and scope of tests

3.1 Tensile testing of Z specimens

3.1.3 Tensile test with extension pieces

Steel extension pieces, e.g. studs, shall be welded to the two surfaces of the sample which lie perpendicular to the thickness direction of the steel product; see Fig. 4.8. Examples of permissible welding processes are stud or friction welding.

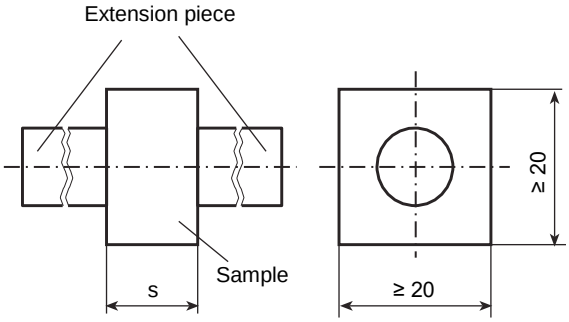

Fig. 4.8 Specimen blank, consisting of test piece and welded-on extension pieces

Before welding on the extension pieces, the abutting surfaces of the sample and the extension pieces shall be carefully cleaned to remove rust, scale and grease. The heat affected zone due to welding shall penetrate into the sample to the minimum possible depth.

The tensile test specimen shall be machined out of the specimen blank in accordance with Fig. 4.9

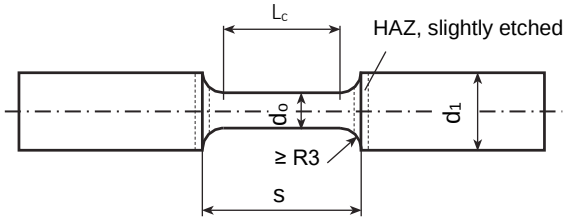

Fig. 4.9 Tensile test specimen with extension pieces

The diameter d_O of the tensile test specimen shall be as follows:

d_o = 6 or 10 mm in the case of product thicknesses s of ≤ 25 mm,

= 10 mm in the case of product thicknesses s of > 25 mm.

The test length L_c of the tensile test specimen shall be at least $1,5 \cdot d_o$ and shall not exceed 150 mm.

Note:

For further details see EN 10164 :2018.

----------*end*----------

M. High Manganese Austenitic Steel for Cryogenic Service

1. Application

1.1 This sub-section provides requirements for manufacturing approval and batch release testing of high manganese austenitic steel as plate for cryogenic service with thickness between 6 mm to 40 mm. For greater thickness, special consideration shall be given by each BKI

1.2 High manganese austenitic steels differing in chemical composition, deoxidation practice, condition of supply and mechanical properties may be considered, subject to the special approval of the BKI.

2. Definitions

2.1 High manganese austenitic steel means the steel with a high amount of manganese in order to retain austenite as its primary phase at atmospheric and service temperature.

2.2 For meaning of piece see B.11.1.1.

3. Approval

3.1 High manganese austenitic steel shall be manufactured at steel works which have been approved by the BKI. The suitability of steel for forming and welding shall be demonstrated during the initial approval test at the steelworks. Approval of the steelworks shall follow a scheme given in Guidance for The Approval and Type Approval of Materials and Equipment for Marine Use (Pt.1, Vol.W).

3.2 It is the steelmaker's responsibility to assure that effective quality, process and production controls during manufacturing are adhered to within the manufacturing specifications. The manufacturing specification shall be submitted to BKI at the time of initial approval.

3.3 Where non-conformities arise, the manufacturer shall identify the cause and establish countermeasures to prevent its recurrence. The non-conformities and the countermeasures are to be documented and reported to BKI

4. Method of manufacture

4.1 Steel shall be manufactured by the basic oxygen, electric furnace or open hearth processes or by other processes specially approved by BKI.

4.2 The deoxidation practice shall be fully killed for steel.

4.3 The steel shall be fine grain treated and shall have a fine grain structure. The fine grain practice shall be as detailed in the manufacturing specification.

5. Chemical composition

5.1 The chemical composition of samples taken from each ladle of each cast shall be determined by the steelmaker in an adequately equipped and competently staffed laboratory and shall comply with the appropriate requirements of Table 4.29.

5.2 The aim analysis shall be in accordance with the manufacturing specification. All the elements listed in Table 4.29 shall be reported.

Table 4.29 Chemical composition for high manganese austenitic steel

Chemical composition (%) [1]								
C	Si [2]	Mn	P	S	Cr	B	N	Cu
0,35 - 0,55	0,10 - 0,50	22,50 ~25,50	≤0,030	≤0,010	3,00 ~4,00	≤0,005	≤0,050	0,30 ~0,70

[1] The content of other elements used for alloying and fine grain treatment may be specified by steelmaker, as appropriate.
[2] Silicon(Si) may be less than 0,1 %, provided total aluminium is 0,03 % or higher, or provided acid soluble aluminium is 0,025 % or higher.

6. Condition of supply

6.1 Condition of supply for all material is hot rolled and subsequent controlled cooling if necessary. Other conditions of supply are to be in accordance with BKI's procedure.

6.2 The reduction ratio of slab to finished product thickness shall be not less than 3:1.

7. Mechanical properties

7.1 Material specifications for high manganese austenitic steel plates are defined in Table 4.30.

Table 4.30 Conditions of grade and mechanical properties for high manganese austenitic steel plates

Grade	Yield Strength (N/mm^2)	Tensile Strength (N/mm^2)	Elongation (%) min	Charpy Impact Energy, Average		
				Test Temp. (°C)	Transverse (J)	Longitudinal (J)
HMA400	≥400	800 - 970	≥22	-196	≥27	≥41

8. Surface quality and internal soundness

8.1 The steel shall be reasonably free from segregations and non-metallic inclusions.

8.2 The finished material shall have a workmanlike finish and shall be free from internal and surface defects prejudicial to the use of the material for the intended application.

8.3 Surface finish of steel shall be in accordance with the relevant requirements in B.7.

8.4 Verification of internal soundness is the responsibility of manufacturer. The acceptance by the BKI's Surveyor shall not absolve the manufacturer of this responsibility.

9. Tolerances

9.1 Unless otherwise agreed or specially required, the thickness tolerances of high manganese austenitic steel plate shall be in accordance with A.6.

10. Identification of materials

10.1 The steelmaker shall adopt a system for the identification of ingots, slabs and finished pieces which will enable the material to be traced to its original cast.

10.2 The surveyor shall be given full facilities for so tracing the material when required.

11. Testing and inspection

11.1 Facilities for inspection

Testing shall be carried out under the witness of the surveyor, or an authorized deputy, in order to verify whether the test results meet the specified requirements.

The manufacturer shall afford the surveyor all necessary facilities and access to all relevant parts of the steel works to enable him to verify the approved process is adhered to, for the selection of test materials, the witnessing of tests, and verifying the accuracy of the testing, calibration of inspection equipment.

11.2 Testing procedures

The tests and inspections may be carried out at the manufacturing place before dispatch.

The test specimens and test methods shall comply with the information given in Section 2. All the test specimens are to be tested in his presence, unless otherwise agreed.

