



# RUSSIAN MARITIME REGISTER OF SHIPPING

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**CIRCULAR LETTER**

**No. 314-04-1595c**

dated 02.07.2021

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Re:

amendments to the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships in connection with coming into force of IACS recommendations No. 68 (Rev.1 Apr 2021) and No.69 (Rev.2 Oct 2020)

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Item(s) of supervision:

ships under construction

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Entry-into-force date:

**From the date of publication**

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~~Cancels / amends / adds Circular Letter No.~~

~~dated~~

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Number of pages:

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Appendices:

Appendix 1: information on amendments introduced by the Circular Letter

Appendix 2: text of amendments to Part III "Technical Supervision during Manufacture of Materials"

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Director General

Konstantin G. Palnikov

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Text of CL:

We hereby inform that the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships shall be amended as specified in the Appendices to the Circular Letter.

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It is necessary to do the following:

1. Bring the content of the Circular Letter to the notice of the RS surveyors, interested organizations and persons in the area of the RS Branch Offices' activity.
  2. Apply the provisions of the Circular Letter during review and approval of the technical documentation on ships contracted for construction or conversion on or after 02.07.2021, in the absence of a contract, the keels of which are laid or which are at a similar stage of construction on or after 02.07.2021, as well as during review and approval of the technical documentation on ships, the delivery of which is on or after 02.07.2021.
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List of the amended and/or introduced paras/chapters/sections:

Part III: Chapter 2.5

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"Thesis" System No. 21-128729

**Information on amendments introduced by the Circular Letter  
(for inclusion in the Revision History to the RS Publication)**

Nos.	Amended paras/chapters/sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
1	Chapter 2.5	Chapter has been completely revised considering IACS recommendations No.68 (Rev.1 Apr 2021) and No.69 (Rev.2 Oct 2020)	314-04-1595c of 02.07.2021	02.07.2021

# **RULES FOR TECHNICAL SUPERVISION DURING CONSTRUCTION OF SHIPS AND MANUFACTURE OF MATERIALS AND PRODUCTS FOR SHIPS, 2021,**

## **ND No. 2-020101-139-E**

### **PART III. TECHNICAL SUPERVISION DURING MANUFACTURE OF MATERIALS**

#### **2 METALS**

**Chapter 2.5** is replaced by the following text:

#### **"2.5 NON-DESTRUCTIVE TESTING OF HULL AND MACHINERY STEEL FORGINGS AND CASTINGS**

##### **2.5.1 Non-destructive testing of steel forgings.**

##### **2.5.1.1 General.**

**2.5.1.1.1** These requirements shall be mandatorily fulfilled in cases provided by other parts of the Rules. They may complement the requirements for steel forgings specified in 3.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships as well as other parts of the RS Rules. General guidance for the non-destructive testing (NDT) methods, the extent of testing and the minimum recommended quality levels to be complied with unless otherwise agreed with the Register is introduced herewith. These requirements may be also applied to the testing of austenitic stainless steel and ferritic-austenitic (duplex) stainless steel forgings.

**2.5.1.1.2** These requirements apply to for surface inspections by visual examination, magnetic particle testing and penetrant testing and volumetric inspection by ultrasonic testing.

**2.5.1.1.3** Requirements of this Chapter also cover steel forgings (e.g. components for couplings, gears, boilers and pressure vessels) other than those specified herein, considering their materials, kinds, shapes and stress conditions of operation.

**2.5.1.1.4** Forgings shall be subject to non-destructive testing in the final delivery condition. For specific requirements refer to 2.5.1.2.5.2 and 2.5.1.3.4.2.

**2.5.1.1.5** Where intermediate inspections have been performed, the manufacturer shall provide reports of the results upon the request of the RS representative.

**2.5.1.1.6** Where a forging is supplied in semi-finished condition, the manufacturer shall take into consideration the quality level of final finished machined components.

**2.5.1.1.7** Where advanced ultrasonic testing methods are applied, (e.g. phased array ultrasonic testing (PAUT) or time of flight diffraction (TOFD)), relevant requirements of Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships. Herewith shall be complied with, the acceptance levels regarding acceptance/rejection criteria shall comply with the stated below.

**2.5.1.1.8** Personnel carrying out NDT shall be certified to a national or international certification scheme, e.g. ISO 9712:2012 and personnel qualification shall be certified by an employer-based qualification scheme such as SNT-TC-1A, 2016 or ANSI/ASNT CP-189, 2016. The procedure in the employer-based schemes applied for personnel qualification may be accepted upon agreement with the Register. Certification procedure shall comply with the requirements of ISO 9712 apart from the impartiality requirements of a certification body.

**2.5.1.1.9** The NDT personnel's certificates and competence shall comprise all industrial sectors and techniques being applied by the manufacturer or its subcontractors.

**2.5.1.1.10** Personnel's certificates shall be made available to the Register for verification, when requested.

**2.5.1.1.11** Procedures shall be approved by Level 3 personnel for the appropriate NDT method.

**2.5.1.1.12** The operators carrying out NDT and interpreting indications, shall as a minimum, be qualified and certified to Level 2 in NDT methods concerned.

However, operators only undertaking the gathering of data using any NDT method and not performing data interpretation or data analysis may be qualified and certified as appropriate, at Level 1.

The operator shall have knowledge of materials, weld, structures or components, NDT equipment and limitations that is sufficient to apply relevant NDT method for each application appropriately.

**2.5.1.2** Surface inspection.

**2.5.1.2.1** General.

**2.5.1.2.1.1** Surface inspection of steel forgings shall be carried out by visual examination, magnetic particle testing or penetrant testing, for the purpose of detecting defects and assessing them against acceptance/rejection criteria stated below. Personnel engaged in visual examination shall have sufficient knowledge and experience, however, may be exempted from formal qualification requirements specified herein.

**2.5.1.2.1.2** The testing procedures, apparatus and conditions of magnetic particle testing and penetrant testing shall comply with agreed national or international standards.

**2.5.1.2.1.3** Other surface inspection methods e.g. eddy current testing, may be required by the Register as a supplementary method, to confirm the presence of indications, or for detecting the presence of undocumented weld repairs. The criteria of this inspection shall be agreed with the Register in advance.

**2.5.1.2.2** Items of testing.

**2.5.1.2.2.1** The steel forgings specified in 3.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships shall be subjected to a 100 % visual examination of all accessible surfaces by the manufacturer. The results shall be made available to the RS surveyor upon request. For mass produced forgings the extent of examination shall be agreed with the Register in advance.

**2.5.1.2.2.2** Forgings application of which is not specified herein or in 3.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, but which are used for manufacture of the RS items shall be subjected to non-destructive testing in accordance with the extent, procedures and criteria of agreed national and international standards.

**2.5.1.2.2.3** Austenitic stainless steel and ferritic-austenitic (duplex) stainless steel forgings acceptance criteria details are specified below. However, other acceptance criteria set by national or international standards may be applied, upon agreement with the Register.

**2.5.1.2.2.4** Where national and international standards in accordance with 2.5.1.2.2.2 and 2.5.1.2.2.3 are applied, the quality level shall provide reasonable equivalence to the allowable criteria stated in 2.5.1.2.6. As a rule, the quality level shall comply with more stringent requirements than specified in 2.5.1.2.6.

**2.5.1.2.2.5** Surface inspections by magnetic particle and/or penetrant methods generally apply to the following steel forgings:

.1 all crankshafts;

.2 propeller shafts, intermediate shafts, thrust shafts and rudder stocks with minimum diameter not less than 100 mm;

.3 cylinder heads, connecting rods, piston rods and crossheads, as per the engine type and size requirements in accordance with Appendix 8, Part IV "Technical Supervision during Manufacture of Products";

.4 bolts with minimum diameter not less than 50 mm, which are subjected to dynamic stresses such as cylinder cover bolts, coupling bolts for crankshafts, tie rods, crankpin bolts, main bearing bolts;

.5 propeller blade fastening bolts which are subjected to dynamic stresses.

**2.5.1.2.3** Zones for surface inspections.

Magnetic particle, or where permitted penetrant testing, shall be carried out in Zones I, II and III (as applicable), as indicated in Figs 2.5.1.2.5.1-1 — 2.5.1.2.5.1-4.

**2.5.1.2.4** Surface condition.

The surfaces of forgings to be examined shall be free from scale, dirt, grease or paint.

**2.5.1.2.5** Surface inspection.

**2.5.1.2.5.1** Where indicated by Figs 2.5.1.2.5.1-1 — 2.5.1.2.5.1-4, magnetic particle testing shall be carried out with the following exceptions, when penetrant testing shall be permitted: austenitic and ferritic-austenitic (duplex) stainless steels;

interpretation of open visual or magnetic particle indications,  
at the instruction of the RS surveyor.

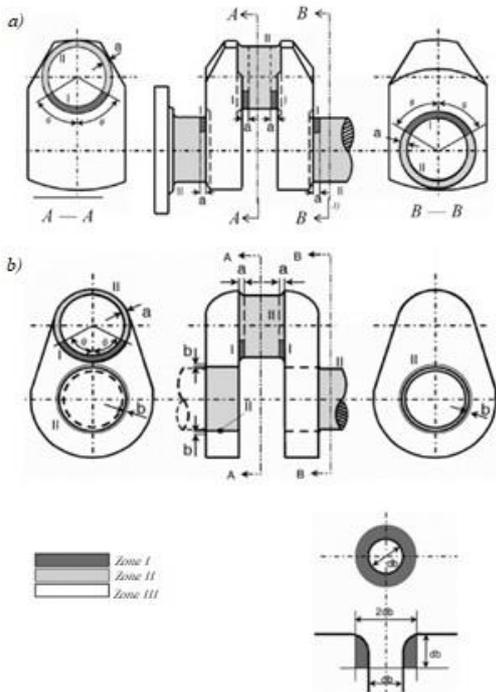


Fig. 2.5.1.2.5.1-1  
Zone for magnetic particle/penetrant testing  
on crankshaft:  
a — solid crankshaft; b — semi built-up crankshaft

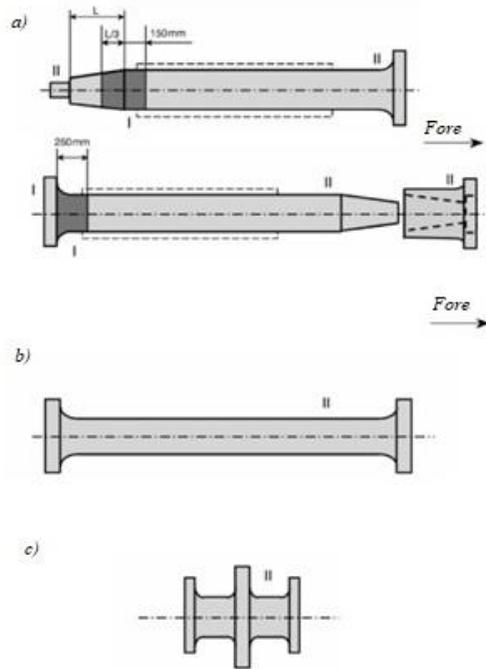


Fig. 2.5.1.2.5.1-2  
Zone for magnetic particle/penetrant testing on shafts:  
a — propeller shaft; b — intermediate shaft;  
c — thrust shaft

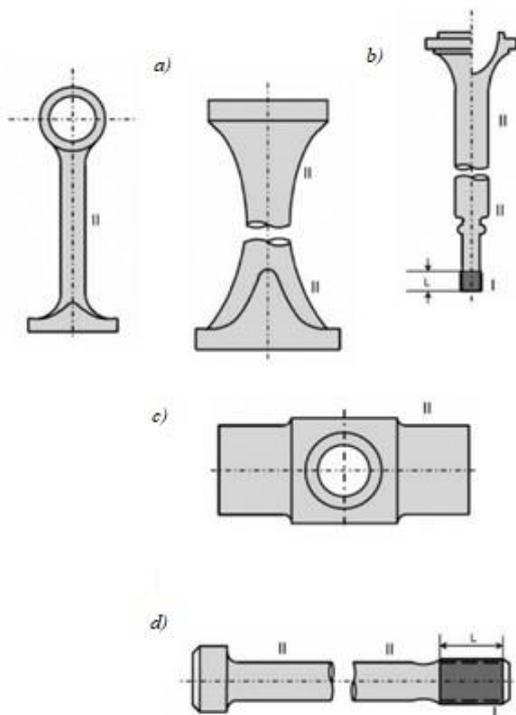


Fig. 2.5.1.2.5.1-3  
Zone for magnetic particle/penetrant testing on  
machinery components:  
a — connecting rod; b — piston rod; c — crosshead;  
d — bolt  
Notes: 1. Threads, holes and their circumstances  
shall be treated as Zone I.  
2. L is the length of thread.

