INDIAN REGISTER OF SHIPPING

CLASSIFICATION NOTES

Guidelines for Non-Destructive Testing of Steel Castings for Marine Application

Rev-1, July 2021

IRCLASS
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TABLE 1 – AMENDMENTS INCORPORATED IN THIS VERSION

These amendments will come into force on 1 July 2021

Clause	Subject/ Amendments
Section 1 : General	
1.1.1	The term 'NDE' is replaced with 'NDT'
1.1.3 to 1.1.9 (all new)	More clarity is provided on the Scope of the Classification Note and the stage of manufacturing for inspections
Section 2 : Qualification of Personnel involved in NDT	
2.1.1	It is specified that personnel engaged in visual examination may be exempted from the formal qualifications specified, provided they have sufficient knowledge and experience.
2.1.2, 2.1.4, 2.1.5 (all new)	Acceptable personnel qualification requirements are indicated.
Section 3 : Casting Condition	
3.1.1	Editorial changes are made for better clarity.
3.2.1	It is specified that for surface inspection NDT methods, the surface quality is to be a minimum value of Ra ≤ 6.3 µm.
3.2.2	For UT, the minimum surface quality specified is Ra ≤ 12.5 µm.
Section 4: Extent of Inspections	
4.1.1	Clause is moved to 1.1.3 and other Clauses are renumbered accordingly.
Section 5: Examination Procedures	
5.1.1, 5.2.1, 5.3.1, 5.3.4	Editorial changes are made for better clarity.
5.2.2	It is clarified that The pole of the magnets is to have close contact with the component during MPT.
5.2.3 (new)	Occasions for use of AC and DC magnetization methods are clarified.
5.3.2 (new)	Guidance on requirements and standards for radiographic testing is provided.
5.3.3	It is specified that there may be need for further evaluation based on indications during initial testing and this could entail extension of testing areas, beyond those shown in agreed inspection plan.
5.3.5	It is specified that cases of excessive attenuation are to be investigated, and suitable mitigation measures carried out for effective ultrasonic testing to continue, where possible.
5.3.6	It is clarified that examination of filet radii using various angle probes is primarily to determine the presence of any cracks within the

Clause	Subject/ Amendments
	radiused areas, and as an additional scan to confirm any indications that may have been detected with 0° probe(s) within that area.
5.3.7	Distance-amplitude-correction (DAC) is added as a method for transfer correction.
5.3.8 (new)	Requirement for establishing reference sensitivity of angle probes is specified.
Section 6:Visual Inspection	
6.1.1, 6.1.2, 6.2.3, Table 1, 6.3.1	Editorial changes are made for better clarity.
6.2.1	The definitions for various indications are amended.
6.3.2 (new), 6.3.4 to 6.3.11 (all new)	Update on general UT requirements, and details regarding the setting up of, and using DAC sensitivity is provided. Clarification of UT acceptance criteria, to account for DAC sensitivity method, with a direct comparison to existing DGS method is given. Guidance on the use of other Flat Bottom Holes (FBH) for setting up equivalent DAC on different size FBH's is provided.
Fig. 6.3.8 (new)	A new figure is introduced to clarify DAC method sensitivity
Table 2	Ultrasonic acceptance criteria for steel castings using DGS or DAC system are clarified.
Section 7:Reporting	
7.1	Amendments are made to the list of items to be included in the non-destructive examination reports.
7.2 & 7.3	Certain items to be included in surface detection inspection reports and ultrasonic inspection reports are added to the list (in addition to 7.1).
Section 8 :Rectification of Defects	
8.1 (new)	It is specified that indications that exceed the requirements of Table 1 and Table 2, should be classed as defects, and are to be repaired or rejected as appropriate.
8.2 (new)	It is stipulated that defect removal is to be proved by magnetic particle testing or penetrant testing, as appropriate.

CLASSIFICATION NOTES

Guidelines for Non-Destructive Testing of Steel Castings for Marine Application

Rev-1, July 2021

Contents

Sections

1. General

1.1 Scope

1.1.1 These guidelines complement the requirements for hull and machinery steel castings given in IRS Rules Pt.2, Ch.4 “Steel Castings” and in Pt.4, Ch.4 “Prime Movers and Propulsion Shafting systems” and contain general guidance on the extent, methods and recommended quality levels applicable to the non-destructive testing (NDT), of marine steel castings, except in those cases where alternative criteria have been otherwise approved or specified.