11.3 Ultrasonic examination

If required by the BKI, the manufacturer shall perform ultrasonic examination in accordance with an approved standard.

11.4 Surface inspection and dimensions

Surface inspection and verification of dimensions are the responsibility of the steelmaker.

The acceptance by BKI's surveyor shall not absolve the steelmaker of this responsibility in case defective material is found later.

12. Test material

12.1 All material in a batch presented for acceptance tests shall be of the same product form from the same cast and in the same condition of supply.

12.2 The test samples are to be fully representative of the material and, where appropriate, are not to be cut from the material until heat treatment has been completed.

12.3 The test specimens are not to be heat treated separately from the test samples in any way.

12.4 Unless otherwise agreed, the test samples are to be taken from one end at a position approximately midway between the axis in the direction of the rolling and the edge of the rolled product (see Fig. 4.1).

Unless otherwise agreed, the tensile test specimens are to be prepared with their longitudinal axis transverse to the final direction of rolling.

13. Mechanical test specimens

13.1 Tensile Test Specimens

The dimensions of the tensile test specimens are to be in accordance with Section 2,D. Test specimens of full product thickness are to be used.

13.2 Impact test specimens

The impact test specimens are to be of the Charpy V-notch type cut with their longitudinal axis as near as practicable to a point midway between the surface and the centre of the thickness and with their longitudinal axis either parallel or transverse to the final direction of rolling of the material. The notch shall be cut in a face of the test specimen which was originally perpendicular to the rolled surface. The position of the notch is not to be nearer than 25mm to a flame cut or sheared edge.

14. Number of test specimens

14.1 Number of tensile tests

One tensile test shall be made from each piece.

14.2 Number of impact tests

At least one set of three charpy V-notch test specimens shall be made from each piece.

15. Retest procedures

15.1 Retest procedures for tensile tests and charpy impact tests are to be in accordance with Section 2, H.

15.2 If any test specimen fails because of faulty preparation, visible defects or (in the case of tensile test) because of fracturing outside the range permitted for the appropriate gauge length, the defective test piece may, at the surveyor's discretion, be disregarded and replayed by an additional test piece of the same type.

15.3 In the event of any material proving unsatisfactory during subsequent working or fabrication, such material may be rejected, notwithstanding any previous satisfactory testing and/or certification.

16. Marking

16.1 Each finished piece shall be clearly marked by the manufacturer with the following particulars:

1) Name or mark to identify the steel works
2) Unified identification mark for the grade of steel
3) Cast number/Heat number, plate number or equivalent identification mark
4) Delivery condition
5) BKI's brand mark

16.2 The marking particulars, but excluding the manufacturer's name or trade mark where this is embossed on finished products shall be enriched with paint or otherwise marked so as to be easily recognizable.

17. Documentation

17.1 The surveyor shall be supplied with the number of copies of the test certificates or shipping statements for all accepted materials. In addition to the description, dimensions, etc., of material, the following particulars shall be included:

1) Purchaser's order number and if known the hull number for which the material is intended
2) Identification of the cast and piece including, where appropriate, the test specimen number
3) Steelwork's identification

4) Chemical analysis
5) Condition of supply with heat treatment temperatures
6) Mechanical properties test result, including traceable test identification
7) Surface quality and inspection results
8) UT result, where applicable
9) Identification of the grade of steel

17.2 Before the test certificates or shipping statements are signed by surveyor, the manufacturer is required to furnish him with a written declaration stating that the material has been made by an approved process and that it has been subjected to and has withstood satisfactory the required tests in the presence of surveyor or his authorized deputy. The name of BKI shall appear on the test certificate. The following form of declaration will be accepted if stamped or printed on each test certificate or shipping statement with the name of the steelworks and initialled for the makers by an authorized official:

"We hereby certify that the material has been made by an approved process and has been satisfactorily tested in accordance with the Rules of BKI"

----------*end*----------

Section 10 Aluminium Alloys

A. Wrought Aluminium Alloys

1. Scope

1.5 With regard to the definition of the material conditions EN 515:2017 or ANSI H35.1:2017 is applicable.

----------*end*----------

4. Suitable alloys

4.2 Wrought aluminium and wrought alloys for use in non-load bearing structures and for rivets

Aluminium and aluminium alloys which are suitable as welded, bonded or mechanically joint structural members in non-load bearing structures exposed to marine environment are given in Table 10.2.

The chemical composition of these materials shall be taken from EN 573-3:2019 or equivalent standards.

The recommended product types for these alloys are also given in Table 10.2. They may be used in the material conditions specified in the relevant European or equivalent standards.

The alloys specified in Table 10.1 may also be used for non-load bearing structures applicable to all products and material conditions.

Note:

Products made from the 5000 and 6000 series of alloys shall not come into direct contact with seawater. Where necessary, they are to be protected by anodes or coatings.

----------*end*----------

9. Tests

9.5 Corrosion test

9.5.1 On rolled products from alloys of the series 5XXX supplied in the condition H116, H32 or H321, a test of resistance against exfoliation corrosion and intercrystalline corrosion is to be carried out according to ASTM-G66:2018 (ASSET) and ASTM-G67:2018 (NAMLT).

9.5.2 The manufacturers shall establish the relationship between microstructure and resistance to corrosion when the above alloys are approved. A reference photomicrograph taken at 500x, under the conditions specified in ASTM B928:2015, Section 9.4.1, shall be established for each of the alloy-tempers and thickness ranges relevant. The reference photographs shall be taken from samples which have exhibited no evidence of exfoliation corrosion and a pitting rating of PB or better, when subjected to the test described in ASTM G66:2018 (ASSET).The samples shall also have exhibited resistance to intergranular corrosion at a mass loss no greater than 15mg/cm^2, when subjected to the test described in ASTM-G67:2018 (NAMLT). Upon satisfactory establishment of the relationship between microstructure and resistance to corrosion, the master photomicrographs and the results of the corrosion tests are to be approved by the ~~Classification Society~~ BKI. Production practices shall not be changed after approval of the reference micrographs. Other test methods may also be accepted at the discretion of the ~~Classification Society~~ BKI .

9.5.3 For batch acceptance of 5xxx-alloys in the H116 and H321 tempers, metallographic examination of one sample selected from mid width at one end of a coil or random sheet or plate is to be carried out. The microstructure of the sample is to be compared to the reference photomicrograph of acceptable material in the presence of the Surveyor. A longitudinal section perpendicular to the rolled surface shall be prepared for metallographic examination, under the conditions specified in ASTM B928:2015, Section 9.6.1. If the microstructure shows evidence of continuous grain boundary network of aluminium-magnesium precipitate in excess of the reference photomicrographs of acceptable material, the batch is either to be rejected or tested for exfoliation corrosion resistance and intergranular corrosion resistance subject to the agreement of the Surveyor. The corrosion tests are to be in accordance with ASTM-G66:2018 and ASTM-G67:2018 or equivalent standards. Acceptance criteria are that the sample shall exhibit no evidence of exfoliation corrosion and a pitting rating of PB or better when test subjected to ASTM-G66:2018 ASSET test, and the sample shall exhibit resistance to intergranular corrosion at a mass loss no greater than 15mg/cm2 when subjected to ASTM-G67:2018 NAMLT.test. If the results from testing satisfy the acceptance criteria stated in paragraph ~~8~~9.5.2 the batch is accepted, else it is to be rejected.