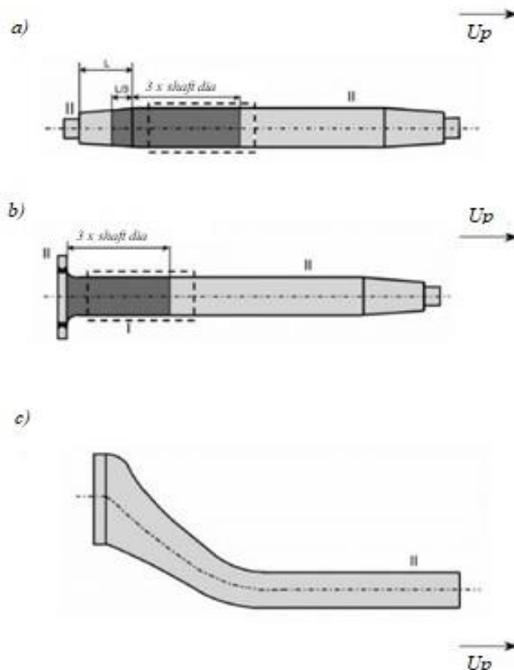


Fig. 2.5.1.2.5.1-4  
Zone for magnetic particle/penetrant testing on rudder  
stocks:  
a — Type A, b — Type B, c — Type C  
Notes: 1. Welded areas shall be treated as Zone I.  
2. L is the length of tapered portion.

**2.5.1.2.5.2** Unless otherwise detailed in the specification, the magnetic particle test shall be performed on a forging in the final machined surface condition and final thermally treated condition.

**2.5.1.2.5.3** Unless otherwise agreed, the surface crack detection shall be carried out in the presence of the RS surveyor. The surface crack detection shall be carried out before the shrink fitting, where applicable.

**2.5.1.2.5.4** For magnetic particle testing, attention shall be paid to the contact between the forging and the clamping devices of stationary magnetization benches in order to avoid local overheating or burning damage in its surface. Prods shall not be permitted on finished machined items.

**2.5.1.2.5.5** When indications are detected as a result of the surface crack detection, acceptance or rejection shall be decided in accordance with 2.5.1.2.6.

**2.5.1.2.6** Acceptance criteria and rectification of defects.

**2.5.1.2.6.1** Acceptance criteria for visual examination.

**2.5.1.2.6.1.1** All forgings shall be free of cracks, crack-like indications, laps, seams, folds, or other detrimental indications. At the request of the RS surveyor, additional magnetic particle, penetrant and ultrasonic testing may be required for a more detailed evaluation of surface irregularities.

**2.5.1.2.6.1.2** The bores of hollow propeller shafts shall be visually examined and measured from both ends of the shaft.

**2.5.1.2.6.2** Acceptance criteria for magnetic particle testing and penetrant testing.

**2.5.1.2.6.2.1** Indications or defects detected during surface inspection are defined as follows:

**Linear indication** is an indication with a largest dimension three or more times its smallest dimension (i.e.  $l \geq 3w$ ).

**Nonlinear indication** is an indication with a largest dimension less than three times its smallest dimension (i.e.  $l < 3w$ ).

**Aligned indication** is a unique indication. The aligned indication may have the following structure:

three or more non-linear or aligned indications aligned with the distance between indications less than 2 mm. This indication is considered to be a unique indication and its length is equal to the overall length of the alignment;

linear indications aligned with the distance between two indications smaller than the length of the longest indication.

**Open indication** is an indication visible after removal of the magnetic particles or that can be detected by the use of penetrant testing.

**Non-open indication** is an indication that is not visually detectable after removal of the magnetic particles or that cannot be detected by the use of penetrant testing.

**Relevant indication** is an indication that is caused by a condition or type of discontinuity that requires evaluation. Only indications which have any dimension greater than 1,5 mm shall be considered relevant for the categorization of indications.

**2.5.1.2.6.2.2** For the purpose of evaluating indications, the surface shall be divided into reference areas of 225 cm<sup>2</sup>. The area shall be taken in the most unfavourable location relative to the indication being evaluated, i.e. the shape and dimensions of each reference area are chosen so that they cover the maximum number of defects (discontinuities) without their distribution to an adjacent reference area.

**2.5.1.2.6.2.3** For crankshaft forgings, the allowable number and size of indications in the reference area is given in Table 2.5.1.2.6.2.3-1, and for other forgings, in Table 2.5.1.2.6.2.3-2 (including austenitic stainless steel and ferritic-austenitic (duplex) stainless steel forgings), respectively. Cracks are not acceptable. Irrespective of the results of non-destructive testing, the RS surveyor may reject the forging if the total number of indications is excessive.

Table 2.5.1.2.6.2.3-1

**Crankshaft forgings. Allowable number and size of surface indications in a reference area of 225 cm<sup>2</sup>**

Inspection zone	Total allowable number of indications	Type of indication	Permissible number of indications for each type	Max. Dimension, in mm
I Fillet	0	Linear	0	–
		Nonlinear	0	–
		Aligned	0	–
II Crankpin	3	Linear	0	–
		Nonlinear	3	3
		Aligned	0	–
II Journal	3	Linear	0	–
		Nonlinear	3	5
		Aligned	0	–

Table 2.5.1.2.6.2.3-2

**Forgings excluding crankshaft forgings. Allowable number and size of surface indications in a reference area of 225cm<sup>2</sup>**

Inspection zone	Total allowable number of indications	Type of indication <sup>1</sup>	Permissible number of indications for each type	Max. Dimension, in mm
I	3	Linear	0	–
		Nonlinear	3	3
		Aligned	0	–
II	10	Linear	3 <sup>1</sup>	3
		Nonlinear	7	5
		Aligned	3 <sup>1</sup>	3

<sup>1</sup> Linear and aligned indications shall not be permitted on bolts, which receive direct fluctuating load, e.g. main bearing bolts, connecting rod bolts, crosshead bearing bolts, cylinder cover bolts.

**2.5.1.2.6.3** Rectification of defects.

**2.5.1.2.6.3.1** Indications that exceed values given in Tables 2.5.1.2.6.2.3-1 and 2.5.1.2.6.2.3-2 shall be classed as defects, and shall be repaired or rejected as appropriate, in accordance with the approved documentation.

**2.5.1.2.6.3.2** Generally it may be permitted to remove shallow indications by light grinding to a maximum depth of 1,5 mm, however, grinding procedure shall be agreed with the Register.

**2.5.1.2.6.3.3** Complete removal of the defect shall be proved by magnetic particle or penetrant testing, as appropriate.

**2.5.1.2.6.3.4** Repair welding shall not be permitted for crankshafts or rotating items (such as propeller shafts) subjected to torsional fatigue. Repair welding possibility and procedure of other forgings shall be agreed with the Register.

**2.5.1.2.6.3.5** Grinding is not permitted in way of finished machined threads.

**2.5.1.2.7** Reporting.

**2.5.1.2.7.1** Test results of surface inspections shall be recorded at least with the following data:

- .1 date of testing;
- .2 names, signatures and qualification level of inspection personnel involved in non-destructive testing;
- .3 testing method and testing details, including procedure number and the following data:
  - for penetrant testing: the penetrant system used and viewing conditions (as appropriate to the penetrant technique and media used);
  - for magnetic particle testing: method of magnetizing, test media, magnetic field strength, magnetic flux indicators (where appropriate), and viewing conditions (as appropriate to the magnetizing technique and media used);
- .4 type of product (forging application);
- .5 unique forging identification number;
- .6 steel grade;
- .7 heat treatment;
- .8 stage of testing;

- .9 position (zone) of testing;
- .10 surface condition (roughness);
- .11 test standards used, including references to the appropriate acceptance criteria;
- .12 testing condition;
- .13 results, including documentation regarding the repair and testing history (as appropriate);
- .14 statement of acceptance/non-acceptance;
- .15 details of weld repair including sketch/drawings (where applicable).

#### **2.5.1.3 Volumetric inspection.**

##### **2.5.1.3.1 General.**

**2.5.1.3.1.1** Volumetric inspection shall be carried out by ultrasonic testing using the contact method with straight beam and/or angle beam technique. In case of advanced UT methods (e.g. phased array ultrasonic testing (PAUT) or time of flight diffraction (TOFD)), one shall be guided by relevant requirements of Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.5.1.3.1.2** The testing procedures, apparatus and conditions of ultrasonic testing shall comply with recognized national or international standards. Generally, the methods of setting test sensitivity and testing evaluation utilize the DAC (distance amplitude correction, is a method for expressing the echo height from a reflector in relation to DAC curve) or DGS (distance-gain size, is a method using the DGS diagram for expressing the echo height from a reflector in terms of the flat bottom hole giving the equivalent echo in terms of the equivalent echo height from disc-shaped reflectors) methods. The applied methodology shall use 2 — 4 MHz straight beam (or normal) probes and/or angle beam probes. For near surface testing (up to a depth of 25 mm) twin crystal 0° probe shall be used, plus a 0° probe (usually single crystal beyond a depth of 25 mm) for the remaining volume. The appropriate acceptance criteria tables shall be used, depending on the sensitivity method selected.

**2.5.1.3.1.3** Fillet radii shall be examined using 45°, 60° or 70° probes, primarily to determine the presence of any cracks within the radiused areas, and as an additional scan to confirm any indications that may have been detected with 0° probe within this area.

**2.5.1.3.1.4** For fabricated forgings and weld repairs, weld testing shall be carried out to the appropriate agreed national and international standard. In these cases, acceptance criteria specified herein shall not be used.

**2.5.1.3.1.5** Construction of DAC curves for normal probes shall be performed using reference blocks containing suitably sized Flat Bottom Holes (FBH) spaced over the inspection thickness.

Reference blocks shall be manufactured from similar material, with similar surface condition to that being inspected.

Where necessary, allowances shall be made for attenuation losses by performing a transfer correction and adjusting the DAC curve as required. The applied transfer correction (measured in decibels (dB)) shall become the new reference sensitivity, to which indications are evaluated against, according to the appropriate table below.

##### **2.5.1.3.2 Items of testing.**

###### **2.5.1.3.2.1** These requirements cover volumetric inspection of steel forgings:

- .1 all crankshafts;
- .2 propeller shafts, intermediate shafts, thrust shafts and rudder stocks with minimum diameter not less than 200 mm,
- .3 cylinder heads, connecting rods, piston rods, coupling bolts and studs, as well as crossheads as per the engine type and size requirements in accordance with Appendix 8, Part IV "Technical Supervision during Manufacture of Materials".