1.1.2 The requirements in these guidelines may also be applied for other machinery components, giving due consideration to their materials, types, shapes and stress conditions etc.

1.1.3 Castings intending to be examined by NDT methods are identified in Figures 1 to 6 of this document. The list of castings is not definitive. Criteria for the inspection of other castings not listed in Figures 1 to 6 will be subject to agreement.

1.1.4 The requirements do not include every cast component type that may be subject to Classification. In such cases where the particular component or type is not included, appropriate national/ international standards, may be applied, to determine the appropriate testing regime and defect acceptance criteria.

1.1.5 These guidelines complement and reference the requirements of Part 2 of the Rules and contain general guidance for the non-destructive testing methods, the extent of testing and the minimum recommended quality levels that should be complied with unless otherwise approved or specified.

1.1.6 Castings are to be examined in the final delivery condition.

1.1.7 Where intermediate inspections have been performed the manufacturer is to provide reports of the results upon the request of the Surveyor.

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

1.1.9 Where advanced ultrasonic testing methods are applied, e.g. PAUT or TOFD, reference is made to Section 2 of IRS Classification Note: *‘Requirements for Non Destructive Testing’*, for general approach in adopting and application of these advanced methods. Acceptance levels regarding accept/ reject criteria are specified in the applicable section in this Classification Note.

2. Qualification of Personnel involved in NDT

2.1 Qualifications

2.1.1 Personnel engaged in visual examination are to have sufficient knowledge and experience, however, may be exempted from formal qualifications specified in this document.

2.1.2 Personnel carrying out NDT are to be certified to a recognised national or international certification scheme, e.g. ISO 9712:2012, or an employer based scheme such as SNT-TC-1A: 2016, or ANSI/ ASNT CP-189: 2016. Where employer based schemes are applied, personnel qualification to these schemes may be accepted if the written practice is reviewed and found acceptable by IRS. The written practice is to align with the main requirements of ISO 9712 (apart from the impartiality requirements of a certification body).

2.1.3 Personnel responsible for the NDT activity including approval of procedures are to be qualified and certified to Level III of ISNT/ASNT.

2.1.4 The NDT personnel's certificates and competence is to comprise all industrial sectors and techniques being applied by the manufacturer or its subcontractors. Certificates are to be made available to IRS for verification, when requested.

2.1.5 The operator carrying out the NDT and interpreting indications, is to as a minimum, be qualified and certified to Level II in the NDT method(s) 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 I. The operator is to 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.

3. Casting Condition

3.1 Heat Treatment

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

3.2 Surface Condition

3.2.1 Castings are to be examined in the final delivery condition free from any extraneous materials such as scale, dirt, grease or paint that may affect the effectiveness of the testing being performed. A thin coating of

contrast paint is permissible when using magnetic particle techniques. For surface inspection NDT methods, the surface quality is to be a minimum value of $R_a \leq 6.3$ µm.

3.2.2 Ultrasonic testing is to be carried out after the castings have been ground, machined or shot blasted to a suitable condition, with a minimum value surface quality of $R_a \leq 12.5$ µm. The surfaces of castings to be examined is to be such that adequate coupling can be established between the probe and the casting and that excessive wear of the probe is avoided.

4. Extent of Inspections

4.1 Zones to be examined

4.1.1 Zones to be examined in nominated castings are identified in Figures 1 to 6. Testing is to be carried out in accordance with an approved inspection plan. The plan is to specify the extent of the testing, the examination procedure, the quality level or, where necessary, quality level for different locations of the castings.

4.1.2 In addition to the areas identified in Figures 1 to 6, surface inspections are to 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.

4.1.3 Ultrasonic testing is to be carried out in the zones indicated in Figures 1 to 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.

4.1.4 In the case 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 are to be made along continuous perpendicular grid lines on nominal 225 [mm] centres, scanning from one surface only.