As an alternative to metallographic examination, each batch may be tested for exfoliation-corrosion resistance and intergranular corrosion resistance, in accordance with ASTM-G66:2018 and ASTM-G67:2018 under the conditions specified in ASTM B928:2015, or equivalent standards. If this alternative is used, then the results of the test must satisfy the acceptance criteria stated in this paragraph ~~9.5.3~~.

For rolled plates of grade 5083, 5383, 5059, 5086 and 5456 delivered in the tempers H116 or H321, one sample is to be tested per batch.

----------*end*----------

B. Aluminium Casting Alloys

3. Permitted grades of casting

3.1 Suitable grades of castings to international or national standards, e.g. to EN 1706:2020 shall generally be used. Where castings conforming to manufacturer's specifications are to be used, these are to be submitted to BKI for examination and approval.

3.2 Castings such as fittings, housings and fan rotors which are exposed without protection to the action of seawater or salty atmosphere should be made of alloys suitable for this kind of use. AlSi-, AlSiMg- and AlMg-alloys with a maximum copper content of 0,1 % should normally be used. AlSi- and AlSiMg-alloys shall not come into direct contact with seawater. Where necessary, they are to be protected by anodes or coatings.

3.3 For the applications mentioned in 1.1, use may be made of the casting alloys conforming to EN 1706:2020 listed in Table 10.9.

Use may be made of other alloys provided these are suitable for the intended application and their use has been approved by BKI.

----------*end*----------

Section 13 Chain Cables and Accessories

A. Anchor Chain Cables and Accessories Chain

3. Construction and manufacture

3.2 Construction

Anchor chain cables shall be manufactured according to a standard recognized by BKI, e.g. ISO 1704:2008. Conventional constructions of chain cable links are shown in Fig. 13.4, 13.5 and 13.6. A length of chain cable shall comprise an odd number of links.

If the construction does not comply with this provision or if accessories are to be of welded construction, drawings giving full details of the manufacturing process and the method of heat treatment shall be submitted to BKI for approval.

3.3 Heat treatment

Depending on the grade of steel, chain cables shall be supplied in one of the conditions specified in Table 13.4. Heat treatments shall always be performed before the tests at proof and breaking loads.

Table 13.4 Heat treatment of chain cables and accessories

Grade	Condition of supply	Accessories
KI-K1 ~~(KI-K2) 1)~~	Untreated or normalized after welding	NA 2) ~~Normalized~~
KI-K2 1)	Untreated or normalized after welding	Normalized
KI-K3	Normalized, normalized and tempered or quenched and tempered	Normalized, normalized and tempered or quenched and tempered

1) Chain cables made of grade KI-K2 steel shall generally be normalized. BKI may waive this stipulation if it is proved by means of an approval test that the chain cables meet the requirements. An extended scope of testing may be prescribed for such chain cables.

2) NA = Not Applicable

----------*end*----------

C. Offshore Mooring Chain

1. General Requirement

1.1 Scope

1.1.4 Requirements for chafing chain for single point mooring arrangements are given in ~~Section 13.~~B.

----------*end*----------

1.3 Approval

1.3.3 For initial approval CTOD tests are to be carried out on the particular IACS mooring grade of material. CTOD tests are to be tested in accordance with a recognized standard such as ~~BS 7448 Part 1~~ ISO 12135:2021 & ~~BS EN~~ ISO 15653:~~2010~~ 2018. The CTOD test piece is to be a standard 2 x 1 single edge notched bend piece, test location as shown in Fig.13.12.

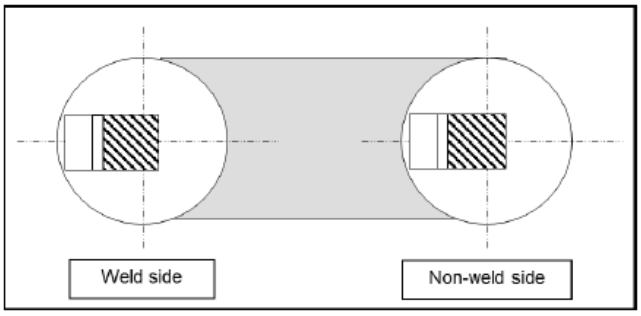

Fig. 13.12: Location of CTOD test specimens for chain

The notch of the CTOD specimen is to be located as close to the surface as practicable. The minimum cross section of the test piece shall be 50 x 25 mm for chain diameters less than 120 mm, and 80 x 40 mm for diameters 120 mm and above.

CTOD specimens are to be taken from both the side of the link containing the weld and from the opposite side. Three links are to be selected for testing, a total of six CTOD specimens. The tests are to be taken at minus 20° C and the lowest CTOD of each set of 3 specimens shall meet the minimum values indicated below in Table 13.9.

Table 13.9 Minimum CTOD test values for chain type

Chain type	R3 in mm		R3S in mm		R4 in mm		R4S & R5 in mm	
	BM	*WM*	*BM*	*WM*	*BM*	*WM*	*BM*	*WM*
Stud link	0.20	0.10	0.22	0.11	0.24	0.12	0.26	0.13
Studless	0.20	0.14	0.22	0.15	0.24	0.16	0.26	0.17

----------*end*----------

1.5. Approval of steel mills; Rolled bar

1.5.2 Approval will be given only after successful testing of the completed chain. Each Grade is to be individually approved. Approval for a higher grade does not constitute approval of a lower grade. If it is demonstrated to the satisfaction of ~~the Classification Society~~ BKI that the higher and lower grades are produced to the same manufacturing procedure using the same chemistry and heat treatment, consideration will be given to qualification of a lower grade by a higher. The parameters applied during qualification are not to be modified during production. The approval will normally be limited up to the maximum diameter equal to that of the chain diameter tested. The rolling reduction ratio is to be recorded and is to be at least 5:1 for KI-R3, KI-R3S, KI-R4, KI-R4S and KI-R5. The rolling reduction ratio used in production can be higher, but should not be lower than that qualified.

----------*end*----------

1.6 Approval of forges and foundries for accessories

1.6.6 For initial approval CTOD tests are to be carried out on the particular IACS mooring grade of material. Three CTOD tests are to be tested in accordance with a recognized standard such as ~~BS 7448 Part 1~~ ISO 12135:2021 & ~~BS EN~~ ISO 15653:~~2010~~ 2018. For rectangular accessories, the CTOD test piece is to be a standard 2 x 1 single edge notched bend specimen of thickness equal to full thickness of material

to be tested. Subsized specimens can be used subject to approval of BKI. For circular geometries, the minimum cross section of the test piece shall be 50 x 25mm for accessory diameters less than 120mm, and 80 x 40mm for diameters 120mm and above. The notch of the CTOD specimen is to be located as close to the surface as practicable. The tests are to be taken at minus 20º C and the results submitted for review.

The minimum values of each set of three specimens are to at least meet the requirements as indicated in Table 13.10 (same as that of the studless chain material shown in Table 13.9).