**2.5.1.3.2.2** Forgings application of which is not specified herein or in 3.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, but which are used for manufacture of the RS items shall be subjected to non-destructive testing in accordance with the extent, procedures and criteria of agreed national and international standards.

**2.5.1.3.2.3** Where national and international standards are used or referenced in accordance with 2.5.1.3.2.2, the quality level shall provide reasonable equivalence to the allowable criteria specified in 2.5.1.3.5. The quality levels shall normally be more stringent as specified in 2.5.1.3.5.

**2.5.1.3.2.4** Ultrasonic acceptance criteria detailed in Tables 2.5.1.3.5.1-1 — 2.5.1.3.5.1-4 are intended for C, C-Mn, and alloy steel forgings, and do not apply to austenitic stainless steel or ferritic-austenitic (duplex) stainless steel forgings. To determine acceptance criteria for

corrosion-resistant steel forgings, standards ASTM A745/A745/M-20 and EN 10228-4.2016 may be used. Other national or international standards may be used, as agreed with the Register. The required inspection level shall be agreed with the Register in advance.

**2.5.1.3.3 Zones for volumetric inspection.**

Ultrasonic testing shall be carried out in the Zones I, II and III as indicated in Figs. 2.5.1.3.3-1 — 2.5.1.3.3-4. Colour identification of zones corresponds to Fig. 2.5.1.2.5.1-1. Areas may be upgraded to a higher zone at the discretion of the RS surveyor.

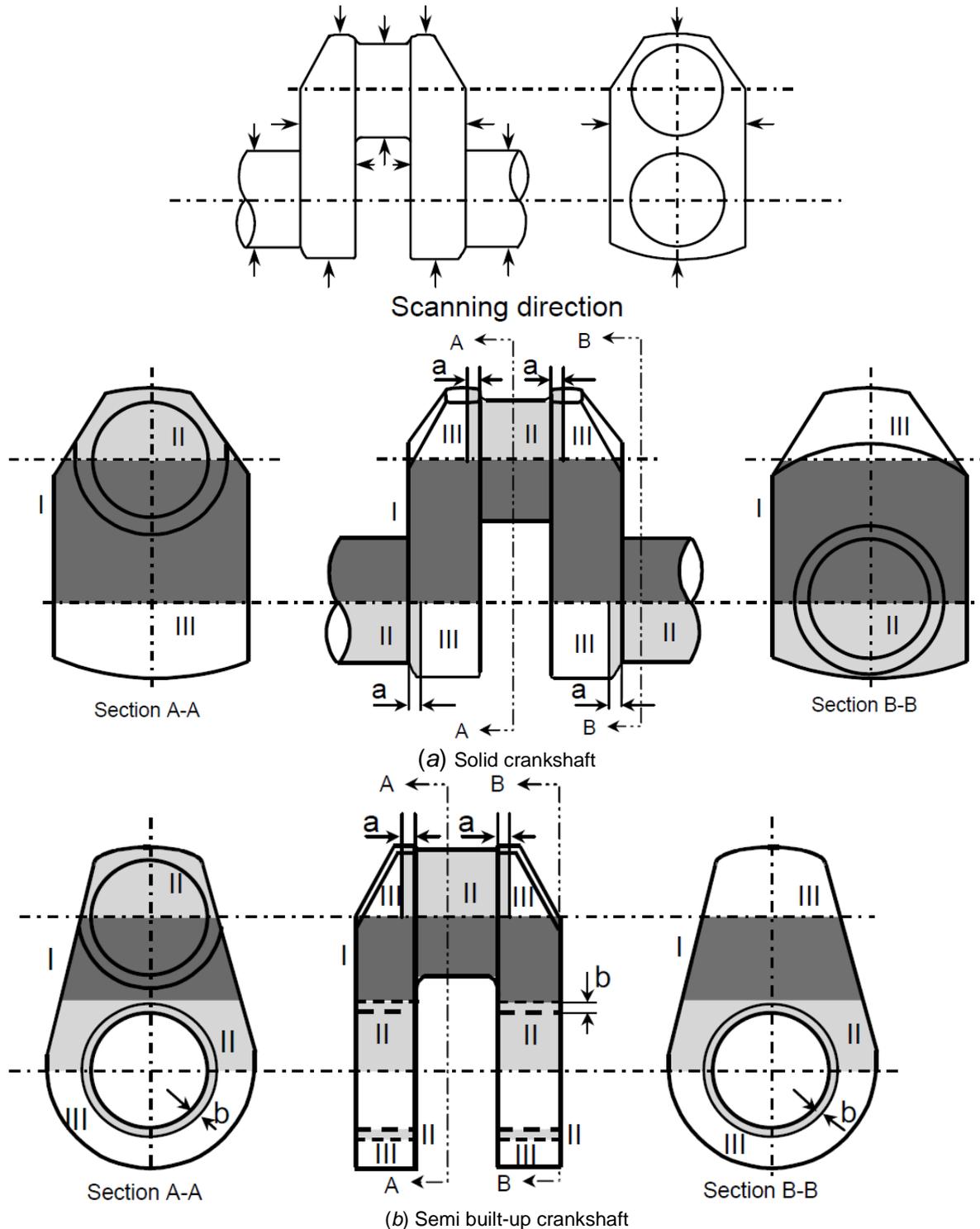
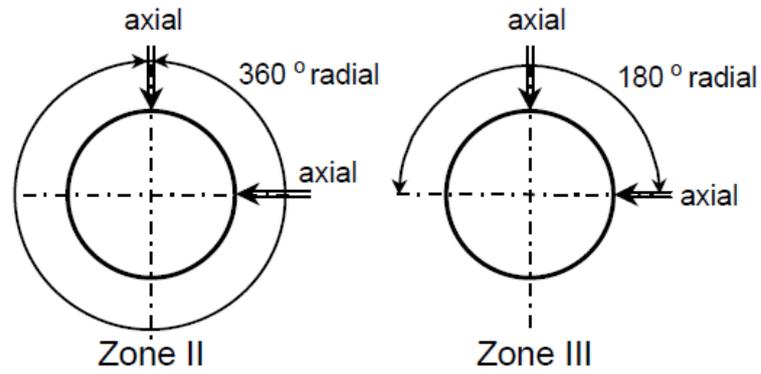


Fig. 2.5.1.3.3-1

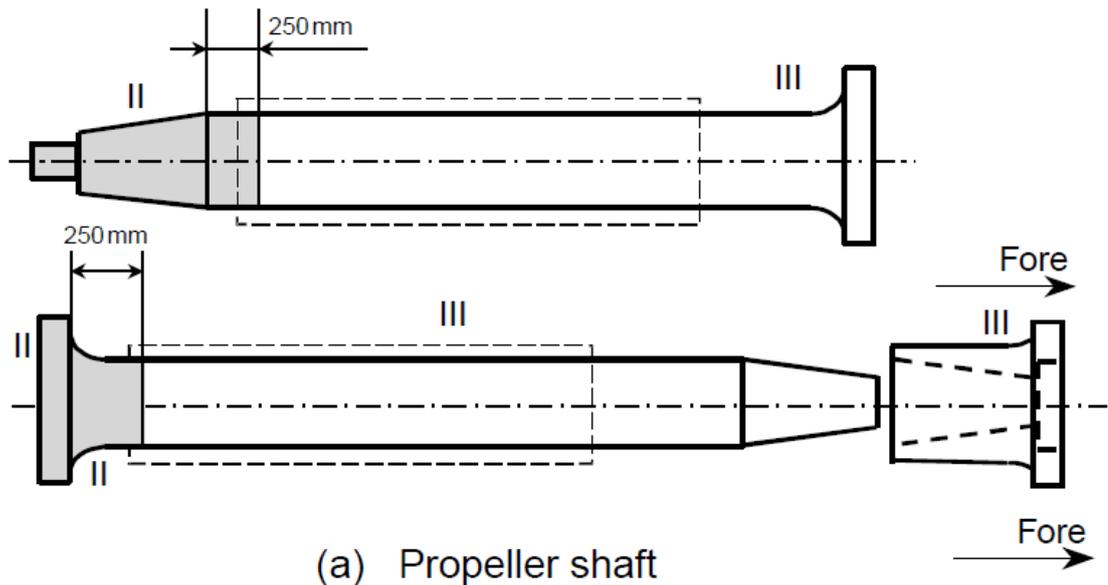
Zones for ultrasonic testing on crankshafts

- Notes . 1.  $a = 0,1d$ , but at least 25 mm;  $b = 0,05d$  or 25 mm, whichever is greater (circumstances of shrinkage fit);  
 2. core areas of crank pins and journals within a radius of  $0,25d$  between the webs may generally be coordinated to Zone II;  
 3. Colour identification of the Zones refers to Fig. 2.5.1.2.5.1-1.

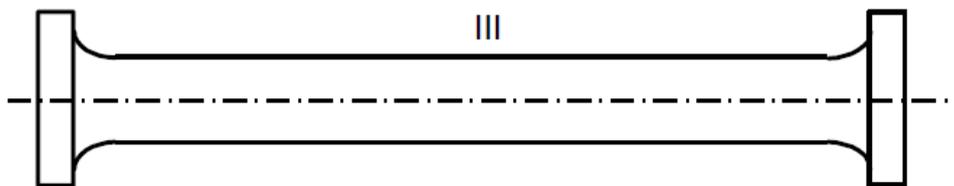
Zones for radial and axial scanning



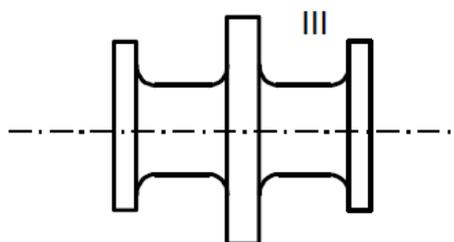
Scanning direction



(a) Propeller shaft



(b) Intermediate shaft

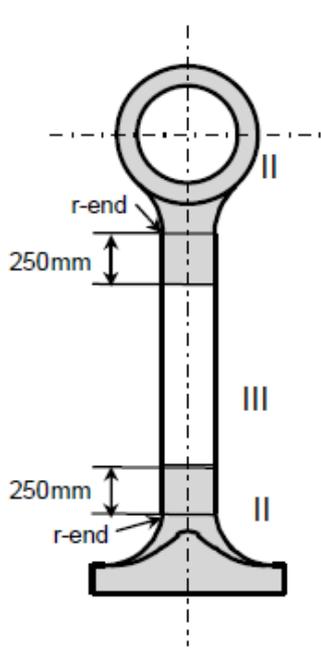
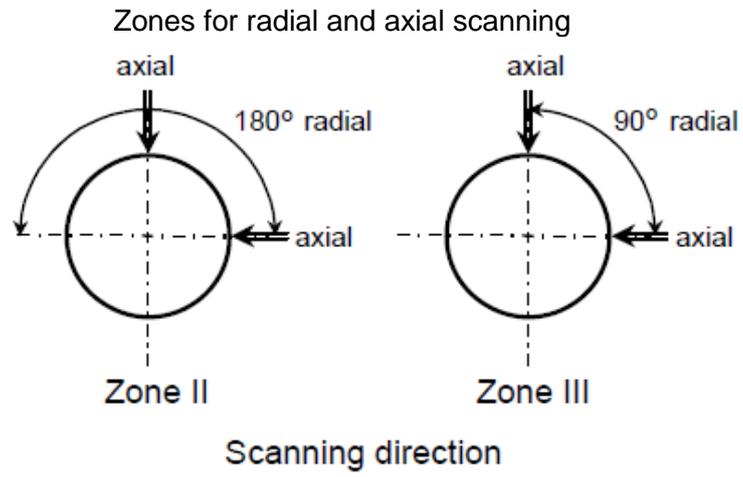