5. Examination Procedures

5.1 Visual Inspection

5.1.1 Steel castings which are required to undergo NDT are to be subjected to 100% visual examination of all surfaces by the manufacturer and made available to the Surveyor. Unless otherwise agreed, the visual and surface crack detection inspections are to be carried out in the presence of the Surveyor.

5.2 Surface Inspection

5.2.1 The testing procedures, apparatus and conditions of magnetic particle testing and liquid penetrant testing are to comply with recognized national or international standards. Magnetic particle testing is preferable to penetrant testing except in the following cases:

- austenitic stainless steels,
- interpretation of open visual or magnetic particle indications,
- at the instruction of the Surveyor, where a particular need for penetrant testing has been identified.

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

5.2.3 AC magnetisation method is normally to be used, as it is more sensitive for detecting surface indications. Where DC magnetisation method is used, this is to be in agreement with IRS, and the reason for use clearly stated.

5.2.4 When indications have been detected as a result of the surface inspection, acceptance or rejection is to be decided in accordance with Section 6.

5.3 Volumetric Inspection

5.3.1 Volumetric inspection in accordance with these guidelines is normally to be carried out by ultrasonic testing using the contact method with normal (0^o) beam and/or angle beam technique. The testing procedures, apparatus and conditions of ultrasonic testing are to comply with the recognized national or international standards.

5.3.2 In some cases, due to the shape, nature, complexity of casting, or defect type or orientation, there may be a need for radiographic testing. In such cases, radiographic testing may be carried out on the basis of prior agreement with IRS. Where radiographic testing is to be applied, national or international standards for both the testing method, and the quality or severity level to be applied, is to be agreed with IRS.

Guidance on standards:

- ASTM E446-15 : Standard Reference Radiographs for Steel Castings Up to 2 in. (50.8 mm) in Thickness.
- ASTM E186 -15(2019) e1: Standard Reference Radiographs for Heavy-Walled (2 to 412 in. (50.8 to 114 mm)) Steel Castings.
- ASTM E280-15(2019) e1 : Standard Reference Radiographs for Heavy-Walled (412 to 12 in. (114 to 305 mm)) Steel Castings.
- ISO 4993:2015 : Steel and iron castings-Radiographic testing

The above are examples of suitable national or international standards as appropriate to the radiographic testing of castings, and casting thickness.

A suitable quality level for marine castings would 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 should be agreed with IRS.

5.3.3 Unless otherwise considered necessary, only those areas shown in the agreed inspection plan need to be tested. However, the inspections may reveal indications that require further evaluation, or an extension of testing. In such cases this should be agreed with IRS.

5.3.4 Ultrasonic scans are to be made using a 0° probe of 1 – 4 MHz (usually 2MHz) frequency and angle probes, where required. Whenever possible scanning is to be performed from both surfaces of the casting and from surfaces perpendicular to each other. Lower frequency probes are recommended in order to increase signal to noise ratio.

5.3.5 The back wall echo obtained on parallel sections is to 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 is to be corrected. Attenuation in excess of 30 dB/m could be indicative of an unsatisfactory annealing heat treatment, and may render the effectiveness of the testing as unsuitable. In such cases of excessive attenuation, this is to be investigated, and suitable mitigation measures carried out for effective ultrasonic testing to continue, where possible.

5.3.6 Machined surfaces, especially those in the vicinity of riser locations and in the bores of stern boss castings, are also to be subject to a near surface (approximately 25 mm) scan using a twin crystal 0° probe. Additional scans on machined surfaces are of particular importance in cases where boltholes are to be 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, it is good practice 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 should 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° probe(s) within this area.

5.3.7 In the examinations of those zones nominated for ultrasonic examination the reference sensitivity for the 0° probe is to 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.

5.3.8 The reference sensitivity of angle probes (where required for testing) is to be established against an appropriate 6mm reflector (e.g. reference reflectors angled perpendicular to the sound beam) for the DAC method, or equivalent using the DGS method.

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

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 is to be marked for evaluation against the criteria given in 6.3 below. Evaluation is to include additional scans with angle probes in order that the full extent of the discontinuity can be plotted.