Table 13.10 Minimum CTOD test values for accessories

Grade of accessories	R3 in mm	R3S in mm	R4 in mm	R4S & R5 in mm
CTOD	0,20	0,22	0,24	0,26

The geometry of accessories can vary. Fig. 13.13 shows the CTOD location for circular and rectangular cross sections such as those of the D-shackle and accessories fabricated from rectangular sections. The orientation of the specimen shall consider the direction of the grain flow. Fig. 13.13(b) shows two possible sampling positions for CTOD test specimens with notch orientation for rectangular type accessories.

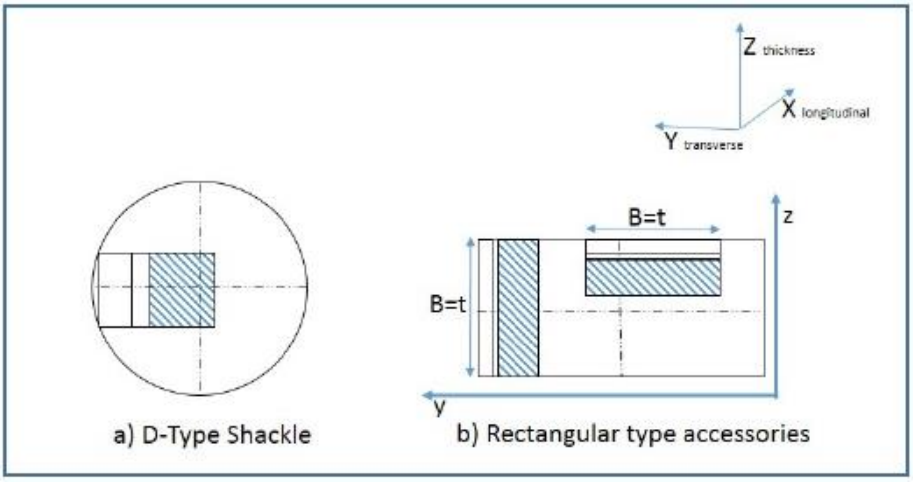

Fig. 13.13 Location of CTOD test specimens: a) Circular type accessory and b) rectangular type accessory, B corresponds to the thickness of material, the grain flow is considered in the longitudinal direction X

1.6.7 Calibration of furnaces shall be verified by measurement and recording of a calibration test piece with dimensions equivalent to the maximum size of link manufactured.

Thermocouples are to be placed both on the surface and in a drilled hole located to the mid thickness position of the calibration block. The furnace dimensions shall be such as to allow the whole furnace charge to be uniformly heated to the necessary temperature. Temperature uniformity surveys of heat treatment furnaces for forged and cast components shall be carried out according to API Spec 6A / ISO 10423:2009 Annex M or ASTM A991-17. The initial survey shall be carried out with maximum charge (load) in the furnace. Subsequent surveys shall be carried out annually and may be carried out with no furnace charge.

The quench bath maximum temperature and the maximum heat treatment transfer times from furnace to quench are to be established and documented. During production the established quenching parameters are to be followed and records are to be maintained of bath temperatures and transfer times.

----------*end*----------

2 Materials

2.2 Rolled steel bars

2.2.1 Steel manufacture

.1 The steels are to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steels are to be killed and fine grain treated. The austenitic grain size for KI-R3, KI-R3S and KI-R4 is to be 6 or finer in accordance with ASTM E112-13(2021) or equivalent grain size index in accordance to ISO 643:2019. Measurements for circular sections are to be taken at 1/3 radius.

.2 Steel for bars intended for KI-R4S and KI-R5 chain is to be vacuum degassed. The austenitic grain size is to be 6 or finer in accordance with ASTM E112-13(2021) or equivalent grain size index in accordance to ISO 643:2019. Measurements for circular sections are to be taken at 1/3 radius.

.3 For KI-R4S and KI-R5 the following information is to be supplied by the bar manufacturer to the mooring chain manufacturer and the results included in the chain documentation:

a) Each heat is to be examined for non-metallic inclusions. The level of micro inclusions is to be quantified and assessed in accordance to the national/international standards; to be sure inclusion levels are acceptable for the final product.

b) A sample from each heat is to be macro etched according to ASTM E381-20 or equivalent, to be sure there is no injurious segregation or porosity.

c) Hardenability data, according to ASTM A255-20a (2020), or equivalent, is to be supplied with each heat.

2.2.2 Chemical composition

.1 For acceptance tests, the chemical composition of ladle samples of each heat is to be determined by the steel maker and is to comply with the approved specification.

2.2.3 Mechanical tests

.1 Bars of the same nominal diameter are to be presented for test in batches of 50 tonnes or fraction thereof from the same heat. Test specimens are to be taken from material heat treated in the same manner as intended for the finished chain.

.2 Each heat of Grade KI-R3S, KI-R4, KI-R4S and KI-R5 is to be tested for hydrogen embrittlement.

In case of continuous casting, test samples representing both the beginning and the end of the charge shall be taken. In case of ingot casting, test samples representing two different ingots shall be taken.

2) Two (2) tensile test specimens shall be taken from the central region of bar material which has been subjected to the heat treatment cycle intended to be used in production. A specimen with a diameter of 20 mm is preferred (consideration will be given to a diameter of 14 mm).

3) One of the specimens is to be tested within a maximum of 3 hours after machining (for a 14 mm diameter specimen, the time limit is 1½ hours). Where this is not possible, the specimen is to be immediately cooled to -60°C after machining and kept at that temperature for a maximum period of 5 days.

4) The second specimen is to be tested after baking at 250°C for 4 hours, alternatively 2 hours for 14 mm diameter specimen.

5) A slow strain rate < 0,0003 s^{-1} must be used during the entire test, until fracture occurs (This is approximately 10 minutes for the 20 mm diameter specimen). Tensile strength, elongation and reduction of area are to be reported.

6) The acceptance requirement for the test is:

$Z_1/Z_2 \geq 0,85$

where:

Z_1 = Reduction of area without baking

Z_2 = Reduction of area after baking

If the requirement $Z_1/Z_2 \geq 0,85$ is not achieved, the bar material may be subjected to a hydrogen degassing treatment after agreement with BKI. New tests shall be performed after degassing.

.3 For all grades, one tensile and three Charpy V-notch specimens are to be taken from each sample selected. The test specimens are to be taken at approx. one-third radius below the surface, as shown in Fig.13.14 and prepared in accordance with ~~UR W2~~ Section 2,E. The results of all tests are to be in accordance with the appropriate requirements of Table 13.11.

.4 Re-test requirements for tensile and Charpy impact tests are detailed in ~~UR W2~~ Section 2,H.

.5 Failure to meet the requirements will result in rejection of the batch represented unless it can be clearly attributable to improper simulated heat treatment.