(c) Thrust shaft

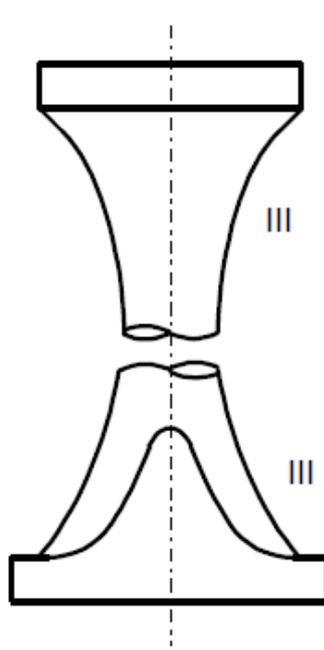
Fig. 2.5.1.3.3-2

Zones for ultrasonic testing on shafts

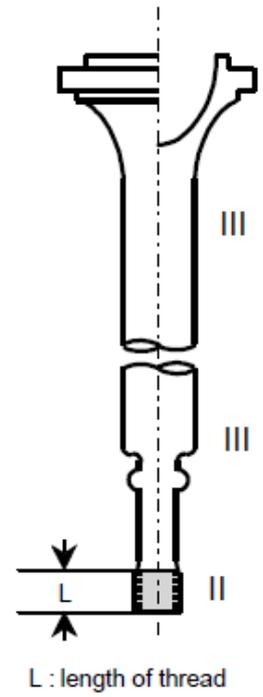
- Notes . 1. For hollow shafts, 360° radial scanning applies to Zone III.  
 2. Circumstances of the bolt holes in the flanges shall be treated as Zone II.



(a) Connecting rod



(b) Piston rod



(c) Cross head

Fig. 2.5.2.3.3-3  
Zones for ultrasonic testing on machinery components

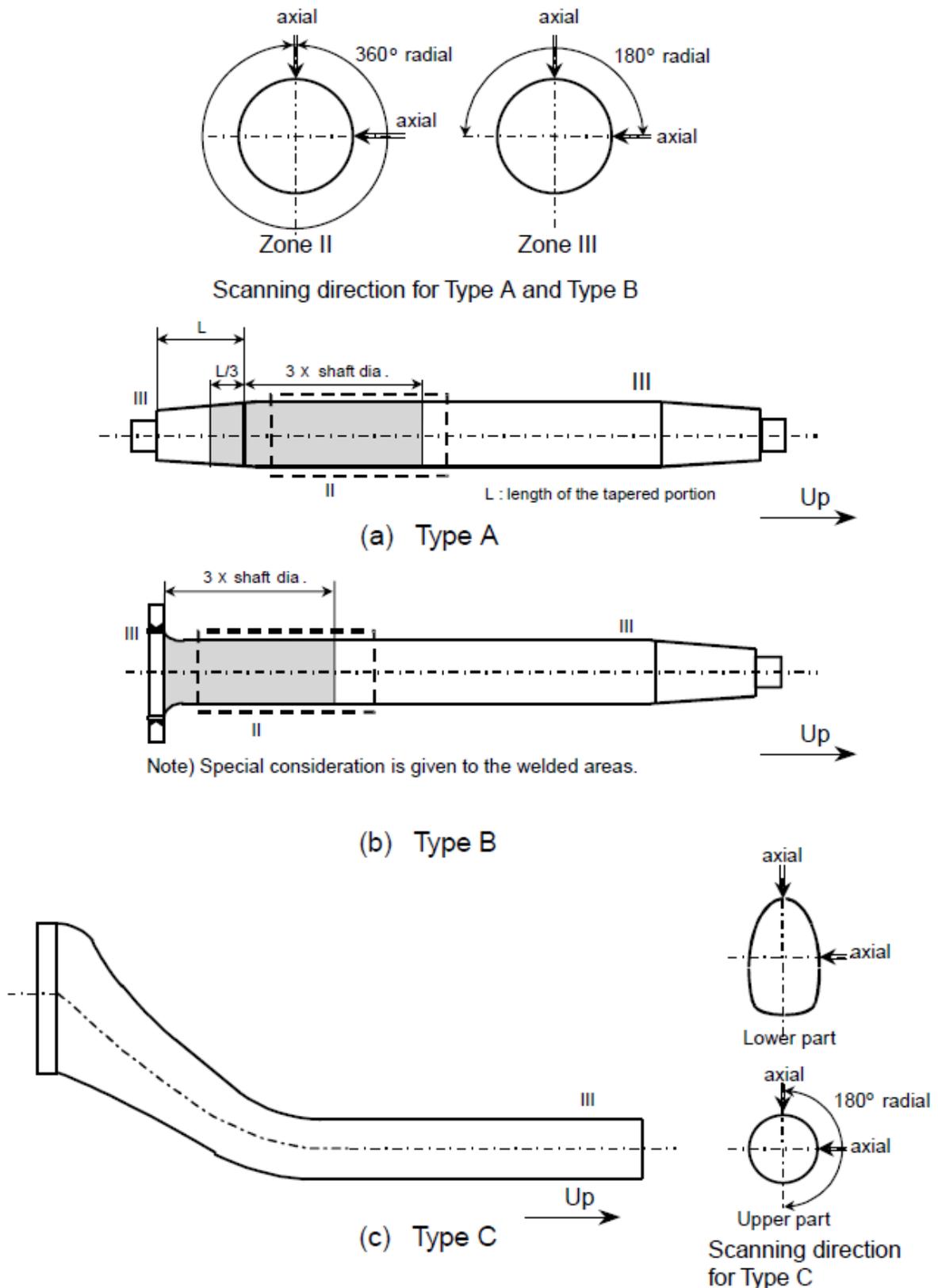


Fig. 2.5.2.3.3-4  
Zones for ultrasonic testing on rudder stock

**2.5.1.3.4 Surface condition.**

**2.5.1.3.4.1** The surfaces of steel forgings to be examined shall be such that adequate coupling can be established between the probe and the forging and that excessive wear of the probe shall be avoided. The surfaces shall be free from scale, dirt, grease or paint.

**2.5.1.3.4.2** The ultrasonic testing shall be carried out after the steel forgings have been machined to a condition suitable for this type of testing and after the final heat treatment, but prior to the drilling of the oil bores, prior to surface hardening and the machining of bolt threads. Black

forgings shall be inspected after removal of the oxide scale by either flame descaling or shot blasting methods.

**2.5.1.3.5 Acceptance criteria.**

**2.5.1.3.5.1** Acceptance criteria of volumetric inspection by ultrasonic testing are shown in Tables 2.5.1.3.5.1-1 — 2.5.1.3.5.1-3.

Table 2.5.1.3.5.1-1

**Ultrasonic acceptance criteria for crankshafts: DGS Method — Normal Probes**

Zone	Allowable disc shape according to DGS <sup>1</sup>	Allowable length of indication	Allowable distance between two indications <sup>2</sup>
I	$d \leq 1,0^3$ mm	not applicable <sup>4</sup>	not applicable
II	$d \leq 2,0$ mm	$\leq 10$ mm	$\geq 20$ mm
III	$d \leq 4,0$ mm	$\leq 15$ mm	$\geq 20$ mm

<sup>1</sup> DGS: distance-gain size.

<sup>2</sup> In case of accumulations of two or more isolated indications which are subjected to registration the minimum distance between two neighbouring indications shall be at least the length of the larger indication.

This also applies to the distance in axial direction as well as to the distance in depth.

Isolated indications with less distances shall be determined as one single indication.

<sup>3</sup> For Zone 1 testing, probe selection shall take into account the limits of probe beam-path length and depth of beam penetration and shall normally be carried out with a minimum probe frequency of 4MHz.

<sup>4</sup> For Zone 1, indications with an echo height greater than a 1,0 mm disc shaped reflector are not acceptable. Indications with an echo height of less than 1,0 mm are acceptable if they are deemed as point reflectors and have no measurable length.

Table 2.5.1.3.5.1-2

**Ultrasonic acceptance criteria for crankshafts: DAC Method – Normal Probes**

Zone	DAC reference level, based on 3,0 mm FBH <sup>1, 2, 3</sup>	Allowable length of indication	Allowable distance between two indications <sup>5</sup>
I	3,0 mm DAC –19 dB	not applicable <sup>4</sup>	not applicable
II	3,0 mm DAC –7 dB	$\leq 10$ mm	$\geq 20$ mm
III	3,0 mm DAC +5 dB	$\leq 15$ mm	$\geq 20$ mm

<sup>1</sup> The requirement of a 3,0 mm FBH shall standardize the DAC reference blocks for clarity and consistency. The dB value for the FBH/DAC setting is equivalent to the disc shaped reflector stated in Table 2.5.1.3.5.1-1, corresponding to the applicable zone.

<sup>2</sup> Other size FBHs may be used for the DAC method (and the dB value adjusted accordingly to provide equivalence with the stated FBH/disc shaped reflector). Where other size FBHs are used, the ultrasonic procedure shall state the equivalence using an appropriate calculation formula.

<sup>3</sup> For Zone 1 testing, probe selection shall take into account the limits of probe beam-path length and depth of beam penetration and shall normally be carried out with a minimum probe frequency of 4MHz.

<sup>4</sup> For Zone 1, indications with an echo height greater than the DAC reference level are not acceptable. Indications with an echo height of less than the DAC reference level are acceptable if they are deemed as point reflectors and have no measurable length.

<sup>5</sup> In case of accumulations of two or more isolated indications which are subject to registration the minimum distance between two neighbouring indications shall be at least the length of the larger indication. This also applies to the distance in axial directions as well as to the distance in depth. Isolated indications with less distances shall be determined as one single indication.

Table 2.5.1.3.5.1-3

**Ultrasonic acceptance criteria for forged machinery components: DGS Method — Normal Probes**

Type of forging	Zone	Allowable disc shape according to DGS <sup>1,2</sup>	Allowable length of indication	Allowable distance between two indications <sup>3</sup>
Propeller shaft	II	outer: $d \leq 2$ mm	$\leq 10$ mm	$\geq 20$ mm
Intermediate shaft		inner: $d \leq 4$ mm	$\leq 15$ mm	$\geq 20$ mm
Thrust shaft	III	outer: $d \leq 3$ mm	$\leq 10$ mm	$\geq 20$ mm
Rudder stock		inner: $d \leq 6$ mm	$\leq 15$ mm	$\geq 20$ mm
Connecting rod Piston rod	II	$d \leq 2$ mm	$\leq 10$ mm	$\geq 20$ mm
Crosshead	III	$d \leq 4$ mm	$\leq 10$ mm	$\geq 20$ mm

<sup>1</sup> DGS: distance-gain size.

<sup>2</sup> Outer part means the part beyond one third of the shaft radius from the centre, the inner part means the remaining core area.

<sup>3</sup> In case of accumulations of two or more isolated indications which are subjected to registration the minimum distance between two neighbouring indications shall be at least the length of the larger indication. This also applies to the distance in axial directions as well as to the distance in depth. Isolated indications with less distances shall be determined as one single indication.