Table 13.11 Mechanical properties of offshore mooring chain and accessories

Grade	Yield stress N/mm² minimum (1)	Tensile strength N/mm² Minimum (1)	Elongation % minimum	Reduction of area (3) % minimum	Charpy V-notch impact tests		
					Test temperature °C	Average energy J minimum	Avg. energy flash weld J minimum
KI-R3	410	690	17	50	0 -20	60 40	50 30
KI-R3S	490	770	15	50	0 -20	65 45	53 33
KI-R4	580	860	12	50	-20	50	36
KI-R4S (4)	700	960	12	50	-20	56	40
KI-R5	760	1000	12	50	-20	58	42

Notes:

(1) Aim value of yield to tensile ratio: 0,92 max.

(2) At the option of ~~the Classification Society~~ BKI the impact test of Grade KI-R3 and KI-R3S may be carried out at either 0°C or minus 20°C (See Table 13.11).

(3) Reduction of area of cast steel is to be for Grades KI-R3 and KI-R3S: min. 40 %, for R4, R4S and R5: min. 35 %, cf. item 2.4.4.

(4) Aim maximum hardness for KI-R4S is HB330 and KI-R5 is HB340.

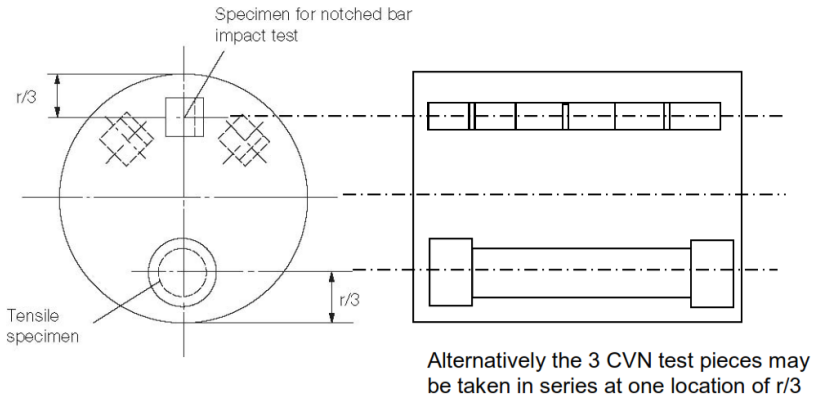

Fig. 13.14: Sampling of steel bars, forgings and castings

2.2.4 Dimensional tolerances

.1 The diameter and roundness shall be within the tolerances specified in Table 13.12, unless otherwise agreed.

Table 13.12 Dimensional tolerance of bar stock

Nominal diameter [mm]	Tolerance on diameter [mm]	Tolerance on roundness (d_{max} - d_{min}) [mm]
Less than 25	-0 + 1.0	0.6
25 – 35	-0 + 1.2	0.8
36 – 50	-0 + 1.6	1.1
51 – 80	-0 + 2.0	1.5
81 – 100	-0 + 2.6	1.95
101 – 120	-0 + 3.0	2.25
121-160	-0 + 4.0	3.00
161 - 222	-0 + 5.0	4.00

2.2.5 Non-destructive examination and repair

.1 Non-destructive examination is to be performed in accordance with recognized Standards such as those indicated below or equivalent. Non-destructive examination procedures, together with rejection/acceptance criteria are to be submitted to BKI.

Magnetic particle testing (MT) of bars:

- ASTM E1444:2021 and ISO 9934:2015

Magnetic Leakage Flux Testing (MLFT)- JIS Z2319:2018

Eddy current testing (ET) of bars:

- ISO 15549:2019

.2 Manufacturers shall prepare written procedures for NDE. NDE personnel shall be qualified and certified according to ISO 9712:2021, ACCP or equivalent. Personnel qualification to an employer or responsible agency based qualification scheme as SNT-TC-1A may be accepted if the employer's written practice is reviewed and found acceptable and the Level III is ASNT Level III, ISO 9712:2021 Level III or ACCP Professional Level III and certified in the applicable method. NDE operators shall be qualified to at least level II.

.3 The manufacturer shall ensure that 100 percent of bar material intended for either chain or fittings is subjected to ultrasonic examination at an appropriate stage of the manufacture to procedures approved by ~~the Classification Society~~ BKI and to the acceptance criteria required. The bars shall be free of pipe, cracks and flakes. If the end length of the delivered bars is not subjected to UT then it must be agreed between the bar supplier and the chain manufacturer of what length of bar is to be removed from the ends. The details are to be documented in the approval of each bar supplier. Phased array UT procedures may be applied, subject to approval by BKI.

.4 100 percent of the bar material is to be examined by magnetic particle (MT) or eddy current (ET) or Magnetic Leakage Flux Testing (MLFT) methods. The bars shall be free of injurious surface imperfections such as seams, laps and rolled-in mill scale. Provided that their depth is not greater than 1% of the bar diameter, longitudinal discontinuities may be removed by grinding and blending to a smooth contour.

All bars supplied in a machined (peeled) condition shall be 100% visually inspected. BKI may also require: 10% inspected with magnetic particle testing (MT) or eddy current testing (ET) or Magnetic Leakage Flux Testing (MLFT), for longitudinal imperfections. The maximum depth of peeling is to be agreed and documented in the approval of each supplier.

.5 The frequency of NDE may be reduced at the discretion of BKI provided it is verified by statistical means that the required quality is consistently achieved.

.6 Weld repair of bar is not permitted.

2.2.6 Marking

.1 Each bar is to be stamped with the steel grade designation and the charge number (or a code indicating the charge number) on one of the end surfaces. Other marking methods may be accepted subject to agreement.

2.3 Forged steel

2.3.1 Manufacture

.1 Forged steels used for the manufacture of accessories must be in compliance with approved specifications and the submitted test reports approved by BKI.

Steel is to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steel is to be killed and fine grain treated. The austenitic grain size for KI-R3, KI-R3S and KI-R4 is to be 6 or finer in accordance with ASTM E112 -13(2021) or equivalent grain size index in accordance to ISO 643:2019. Measurements for circular sections are to be taken at 1/3 radius. Measurements for non-circular sections are to be taken at 1/4t.

.2 Steel for forgings intended for KI-R4S and KI-R5 chain is to be vacuum degassed. The austenitic grain size is to be 6 or finer in accordance with ASTM E112-13(2021) or equivalent grain size index in accordance to ISO 643:2019. Measurements for circular sections are to be taken at 1/3 radius. Measurements for non-circular sections are to be taken at 1/4t.

.3 For steel intended for KI-R4S and KI-R5 accessories the following information is to be supplied by the steel manufacturer to the mooring accessory manufacturer and the results included in the accessory documentation:

a) Each heat is to be examined for non-metallic inclusions. The level of micro inclusions is to be quantified and assessed in accordance with the national/international standards; to be sure inclusion levels are acceptable for the final product.

b) A sample from each heat is to be macro-etched according to ASTM E381-20 or equivalent, to be sure there is no injurious segregation or porosity.

c) Hardenability data, according to ASTM A255-20a (2020), or equivalent, is to be supplied with each heat.

2.3.2 Chemical composition

For chemical composition, see 2.2.2.

2.3.3 Heat treatment

.1 Finished forgings are to be properly heat treated in compliance with specifications submitted and approved.

2.3.4 Mechanical properties

.1 The forgings must comply with the mechanical properties given in Table 13.11, when properly heat treated.