Table 2.5.1.3.5.1-4

**Ultrasonic acceptance criteria for shafts and machinery components:  
DAC Method — Normal Probes**

Type of forging	Zone	DAC reference level, based on 3,0 mm FBH <sup>1,2</sup>	Allowable length of indication	Allowable distance between two indications <sup>3</sup>
Propeller shafts, intermediate shafts	II	Outer: DAC -7 dB Inner: DAC +5 dB	$\leq 10$ mm $\leq 15$ mm	$\geq 20$ mm
	III	Outer: DAC Inner: DAC +12 dB	$\leq 10$ mm $\leq 15$ mm	$\geq 20$ mm
Thrust shaft, rudder stocks	II	Outer: DAC -7 dB Inner: DAC + 5 dB	$\leq 10$ mm $\leq 15$ mm	$\geq 20$ mm
	III	Outer: DAC Inner: DAC + 12 dB	$\leq 10$ mm $\leq 15$ mm	$\geq 20$ mm
Connecting rod, piston rod, crosshead	II	DAC minus 7 dB	$\leq 10$ mm	$\geq 20$ mm
	III	DAC + 5 dB	$\leq 10$ mm	$\geq 20$ mm

<sup>1</sup> The requirement of a 3,0 mm FBH shall standardize the DAC reference blocks for clarity and consistency. The dB value for the FBH/DAC setting is equivalent to the disc shaped reflector stated in Table 2.5.1.3.5.1-1, corresponding to the applicable zone.

<sup>2</sup> Other size FBHs may be used for the DAC method (and the dB value adjusted accordingly to provide equivalence with the stated FBH/disc shaped reflector). Where other size FBHs are used, the ultrasonic procedure shall state the equivalence using an appropriate calculation formula.

<sup>3</sup> In case of accumulations of two or more isolated indications which are subject to registration the minimum distance between two neighbouring indications shall be at least the length of the larger indication. This also applies to the distance in axial directions as well as to the distance in depth. Isolated indications with less distances should be determined as one single indication.

**2.5.1.3.6 Reporting.**

**2.5.1.2.7.1** Test results of volumetric inspection shall be recorded at least with the following items:

- .1 date of testing;
- .2 names, signatures and qualification level of inspection personnel involved in non-destructive testing;
- .3 testing method including procedure number, and details of the following items:
  - equipment used (instrument, probes [and any adaptations to probes for curved surfaces], calibration and reference blocks);
  - technique(s) used to set test sensitivity (including sensitivity method, specific reference blocks, reflector size, transfer correction);

- maximum scanning rate (mm/s);
- details of any testing restrictions;
- .4 type of product (forging application);
- .5 unique forging identification number;
- .6 steel grade;
- .7 heat treatment;
- .8 stage of testing;
- .9 position (zone) of testing;
- .10 surface condition (roughness);
- .11 test standards used, including references to the appropriate acceptance criteria;
- .12 testing condition;
- .13 results, including documentation regarding the repair and testing history (at the Register request);
- .14 statement of acceptance/non-acceptance;
- .15 details of weld repair including sketch/drawing (where applicable).

## **2.5.2 Non-destructive testing of steel castings.**

### **2.5.2.1 General.**

**2.5.2.1.1** These requirements cover the extent, methods and recommended quality levels applicable to the non-destructive testing (NDT), of steel castings, except in those cases where alternative criteria have been otherwise agreed with the Register. The requirements are obligatory for implementation in cases provided by other parts of the Rules.

**2.5.2.1.2** These requirements may apply to castings different from those specified herein considering their materials, kinds, shapes and stress conditions of operation.

**2.5.2.1.3** Castings intending to be examined by NDT methods are listed on Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6. Criteria for NDT of other castings not listed herein shall be subject to agreement with the Register.

**2.5.2.1.4** In cases where the castings not specified herein and/or in 2.8, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships but subjected to survey, relevant national or international standards, or other RS requirements may be applied, to determine the appropriate extent of testing, NDT procedure and defect acceptance criteria.

**2.5.2.1.5** Provisions of 2.5.2 may complement the requirements of Section 3, Part III "Equipment, Arrangements and Outfit", 3.8, 7.2 and Section 8, Part XIII "Materials" and Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships. General requirements for the non-destructive testing methods, the extent of testing and criteria are also specified herein.

**2.5.2.1.6** Castings shall be NDT examined in the final delivery condition.

**2.5.2.1.7** Where intermediate inspections have been performed the manufacturer shall provide reports of the results upon the request of the RS surveyor.

**2.5.2.1.8** Where a casting is supplied in semi-finished condition, the manufacturer shall take into account the quality level of final finished machined components.

**2.5.2.1.9** Where advanced ultrasonic testing methods are applied (e.g. phased array ultrasonic testing (PAUT) or time of flight diffraction (TOFD)), one shall be guided by relevant requirements of Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships. Acceptance levels regarding acceptance/rejection criteria are specified below.

### **2.5.2.2 Qualification of personnel involved in NDT.**

**2.5.2.2.1** Personnel engaged in visual examination shall have sufficient knowledge and experience and may be qualified in accordance with these requirements.

**2.5.2.2.2** Personnel carrying out visual examination and measurements shall be certified to a recognized national or international certification scheme, e.g. ISO 9712:2012, or personnel qualification shall be certified by an employer-based qualification scheme such as SNT-TC-1A: 2016, or ANSI/ASNT CP-189: 2016. The procedure in the employer-based schemes applied for personnel qualification may be accepted upon agreement with the Register. Certification procedure shall comply with the requirements of ISO 9712 apart from the impartiality requirements of a certification body.

**2.5.2.2.3** Personnel responsible for NDT activity including approval of procedures shall be qualified and certified to Level 3.

**2.5.2.2.4** The NDT personnel's certificates and competence shall comprise all industrial sectors and techniques being applied by the manufacturer or its subcontractors. Certificates issued shall be made available to the Register for verification, when requested.

**2.5.2.2.5** The operator carrying out NDT and interpreting indications, shall, as a minimum, be qualified and certified to Level 2 in the NDT methods concerned.

However, operators only undertaking the gathering of data using any NDT method and not performing data interpretation or data analysis may be qualified and certified as appropriate, at Level 1.

The operator shall have adequate knowledge of materials, weld, structures or components, NDT equipment and limitations that are sufficient to apply the relevant NDT method for each application appropriately.

**2.5.2.3** Casting condition.

**2.5.2.3.1** Heat treatment.

Non-destructive testing applied for acceptance purposes to support final casting certification shall be made after the final heat treatment of the casting. Where intermediate inspections have been performed the manufacturer shall provide reports of the results upon request of the RS surveyor.

**2.5.2.3.2** Surface condition.

**2.5.2.3.2.1** The surface of castings to be tested shall be free from scale, dirt, grease, paint, shot and primer, and shall meet the standards of a surface condition for the corresponding types of testing. The roughness of surface to be tested shall be minimum of  $R_a \leq 6.3 \mu\text{m}$ .

**2.5.2.3.2.2** The surface of the casting being subjected to ultrasonic testing shall be machined or shot blasted to a suitable condition, with a minimum value surface quality of  $R_a \leq 12.5 \mu\text{m}$ . The casting surface shall be such that adequate coupling can be established between the probe and the casting and that excessive wear of the probe is avoided.

**2.5.2.4** Scope of survey.

**2.5.2.4.1** Zones of testing.

**2.5.2.4.1.1** Zones to be examined for detection of surface defects are shown in Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6, the extent of testing and quality level are specified in 2.5.2.4 and 2.5.2.6.

NDT shall be made in accordance with an inspection plan approved by the Register. The plan shall specify the extent of the testing, the testing procedure, the quality level or, if necessary, level for different locations of the castings.

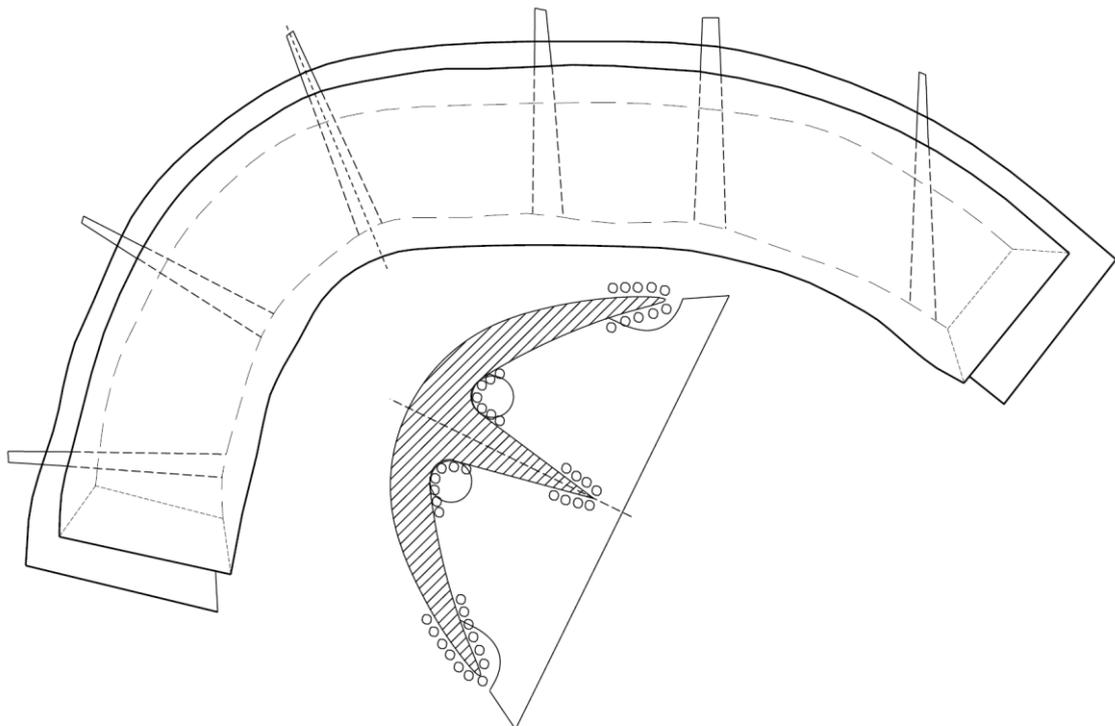


Fig. 2.5.2.4.1-1 Stern Frame

- Notes:
1. All surfaces: visual examination.
  2. Location indicated with (OOO): magnetic particle and ultrasonic testing.

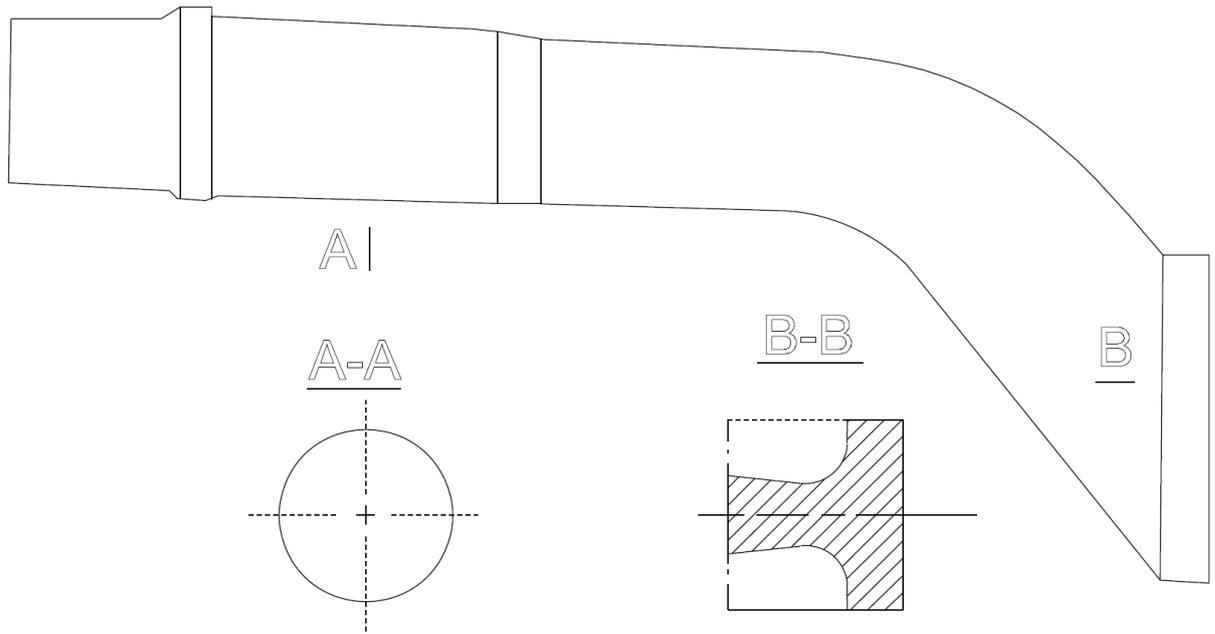


Fig. 2.5.2.4.1-2  
Rudder stock.

Note . All surfaces: visual examination, magnetic particle and ultrasonic testing.

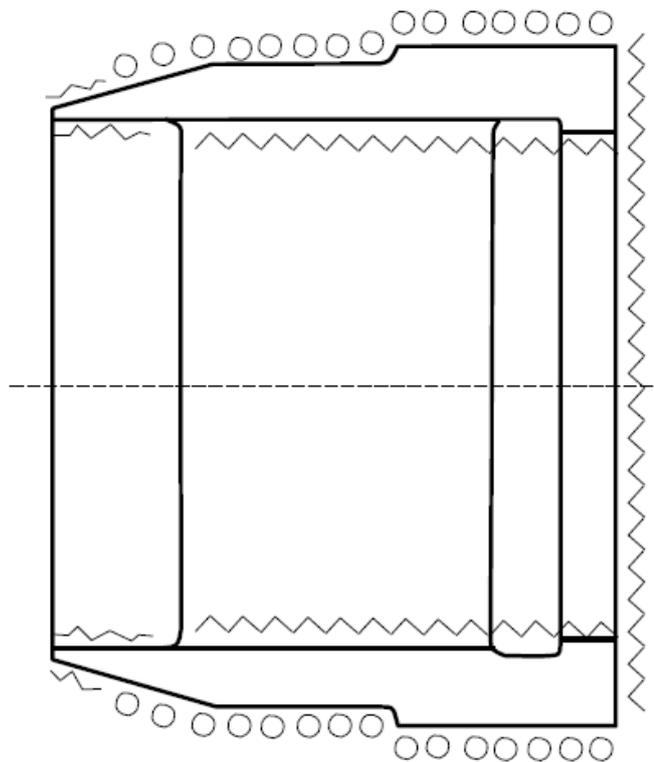
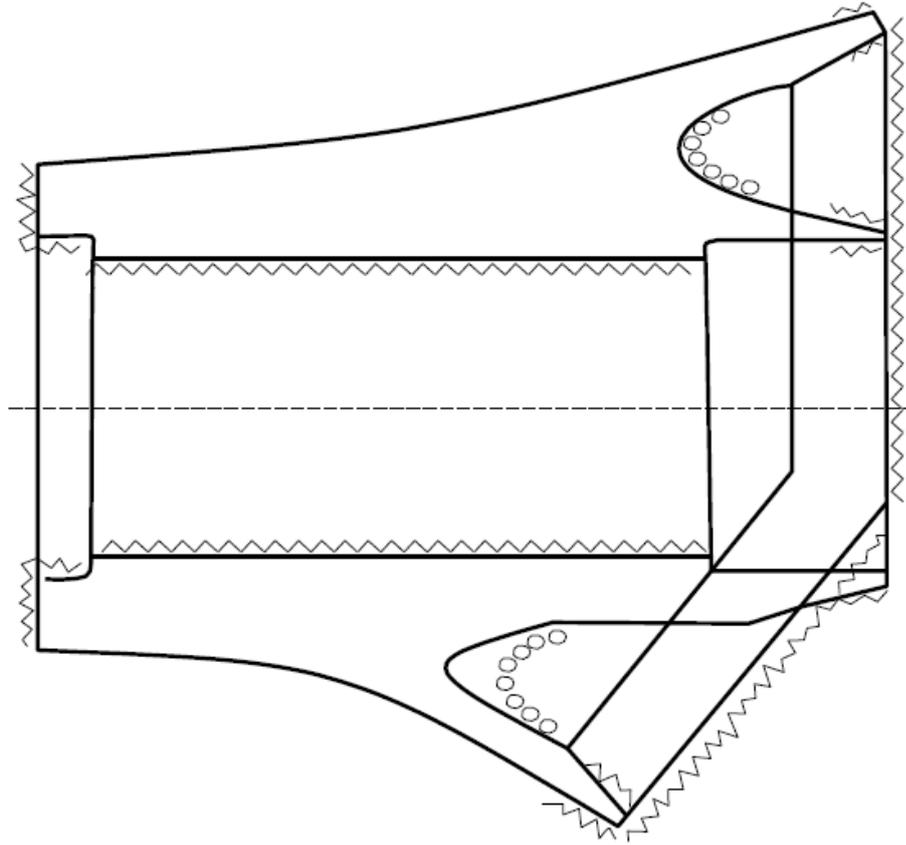


Fig. 2.5.2.4.1-3  
Stern boss

Notes:

1. All surfaces: visual examination.
2. Location indicated with (OOO): magnetic particle and ultrasonic testing.
3. Location indicated with (^^^): ultrasonic testing.

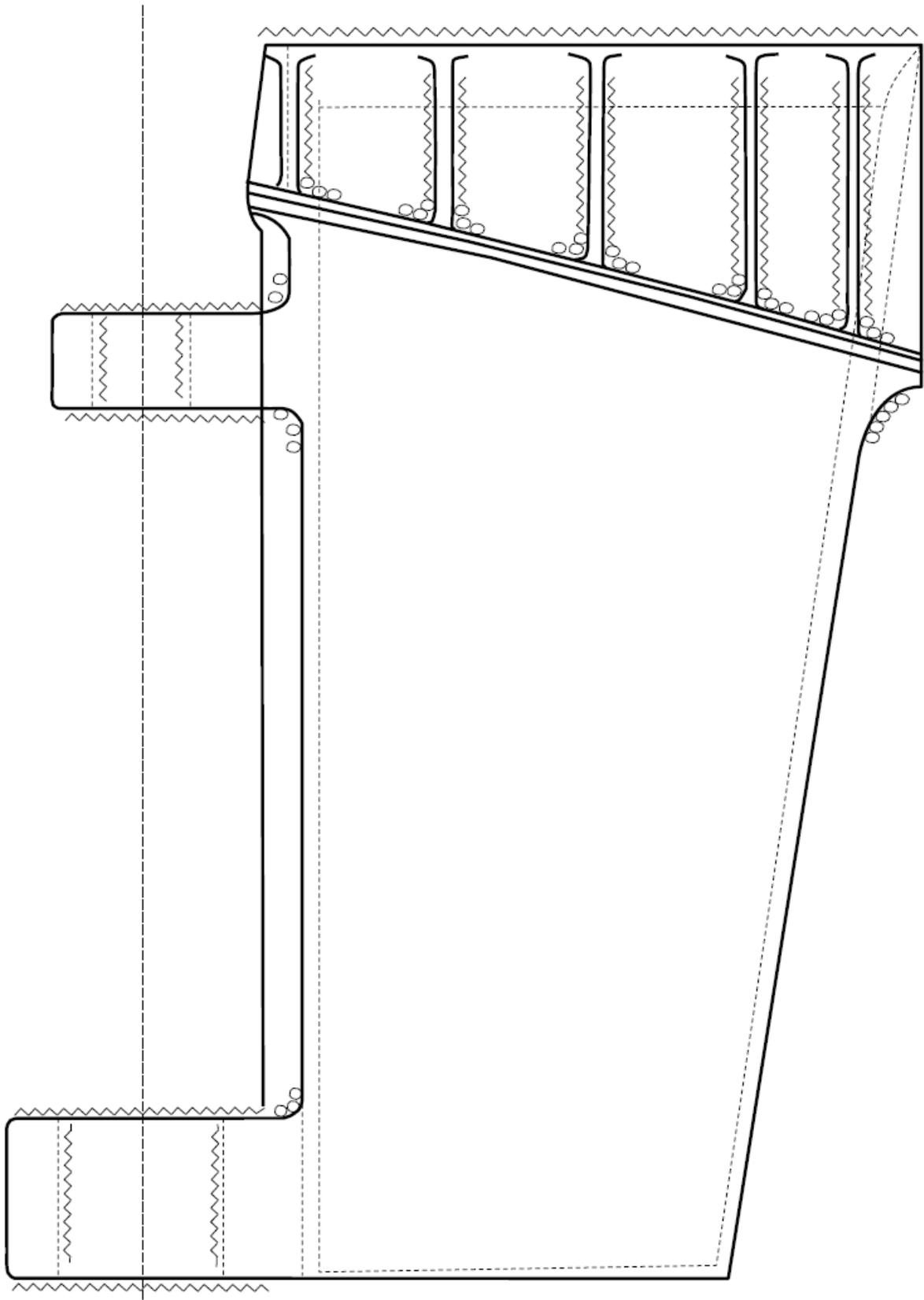


Fig. 2.5.2.4.1-4 Rudder hangings.

- Notes:
1. All surfaces: visual examination.
  2. Location indicated with (OOO): magnetic particle and ultrasonic testing.
  3. Location indicated with (^^^): ultrasonic testing.

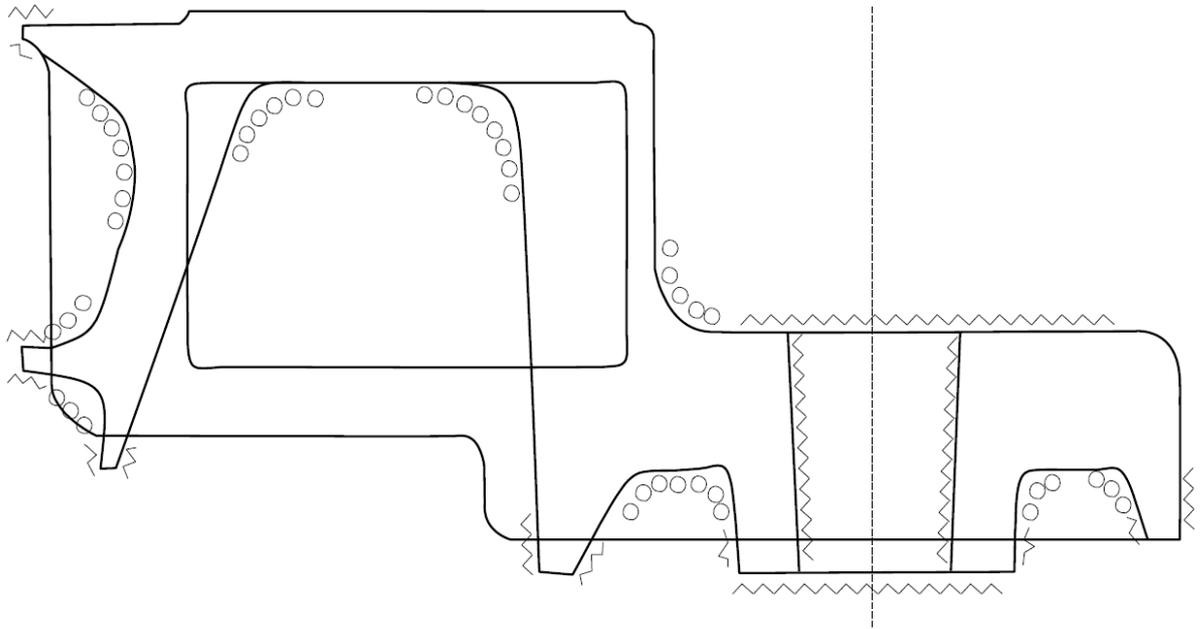


Fig. 2.5.2.4.1-5  
Rudder (upper part).