2.3.5 Mechanical tests

.1 For test sampling, forgings of similar dimensions (diameters do not differ by more than 25mm) originating from the same heat treatment charge and the same heat of steel are to be combined into one test unit. From each test unit one tensile and three impact test specimens are to be taken and tested in accordance with ~~UR W2~~ Section 2. For the location of the test specimens, see Fig. 13.14.

.2 Each heat of Grade KI-R3S, KI-R4, KI-R4S and KI-R5 is to be tested for hydrogen embrittlement.

In case of continuous casting, test samples representing both the beginning and the end of the charge shall be taken. In case of ingot casting, test samples representing two different ingots shall be taken.

1) Two (2) tensile test specimens shall be taken from the central region of bar material which has been subjected to the heat treatment cycle intended to be used in production. A specimen with a diameter of 20 mm is preferred (consideration will be given to a diameter of 14 mm).

2) One of the specimens is to be tested within a maximum of 3 hours after machining (for a 14 mm diameter specimen, the time limit is 1½ hours). Where this is not possible, the specimen is to be immediately cooled to -60°C after machining and kept at that temperature for a maximum period of 5 days.

3) The second specimen is to be tested after baking at 250°C for 4 hours, alternatively 2 hours for 14 mm diameter specimen.

4) A slow strain rate < 0,0003 s^{-1} must be used during the entire test, until fracture occurs (This is approximately 10 minutes for the 20 mm diameter specimen). Tensile strength, elongation and reduction of area are to be reported.

5) The acceptance requirement for the test is:

$$Z_1/Z_2 \geq 0{,}85$$

where:

Z_1 = Reduction of area without baking

Z_2 = Reduction of area after baking

If the requirement $Z_1/Z_2 \geq 0{,}85$ is not achieved, the bar material may be subjected to a hydrogen degassing treatment after agreement with BKI. New tests shall be performed after degassing.

2.3.6 Non-destructive examination and repair

.1 Non-destructive examination is to be performed in accordance with recognized Standards, such as those indicated below, or equivalent. The non-destructive examination procedures, together with rejection/acceptance criteria are to be submitted to BKI.

Magnetic particle testing (MT) of forgings:

– EN 10228-1:2016, ASTM A275/A275M-18 using wet continuous magnetization technique

Ultrasonic testing (UT) of forgings:

– EN 10228-3:2016, ASTM A388/A388M-19, ISO 13588:2019

.2 Manufacturers shall prepare written procedures for NDE. NDE personnel shall be qualified and certified according to ISO 9712:2021, ACCP or equivalent. Personnel qualification to an employer or responsible agency based qualification scheme as SNT-TC-1A may be accepted if the employer's written practice is reviewed and found acceptable and the Level III is ASNT Level III, ISO 9712:2021 Level III or ACCP Professional Level III and certified in the applicable method. NDE operators shall be qualified to at least level II.

.3 The forgings are to be subjected to one hundred percent ultrasonic examination at an appropriate stage of manufacture and in compliance with the standard submitted and approved.

.4 Defects on non-machined surfaces may be removed by grinding to a depth of 5% of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces to a maximum depth of 0.8 mm in order to investigate spurious indications. Welding repairs are not permitted.

2.3.7 Marking

.1 Marking is to be similar to that specified in 2.2.6.

2.4 Cast steel

2.4.1 Manufacture

.1 Cast steel used for the manufacture of accessories must be in compliance with approved specifications and the submitted test reports approved by BKI.

Steel is to be manufactured by basic oxygen, electric furnace or such other process as may be specially approved. All steel is to be killed and fine grain treated. The austenitic grain size for KI-R3, KI-R3S and KI-R4 is to be 6 or finer in accordance with ASTM E112-13(2021) or equivalent grain size index in accordance to ISO 643:2019. Measurements for circular sections are to be taken at 1/3 radius. Measurements for non-circular sections are to be taken at 1/4t.

.2 Steel for castings intended for KI-R4S and KI-R5 accessories is to be vacuum degassed.

The austenitic grain size is to be 6 or finer in accordance with ASTM E112 -13(2021) or equivalent grain size index in accordance to ISO 643:2019. Measurements for circular sections are to be taken at 1/3 radius. Measurements for non-circular sections are to be taken at 1/4t.

.3 For steel intended for KI-R4S and KI-R5 accessories the following information is to be obtained and the results included in the accessory documentation:

a) Each heat is to be examined for non-metallic inclusions. The level of micro inclusions is to be quantified and assessed in accordance to the national/international standards; to be sure inclusion levels are acceptable for the final product.

b) A sample from each heat is to be macro etched according to ASTM E381-20 or equivalent, to be sure there is no injurious segregation or porosity.

c) Hardenability data, according to ASTM A255-20a (2020), or equivalent, is to be supplied with each heat.

2.4.2 Chemical composition (See 2.2.2)

For chemical composition, see 2.2.2.

2.4.3 Heat treatment

.1 All castings are to be properly heat treated in compliance with specifications submitted and approved.

2.4.4 Mechanical properties

.1 The castings must comply with the mechanical properties given in Table 13.11. The acceptance requirement for reduction of area is, however, reduced to 40 percent for grades KI-R3 and KI-R3S and 35 percent for grades KI-R4, KI-R4S and KI-R5.

2.4.5 Mechanical tests

.1 For test sampling, castings of similar dimensions originating from the same heat treatment charge and the same heat of steel are to be combined into one test unit. From each test unit one tensile and three impact test specimens are to be taken and tested. For the location of the test specimens see Fig.13.14.

2.4.6 Non-destructive examination and repair

.1 Non-destructive examination is to be performed in accordance with recognized standards, such as those indicated below, or equivalent. The non-destructive examination procedures, together with rejection/acceptance criteria are to be submitted to BKI.

Magnetic particle testing (MT) of castings:

– ASTM E709-21, using wet continuous magnetisation technique

Ultrasonic testing (UT) of castings:

– ASTM A609/A609M-12(2018), ISO 13588:2019

.2 Manufacturers shall prepare written procedures for NDE. NDE personnel shall be qualified and certified according to ISO 9712:2021, ACCP or equivalent. Personnel qualification to an employer or responsible agency based qualification scheme as SNT-TC-1A may be accepted if the employer's written practice is reviewed and found acceptable and the Level III is ASNT Level III, ISO 9712:2021 Level III or ACCP Professional Level III and certified in the applicable method. NDE operators shall be qualified to at least level II.

.3 The castings are to be subjected to one hundred percent ultrasonic examination in compliance with the standard submitted and approved.

.4 Defects on non-machined surfaces may be removed by grinding to a depth of 5% of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces to a maximum depth of 0,8 mm in order to investigate spurious indications.

.5 Where the repair entails removal of more than 5% of the diameter or thickness, the defective area shall be repaired by welding. The excavations shall be suitably shaped to allow good access for welding.

The resulting grooves shall be subsequently ground smooth and complete elimination of the defective material shall be verified by NDE.

.6 Weld repairs are classified as major or minor. A weld repair is considered major when the depth of the groove prepared for welding exceeds 25% of the diameter/thickness or 25 mm, whichever is smaller. All other weld repairs are considered minor.