- Notes:
1. All surfaces: visual examination.
  2. Location indicated with (OOO): magnetic particle and ultrasonic testing

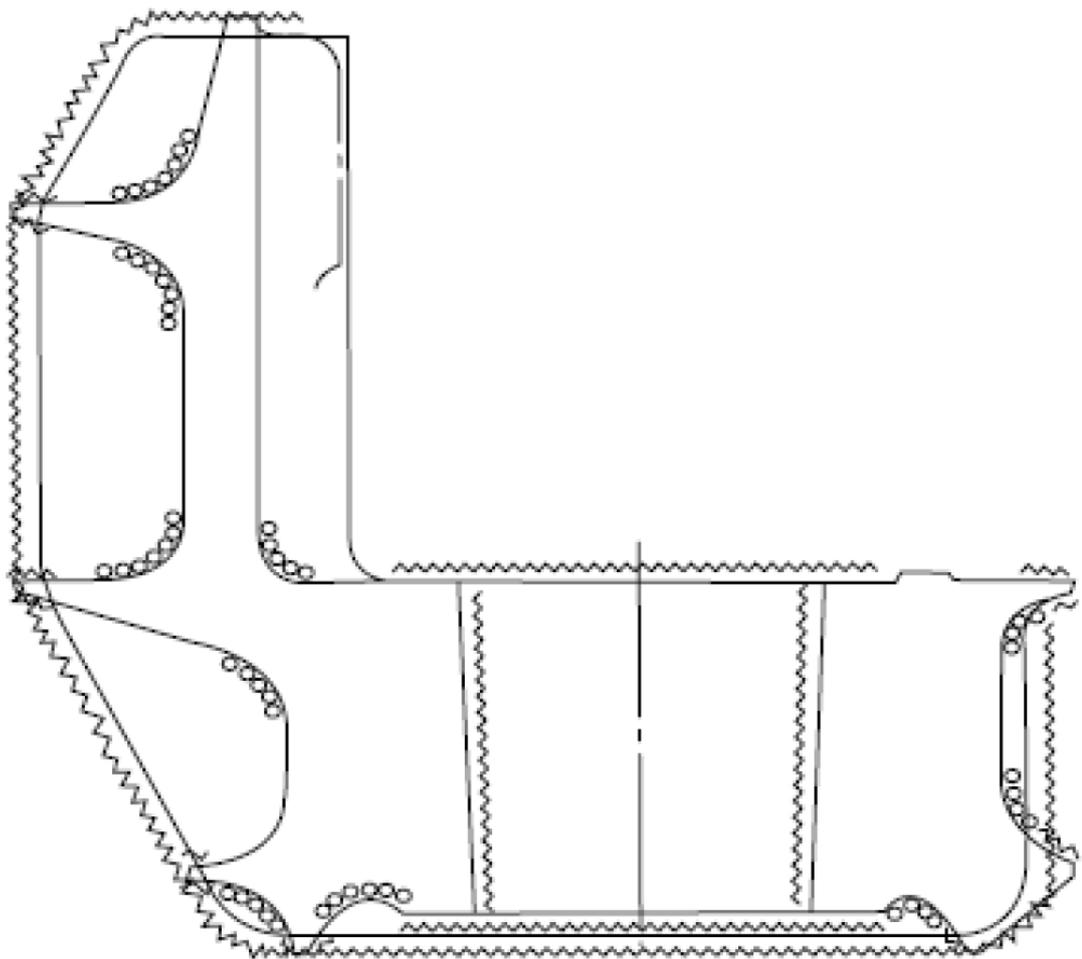


Fig. 2.5.2.4.1-6  
Rudder (lower part).

- Notes:
1. All surfaces: visual examination.
  2. Location indicated with (OOO): magnetic particle and ultrasonic testing
  3. Location indicated with (^^): ultrasonic testing.

**2.5.2.4.1.2** In addition to the areas identified on Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6, surface inspections shall be carried out in the following locations:

at all accessible fillets and changes of section;

in way of fabrication weld preparation, for a band width of 30 mm;

in way of chaplets;

in way of weld repairs;

at positions where surplus metal has been removed by flame cutting, scarifying or arc-air gouging.

**2.5.2.4.1.3** Ultrasonic testing shall be carried out in the zones indicated on Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6 and also at the following locations:

in way of all accessible fillets and at pronounced changes of section;

in way of fabrication weld preparations for a distance of 50 mm from the edge;

in way of weld repairs where the original defect was detected by ultrasonic testing;

in way of riser positions;

in way of machined areas particularly those subject to further machining such as bolt hole positions.

**2.5.2.4.1.4** In cases of survey of castings such as rudder horns, which may have a large surface area still untested after the above inspections have been applied, an additional ultrasonic inspection of the untested areas shall be made along continuous perpendicular grid lines on nominal 225 mm centres, scanning from one surface only.

**2.5.2.5** Testing procedures.

**2.5.2.5.1** Visual examination.

Steel castings nominated for NDT shall be subjected to a 100 % visual examination of all accessible surfaces by the manufacturer and made available to the RS surveyor. Viewing conditions at the inspected surfaces shall be in accordance with agreed national or international standards. Unless otherwise agreed, the visual examination shall be carried out in the presence of the RS surveyor.

**2.5.2.5.2** Surface inspection.

**2.5.2.5.2.1** The testing procedures, apparatus and conditions of magnetic particle testing and penetrant testing shall comply with agreed national or international standards. Magnetic particle testing is preferable to penetrant testing except in the following cases;

austenitic stainless steels,

interpretation of open visual and measurement or magnetic particle indications,

at the instruction of the RS surveyor, where a particular need for penetrant testing has been identified.

**2.5.2.5.2.2** For magnetic particle testing, attention shall be paid to the contact between the casting and the clamping devices of stationary magnetization benches in order to avoid local overheating or burning damage in its surface. Prods shall not be permitted on finished machined items. Damage of finished machined surface by electrical connections shall be avoided. Note that the use of solid copper at the prod tips must be avoided due to the risk of copper contamination into the casting. The pole of the magnets shall have close contact with the component.

**2.5.2.5.2.3** AC magnetization method shall normally be used, as it is more sensitive for detecting surface indications. Where DC magnetization method is used, this shall be substantiated and agreed with the Register.

**2.5.2.5.2.4** When indications have been detected as a result of the surface inspection, acceptance or rejection shall be decided in accordance with 2.5.2.6.

**2.5.2.5.3** Volumetric inspection.

**2.5.2.5.3.1** Volumetric inspection shall normally be carried out by ultrasonic testing using the contact method with normal (0°) beam and/or angle beam technique. The testing procedures, apparatus and conditions of ultrasonic testing shall comply with agreed national or international standards.

**2.5.2.5.3.2** In some cases, due to the shape, nature, complexity of casting, or defect type or orientation, the Register may require radiographic testing. Radiographic testing may be carried out at the initiative of the manufacturer and upon agreement with the Register. Where radiographic testing is applied, procedure, assessment criteria of the results shall comply with the recognized or agreed national or international standards, for example, depending on the thickness of castings: ASTM E446 — 15; ASTM E186 — 15 (2019) e1; ASTM E280 — 15 (2019) e1; ISO 4993:2015. A suitable quality level for marine castings shall normally be severity level 2 or 3

(of the above standards), depending on the location zone and type of casting. Other severity levels may be applied, and shall be agreed with the Register.

**2.5.2.5.3.3** Zone inspection indicated in the approved testing plan is minimum required however if defects are revealed that require amendments in zones to be inspected, the Register may require additional testing of extended zones. Definition of extended zones to be inspected shall be agreed with the Register. The testing plan shall include zones to be inspected in accordance with 2.5.2.4.1.3.

**2.5.2.5.3.4** Ultrasonic testing shall be made using a 0° probe of 1 to 4MHz (usually 2MHz) frequency, and angle probes, where required. Whenever possible scanning shall be performed from both surfaces of the casting and from surfaces perpendicular to each other.

**2.5.2.5.3.5** The backwall echo obtained on parallel sections shall be used to monitor variations in probe coupling and material attenuation. Any reduction in the amplitude of the back wall echo due to material properties shall be corrected. Attenuation in excess of 30 dB/m may be indicative of an unsatisfactory annealing heat treatment and may render the effectiveness of the testing as unsuitable. In such cases, the reasons of excessive attenuation shall be investigated and eliminated, as appropriate.

**2.5.2.5.3.6** Machined surfaces, especially those in the vicinity of riser locations and in the bores of stern boss castings, shall also be subject to a near surface (approximately 25 mm) scan using a twin crystal 0° probe.

Additional scans on machined surfaces may be required by the Register in cases where boltholes are drilled or where surplus material such as "padding" has been removed by machining thus moving the scanning surface closer to possible areas of shrinkage.

Additionally, the Register may require to examine the machined bores of castings using circumferential scans with 70° probes in order that axial radial planar flaws such as hot tears can be detected.

Fillet radii shall be examined using 45°, 60°, or 70° probes scanning from the surfaces/direction likely to give the best reflection, primarily to determine the presence of any cracks within the radiused areas, and as an additional scan to confirm any indications that may have been detected with 0° probes within this area.

**2.5.2.5.3.7** In the examinations of those zones nominated for ultrasonic examination the reference sensitivity for the 0° probe shall be established against a 6 mm reflector. Sensitivity can be calibrated either against 6 mm diameter flat bottomed hole(s) in a reference block (or series of blocks) corresponding to the thickness of the casting provided that a transfer correction is made, using the DAC (distance-amplitude-correction) method, or by using the DGS (distance-gain-size) method.

**2.5.2.5.3.8** Where necessary, the reference sensitivity of angle probes shall be established against an appropriate 6 mm reflector (e.g. reference reflectors angled perpendicular to the sound beam) for the DAC method, or equivalent using the DGS method.

**2.5.2.5.3.9** The DGS diagrams issued by a probe manufacturer identify the difference in dB between the amplitude of a backwall echo and that expected from a 6 mm diameter disk reflector. By adding this difference to the sensitivity level initially set by adjusting a backwall echo to a reference height e.g. 80 %, the amended reference level shall be representative of a 6 mm diameter disk reflector. Similar calculations may be used for evaluation purposes to establish the difference in dB between a backwall reflector and disk reflectors of other diameters such as 12 or 15 mm.

**2.5.2.5.3.10** Having made any necessary corrections for differences in attenuation or surface condition between the reference block and the casting, any indications received from the nominated zones in the casting that exceed the 6 mm reference level shall be marked for evaluation against the criteria given in 2.5.2.6.3. Evaluation shall include additional scans with angle probes in order that the full extent of the discontinuity can be plotted.

**2.5.2.6** Acceptance criteria.

**2.5.2.6.1** Visual examination.

**2.5.2.6.1.1** All castings shall be free of cracks, crack-like indications, hot tears, cold shuts or other detrimental indications. Thickness of the remains of sprues or risers shall be within the casting dimensional tolerance.

**2.5.2.6.1.2** Where non-open indications are suspected, additional magnetic particle, penetrant or ultrasonic testing may be conducted for a more detailed evaluation of surface irregularities at the request of the RS surveyor.

### 2.5.2.6.2 Surface inspection.

#### 2.5.2.6.2.1 The following definitions relevant to indications and defects apply.

Linear indication is an indication with a largest dimension three or more times its smallest dimension (i.e.  $l \geq 3w$ ).

Non-linear indication is an indication with a largest dimension less than three times its smallest dimension (i.e.  $l < 3w$ ).

Aligned indication is a unique indication and its length is equal to the overall length of the alignment. The aligned indication may have the following structure:

three or more non-linear indications aligned with the distance between indications less than 2 mm;

linear indications aligned with the distance between two indications smaller than the length of the longest indication.

Open indication (defect) is a defect visible after removal of the magnetic particles or that can be detected by the use of penetrant testing.

Non-open indication (defect) is a defect that is not visually detectable after removal of the magnetic particles or that cannot be detected by the use of penetrant testing.

Relevant indication (defect) is an indication which have any dimension greater than 1,5 mm and shall be considered relevant for the categorization of indications.

2.5.2.6.2.2 The surface shall be divided into reference band length of 150 mm for level MT1/PT1 and into reference areas of 22500 mm<sup>2</sup> for level MT2/PT2. The band length and/or area shall be taken in the most unfavourable location relative to the indications being evaluated, i.e. the shape and dimensions of each reference area are chosen so that they cover the maximum number of defects (discontinuities) without their distribution to an adjacent reference area.

2.5.2.6.2.3 Level MT1/PT1 is applied for fabrication weld preparation and weld repairs; Level MT2/PT2 is used for other locations.

The required quality level shall be shown in the manufacturer's testing program.

The allowable numbers and sizes of indications in the reference band length and/or area are given in Table 2.5.2.6.2.3. Cracks and hot tears shall not be accepted.

Table 2.5.2.6.2.3

Quality level	Total maximum number of all indications	Type of indication	Maximum number of each type of indication	Maximum dimension (e.g. width, length, diameter) of single indication <sup>1</sup> , mm
M1/P1	4 in 150 mm length	Non-linear	4 <sup>2</sup>	5
		Linear	4 <sup>2</sup>	3
		Aligned	4 <sup>2</sup>	3
M2/P2	20 in 22500 mm <sup>2</sup> area	Non-linear	10	7
		Linear	6	5
		Aligned	6	5

<sup>1</sup> In weld repairs, the maximum dimension is 2 mm.  
<sup>2</sup> 30 mm minimum (measured in any direction) between relevant indications.

### 2.5.2.6.3 Volumetric inspection.

2.5.2.6.3.1 Acceptance criteria for ultrasonic testing are specified in Table 2.5.2.6.3.1 for UT1 and UT2 quality levels. As stated in 2.5.2.4.2, the quality levels applicable to the zones to be examined shall be identified in the testing program.

Table 2.5.2.6.3.1

**Ultrasonic acceptance criteria for steel castings using DGS or DAC system**

Quality level	Allowable disc shape according to DGS <sup>1</sup> , mm or diameter of FBH according to DAC <sup>2,3</sup> curve (mm)	Maximum number of indications to be registered <sup>4</sup>	Allowable size of all relevant indications <sup>5,6</sup> , mm
UT1	> 6	0	0
UT2	12 – 15	5	50
	> 15	0	0

<sup>1</sup> DGS: distance-gain size.  
<sup>2</sup> DAC: distance amplitude correction.  
<sup>3</sup> The corresponding DAC level to each of the FBH reflectors is at 100% DAC.  
<sup>4</sup> Grouped in an area measuring 300 x 300 mm.  
<sup>5</sup> Measured on the scanning surface.  
<sup>6</sup> The measured indication is regarded as the longest dimension, as measured in the scanning process.

For castings specified in 2.5.2.4.1.1 the following quality levels are established.

Level UT1 is applicable to:

fabrication weld preparations for a distance of 50 mm;

50 mm depth from the final machined surface including boltholes;

fillet radii to a depth of 50 mm and within distance of 50 mm from the radius end;

castings subject to cyclic bending stresses (shafts and rudder stocks) — the outer one third of thickness in the zones shown in Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6;

discontinuities within the tested zones interpreted to be cracks or hot tears.

Level UT2 is applicable to:

other zones not indicated in Figs. 2.5.2.4.1-1 — 2.5.2.4.1-6 or on the inspection plan;

positions outside locations nominated for level UT1 examination where feeders and gates have been removed;

castings subject to cyclic bending stresses (shafts and rudder stocks) — at the central one third of thickness in the zones nominated for ultrasonic testing in Figs. 2.5.2.4.1-1 to 2.5.2.4.1-6.

**2.5.2.6.3.2** For ultrasonic testing near surface testing (to an approximate depth of 25 mm) twin crystal 0° (normal beam) probe shall be used, plus a 0° probe (usually single crystal beyond a depth of 25 mm) for the remaining volume.

**2.5.2.6.3.3** Ultrasonic acceptance criteria for other casting areas not nominated in 2.5.2.4.2.1 shall be subject to special consideration based on the anticipated stress levels and the type, size and position of the discontinuity and shall be agreed with the Register.

**2.5.2.6.3.4** Table 2.5.2.6.3.1 contains acceptance criteria for DGS and DAC.

**2.5.2.6.3.5** DGS and DAC methods may be used for determining sensitivity. The DAC method for normal beam probes may be based on a 6,0 mm diameter reflector or flat bottomed hole (FBH). A DAC curve shall be produced using reference blocks containing 6,0 mm FBH reflectors over a range representative of the inspection thickness, after adjustment for transfer and attenuation losses.

**2.5.2.6.3.6** For quality level UT 1, any discontinuity producing a signal amplitude in excess of the 6,0 mm DAC curve is unacceptable.

**2.5.2.6.3.7** For quality level UT2, the sensitivity may be based on actual size FBH (of 12 mm and 15 mm) or based on equivalent 6 mm FBH, and the sensitivity adjusted to obtain equivalent amplitudes, as described in 2.5.2.6.3.8.

**2.5.2.6.3.8** For use of FBH of 6 mm for setting sensitivity, adjustment of signal amplitudes may be determined for 12 mm and 15 mm FBH reflectors: to be DAC +12dB and DAC +16dB (plus any compensation for transfer and attenuation losses). As shown on Fig. 2.5.2.6.3.8, the increase in dB to the indicated levels represents the equivalent FBH sizes (for 12 mm and 15 mm), and their respective corresponding ultrasonic response amplitudes.

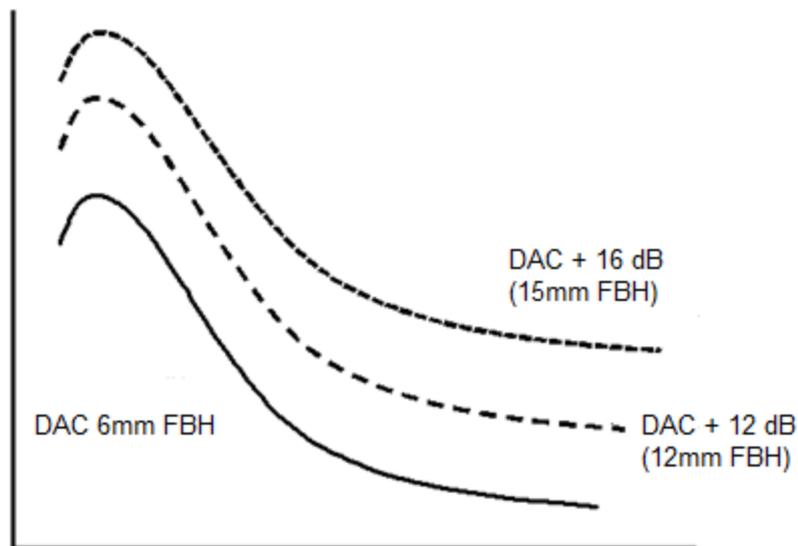


Fig. 2.5.2.6.3.8

DAC curve produced from 6,0 mm FBH reflector and DAC curves adjusted to represent equivalent 12,0 mm and 15,00 mm FBH reflectors

**Notes:**

1. The bottom curve (DAC) represents a sensitivity based on 6 mm FBH, and the two additional curves above this represent the equivalent sensitivities converted for larger FBH's (12 mm and 15 mm).
2. When scanning using these curves, and applying Table 2.5.2.6.3.1 acceptance criteria, for UT2, any indication below DAC +12 mm shall be disregarded, and any indication above DAC +16 mm shall be rejected.
3. Any indication between these two curves DAC +12 mm and DAC +16 mm shall be evaluated according to its size, as per Table 2.5.2.6.3.1.

**2.5.2.6.3.9** The maximum number of indications to be registered and the maximum length of indications permissible for quality level 2 (as stated in Table 2.5.2.6.3.1) apply to normal probes.

**2.5.2.6.3.10** For quality level UT 2, any discontinuity producing a signal amplitude in excess of the 15,0 mm DAC curve shall be regarded as unacceptable.

**2.5.2.6.3.11** Any signal between 12 + 15 curve shall be evaluated for length of defect, and referred to Table 2.5.2.6.3.1 for acceptance.

**2.5.2.7 Reporting.**

**2.5.2.7.1** All reports of non-destructive examinations shall include the following items:

- .1 date of testing;
- .2 names, signatures and qualification level of inspection personnel involved in non-destructive testing;
- .3 type of casting;
- .4 unique casting identification number;
- .5 steel grade;
- .6 casting condition (heat treatment);
- .7 stage of testing;
- .8 locations of testing;
- .9 surface condition;
- .10 test standards used, including reference to the appropriate acceptance criteria;
- .11 results, including documentation regarding the repair and testing history (as appropriate);
- .12 statement of acceptance/non-acceptance;
- .13 locations of reportable indications and received pulses from defects;
- .14 details of weld repair including sketches/drawings (where applicable).

**2.5.2.7.2** In addition to the items listed in 2.5.2.7.1, reports of surface inspections shall include at least the following items:

- .1 for penetrant testing: the penetrant system used;
- .2 for magnetic particle testing: method of magnetising, test media and magnetic field strength and magnetic flux indicators (where appropriate);
- .3 viewing conditions (as appropriate to the penetrant or magnetic technique and media used);
- .4 testing details and procedure number;
- .5 details of any test restrictions.

**2.5.2.7.3** In addition to the items listed in 2.5.2.7.1, reports of ultrasonic inspection shall include at least the following information: flaw detector, probe type, size, angle and frequency (and any adaptations to probes for curved surfaces), calibration and reference blocks, sensitivity method (including reflector size, transfer correction), maximum scanning rate (mm/s), and couplant.

**2.5.2.8** Rectification of defects.

**2.5.2.8.1** Indications that exceed the requirements of Tables 2.5.2.6.2.3 and 2.5.2.6.3.1, shall be classed as defects, and shall be repaired in accordance with the provisions of 3.8, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.5.2.8.2** Generally it may be permitted to remove shallow indications by light grinding.

**2.5.2.8.3** Complete removal of the defect shall be proved by magnetic particle testing or penetrant testing, as appropriate.

**2.5.2.8.4** Castings which are repaired shall be examined by the same method as at initial survey, as well as by any additional methods as requested by the RS surveyor."