.7 Major weld repairs require approval before the repair is commenced. Proposals for major repairs shall be accompanied by sketches or photographs showing the extent and positions of the repairs. A grain refining heat treatment shall be given to the whole casting prior to major repairs. A post weld heat treatment or repeat of original heat treatment of castings shall be carried out.

.8 Minor and major weld repairs must be recorded on sketches or photographs showing the extent and positions of the repairs.

.9 All weld repairs shall be done by qualified welders using qualified procedures. Welders shall be qualified according to ISO 9606, ASME IX, ASTM A488 or equivalent.

Procedures shall be qualified according to ISO 15614, ASME IX, ASTM A488 or equivalent with the following additional requirements: Charpy V notch impact tests with notch locations in weld metal, fusion line and heat affected zone + 2 mm and + 5 mm from fusion line, respectively. Test results shall meet the requirements specified for the parent metal.

2.4.7 Marking (See 2.3.7)

2.5 Materials for studs

2.5.1 Studs intended for stud link chain cable are to be made of steel corresponding to that of the chain or in compliance with specifications submitted and approved. In general, the carbon content should not exceed 0,25 percent if the studs are to be welded in place.

3. Design and Manufacture

3.1 Design

3.1.1 Drawings accompanied by design calculations, giving detailed design of chain and accessories made by or supplied through the chain manufacturer are to be submitted for approval. Typical designs are given in ISO 1704 :2008. For studless chain the shape and proportions are to comply with the requirements of this Sub-Section. Other studless proportions are to be specially approved. It should be considered that new or non-Standard designs of chain, shackles or fittings, may require a fatigue analysis and possible performance, fatigue or corrosion fatigue testing.

3.1.2 In addition, for stud link chain, drawings showing the detailed design of the stud shall be submitted for information. The stud shall give an impression in the chain link which is sufficiently deep to secure the position of the stud, but the combined effect of shape and depth of the impression shall not cause any harmful notch effect or stress concentration in the chain link.

3.1.3 Machining of Kenter shackles shall result in fillet radius min. 3 percent of nominal diameter.

3.2 Chain cable manufacturing process

3.2.1 General

.1 Offshore mooring chains shall be manufactured in continuous lengths by flash butt welding and are to be heat treated in a continuous furnace; batch heat treatment is not permitted, except in special circumstances where short lengths of chain are delivered, such as chafing chain. Refer to D.

.2 The use of joining shackles to replace defective links is subject to the written approval of the end purchaser in terms of the number and type permitted. The use of connecting common links is restricted to 3 links in each 100m of chain.

3.2.2 Chain cable manufacturing process records

.1 Records of bar heating, flash welding and heat treatment shall be made available for inspection by the Surveyor.

3.2.3 Bar heating

.1 Bars for links shall be heated by electric resistance, induction or in a furnace.

.2 For electric resistance heating or induction heating, the heating phase shall be controlled by an optical heat sensor. The controller shall be checked at least once every 8 hours and records made.

.3 For furnace heating, the heat shall be controlled and the temperature continuously recorded using thermocouples in close proximity to the bars. The controls shall be checked at least once every 8 hours and records made.

3.2.4 Flash welding of chain cable

.1 The following welding parameters shall be controlled during welding of each link:

a) Platen motion
b) Current as a function of time
c) Hydraulic pressure

.2 The controls shall be checked at least every 4 hours and records made.

3.2.5 Heat treatment of chain cable

.1 Chain shall be austenitized, above the upper transformation temperature, at a combination of temperature and time within the limits established.

.2 When applicable, chain shall be tempered at a combination of temperature and time within the limits established. Cooling after tempering shall be appropriate to avoid temper embrittlement.

.3 Temperature and time or temperature and chain speed shall be controlled and continuously recorded.

.4 Grain determination shall be made for the final product. The austenitic grain size for KI-R3, KI-R3S, KI-R4, KI-R4S and KI-R5 is to be 6 or finer in accordance with ASTM E112-13(2021) or equivalent grain size index in accordance to ISO 643:2019. Measurements for circular sections are to be taken at surface, 1/3 radius and centre for the base material, HAZ and weld.

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3.2.9 Dimensions and dimensional tolerances

.1 The shape and proportion of links and accessories shall conform to ISO 1704:2008 or to the designs specially approved.

.2 The following tolerances are applicable to links:

a) Nominal diameter measured at the crown:

– up to 40 mm nominal diameter : – 1 mm
– over 40 up to 84 mm nominal diameter : – 2 mm
– over 84 up to 122 mm nominal diameter : – 3 mm
– over 122 up to 152 mm nominal diameter : – 4 mm
– over 152 up to 184 mm nominal diameter : – 6 mm
– over 184 up to 222 mm nominal diameter : – 7,5 mm

Note 1:

The cross sectional area at the crown must have no negative tolerance. For diameters of 20 mm or greater, the plus tolerance may be up to 5 percent of the nominal diameter. For diameters less than 20 mm the plus tolerance is to be agreed with ~~the Classification Society~~ BKI at the time of approval.

Note 2:

The cross sectional area at the crown is to be calculated using the average of the diameters with negative tolerance and plus tolerance, measurements are to be taken from at least 2 locations approximately 90 degrees apart.

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4. Testing and inspection of finished chain

4.5 Non-destructive examination after proof load testing

4.5.1 All surfaces of every link shall be visually examined. Burrs, irregularities and rough edges shall be contour ground. Links shall be free from mill defects, surface cracks, dents and cuts, especially in the vicinity where gripped by clamping dies during flash welding. Studs shall be securely fastened. In order to allow optimal access to the surface area it is recommended that chain be hung in the vertical position, however access to inspect the interlink area may only be possible with the chain in the horizontal position.

4.5.2 Testing is to be performed in accordance with a recognized Standard and the procedures, together with acceptance/rejection criteria are to be submitted to ~~the Classification Society~~ BKI for review. Manufacturers shall prepare written procedures for NDE. NDE personnel shall be qualified and certified according to ISO 9712:2021, ACCP or equivalent. Personnel qualification to an employer or responsible agency based qualification scheme as SNT-TC-1A may be accepted if the employer's written practice is reviewed and found acceptable and the Level III is ASNT Level III, ISO 9712:2021 Level III or ACCP Professional Level III and certified in the applicable method. NDE operators shall be qualified to at least level II.

4.5.3 Magnetic particle procedures shall be employed to examine the flash welded area including the area gripped by the clamping dies. Procedures are to be submitted to BKI for approval. Procedures and equipment in accordance with those approved shall be used. The frequency of examination shall be every link. Link surface at the flash weld shall be free from cracks, lack of fusion and gross porosity. Testing shall be performed in accordance with ASTM E709-21 or another recognized standard (e.g. ISO 9934:2015) using wet continuous fluorescent magnetization technique. Non fluorescent techniques can be accepted in special cases where the standard inspection procedures are impractical.

Links shall be free from:

– relevant linear indications exceeding 1,6 mm in transverse direction
– relevant linear indications exceeding 3,2 mm in longitudinal direction
– relevant non-linear indications exceeding 4,8 mm.

4.5.4 Ultrasonic procedures shall be employed to examine the flash weld fusion. Procedures are to be submitted to BKI for approval. Procedures and equipment in accordance with those approved shall be used. On-site calibration standards for chain cable configurations shall be approved. The frequency of examination shall be every link. The flash weld shall be free from defects causing ultrasonic back reflections equal to or greater than the calibration standard. The flash butt welds shall be ultrasonic tested (UT) in accordance with ASTM E587-15(2020) or another recognized standard using single probe, angle-beam shear waves in the range from 45 to 70°.

Single probe technique has limitations as far as testing of the central region is concerned and the flash weld imperfections such as flat spots may have poor reflectivity. Where it is deemed necessary, detectability of imperfections may need to be carried out by using a tandem technique, TOFD or phased array.

4.5.5. Stud welds, if used, shall be visually inspected. The toes of the fillets shall have a smooth transition to the link with no undercuts exceeding 1,0 mm. Additionally, at least 10% of the stud welds distributed through the length shall be dye penetrant tested according to ASTM E1417/E1417M-21e1 or magnetic particle tested according to ASTM E1444:2021 or equivalent. Cracks, lack of fusion or gross porosity are not acceptable. If defects are found, testing shall be extended to all stud welds in that length.

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5 Testing and Inspection of Accessories

5.4 Mechanical tests

5.4.1 Accessories are to be subjected to mechanical testing as described in 4.2.2.3 and 4.2.2.4. Mechanical tests are to be taken from proof loaded full size accessories that have been heat treated with the production accessories they represent. At least one accessory out of every batch or every 25 accessories, whichever is less, is to be tested. Hardness tests are to be carried out on finished accessories. The frequency and locations are to be agreed with BKI. The recorded values are for information only and used as an additional check to verify that the heat treatment process has been stable during the accessory production.

The use of separate representative coupons is not permitted except as indicated in 5.4.5 below.

5.4.2 Test location of forged shackles. Forged shackle bodies and forged Kenter shackles are to have a set of three impact tests and a tensile test taken from the crown of the shackle. Tensile tests on smaller diameter shackles can be taken from the straight part of the shackle, where the geometry does not permit a tensile specimen from the crown. The tensile properties and impact values are to meet the requirements of Table 13.11 in the locations specified in Fig. 13.14, with the Charpy pieces on the outside radius.

5.4.3 The locations of mechanical tests of cast shackles and cast Kenter shackles can be taken from the straight part of the accessory. The tensile properties and impact values are to meet the requirements of Table 13.11 in the locations specified in Fig. 13.14.

5.4.4 The locations of mechanical tests of other accessories with complex geometries are to be agreed with the BKI.

For non-circular sections, 1/4*t* (thickness) from the surface is considered appropriate.

Rolled plates are to be tested to the Standard to which they are produced.

5.4.5 For individually produced (heat treated) accessories or accessories produced in small batches, (less than 5), alternative testing can be proposed to BKI. Each proposal for alternative testing is to be detailed by the manufacturer in a written procedure and submitted to ~~the Classification Society~~ BKI, and the following additional conditions may apply:

a) If separately forged or cast coupons are used, they are to have a cross-section and, for forged coupon, a reduction ratio similar to that of the accessories represented, and are to be heat treated in the same furnace and quenched in the same tank at the same time, as the actual forgings or castings. Thermocouples are to be attached to the coupon and to the accessories.

b) If separately forged or cast coupons are agreed, it is to be verified by procedure test that coupon properties are representative of accessory properties.

5.4.6 A batch is defined as accessories that originate from the same heat treatment charge and the same heat of steel. Reference sections 2.3 and 2.4.

5.4.7 Mechanical tests of pins are to be taken as per Fig. 13.14 from the mid length of a sacrificial pin of the same diameter as the final pin. For oval pins the diameter taken is to represent the smaller dimension. Mechanical tests may be taken from an extended pin of the same diameter as the final pin that incorporates a test prolongation and a heat treatment buffer prolongation, where equivalence with mid length test values have been established. The length of the buffer is to be at least equal to 1 pin diameter dimension which is removed after the heat treatment cycle is finished. The test coupon can then be removed from the pin. The buffer and test are to come from the same end of the pin as per Fig. 13.17.

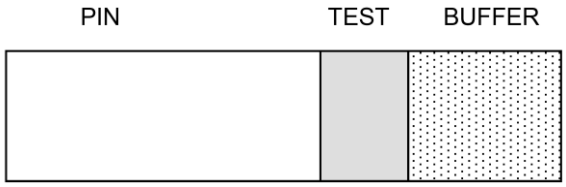

Fig. 13.17 Buffer and test piece location

5.5 Non-destructive examination after proof load testing

5.5.1 All chain accessories are to be subjected to a close visual examination. Special attention is to be paid to machined surfaces and high stress regions. Prior to inspection, chain accessories are to have a suitably prepared surface as per the applied NDE testing standard. All non-machined surfaces are to be sand or shot blasted to permit a thorough examination. Where applicable, accessories shall be dismantled for inspection of internal surfaces. All accessories are to be checked by magnetic particles or dye penetrant. UT of accessories may be required by BKI. The acceptance/rejection criteria of UT established for the design is to be met.

5.5.2 Testing is to be performed in accordance with a recognized Standard, such as those indicated below, or equivalent. The procedures, together with acceptance/rejection criteria are to be submitted to ~~the Classification Society~~ BKI for review. Manufacturers shall prepare written procedures for NDE. NDE personnel shall be qualified and certified according to ISO 9712:2021, ACCP or equivalent. Personnel qualification to an employer or responsible agency based qualification scheme as SNT-TC-1A may be accepted if the employer's written practice is reviewed and found acceptable and the Level III is ASNT Level III, ISO 9712:2021 Level III or ACCP Professional Level III and certified in the applicable method. NDE operators shall be qualified to at least level II.

Magnetic particle testing (MT) of forgings:

– EN 10228-1:2016, ASTM A275/A275M-18, using wet continuous magnetization technique or equivalent standards such as ISO 4986, IACS Rec 69

Ultrasonic testing (UT) of forgings:

– EN 10228-3:2016, ASTM A388/A388M-19, ISO 13588:2019

Magnetic particle testing (MT) of castings:

– ASTM E709-21, using wet continuous magnetization technique

Ultrasonic testing (UT) of castings:

– ASTM A609/A609M-12(2018), ISO 13588:2019

All surfaces shall be magnetic particle tested (MT). Testing shall be performed in accordance with standards referenced using the fluorescent technique. As a minimum surfaces shall be free from:

– relevant linear indications exceeding 1,6 mm in transverse direction
– relevant linear indications exceeding 3,2 mm in longitudinal direction
– relevant non-linear indications exceeding 4,8 mm.

When required by ~~the Classification Society~~ BKI, ultrasonic testing is to be carried out on 100% of cast or forged accessories. The acceptance/rejection criteria established for the design is to be met.

5.5.3 The manufacturer is to provide a statement that non-destructive examination has been carried out with satisfactory results. This statement should include a brief reference to the techniques and to the operator's qualification.

5.5.4 Weld repairs of finished accessories are not permitted.

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