6. Acceptance Criteria

6.1 Visual Inspection

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

6.1.2 Additional magnetic particle, penetrant or ultrasonic testing may be required for a more detailed evaluation of surface irregularities at the request of the Surveyor.

6.2 Surface Crack Detection

6.2.1 The following definitions relevant to indications apply:

Linear indication	=	an indication with a largest dimension three or more times its smallest dimension (i.e. $l \geq 3\ w$).
Non-linear indication	=	an indication with a largest dimension less than three times its smallest dimension (i.e. $l < 3w$).
Aligned indication	=	three or more indications in a line, separated by 2 [mm] or less edge-to-edge which results in a unique indication, defined as follows: a) Non-linear indications form an alignment when the distance between indications is less than 2 [mm] and at least three indications are aligned. An alignment of indications is considered to be a unique indication and its length is equal to the overall length of the alignment. b) Linear indications form an alignment when the distance between two indications is smaller than the length of the longest indication.
Open indication	=	an indication visible after removal of the magnetic particles or that can be detected by the use of penetrant testing.
Non-open indication	=	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	=	an indication that is caused by a condition or type of discontinuity that requires evaluation. Only the indications which have any dimension greater than 1.5 [mm] are to be considered relevant for the categorization of indications.

6.2.2 For the purpose of evaluating indications, the surface is to be divided into reference band length of 150 [mm] for level MT1/PT1 and into reference areas of 22500 [mm^2] for level MT2/PT2. The band length and/or areas are to be taken in the most unfavourable locations relative to the indications being evaluated.

6.2.3 The following quality levels recommended for magnetic particle testing (MT) and/or penetrant testing (PT) area:

Level MT1/PT1 – fabrication weld preparation and weld repairs.

Level MT2/PT2 – other locations nominated for surface inspection in Figures 1 to 6.

The allowable numbers and sizes of indications in the reference band length and/or area are given in Table 1. The required quality level is to be shown on the manufacturer's inspection plan. Cracks and hot tears are not acceptable.

Table 1 : Allowable number and size of indications in a reference band length / area

Quality Level	Total Max. number of all indications	Type of indication	Max. number of each type of indication	Max. dimension of single indication, [mm] 2)
MT1/PT1	4 in 150 mm length	Non-linear Linear Aligned	4 1) 4 1) 4 1)	5 3 3
MT2/PT2	20 in 22500 [mm^2] area	Non-linear Linear Aligned	10 6 6	7 5 5

Notes :

1) 30 [mm] minimum (measured in any direction) between relevant indications.
2) In weld repairs, the maximum dimension is 2 [mm].

6.3 Volumetric Inspection

6.3.1 Acceptance criteria for ultrasonic testing are identified in Table 2 as UT1 and UT2. As stated in 4.2.1 the quality levels applicable to the zones to be examined are to be identified on an inspection plan. The following quality levels are nominated for the castings identified in Figures 1 to 6.

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 e.g. rudder horn, rudder castings and rudder stocks – the outer one third of thickness in the zones nominated for volumetric inspection by Figures 1 to 6.
- discontinuities within the examined zones interpreted to be cracks or hot tears.

Level UT2 is applicable to:

- other locations nominated for ultrasonic testing in Figures 1 to 6 or on the inspection plan.
- positions outside locations nominated for level UT1 inspection where feeders and gates have been removed.
- Castings subject to cyclic bending stresses – at the central one third of thickness in the zones nominated for volumetric inspection by Figures 1 to 6.

6.3.2 For near surface testing (to an approximate depth of 25 [mm]) twin crystal 0^{o} (normal beam) probe is to be used, plus a 0^{o} probe (usually single crystal beyond a depth of 25 [mm]) for the remaining volume.

6.3.3 Ultrasonic acceptance criteria for other casting areas not nominated in Figures 1 to 6 will be subject to special consideration based on the anticipated stress levels and the type, size and position of the discontinuity.

6.3.4 Table 2 describes the acceptance criteria for both methods of applied sensitivity (DGS and DAC).

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 is to 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.

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.

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 6.3.8.

6.3.8 For use of FBH of 6 [mm] for setting sensitivity, adjustment of signal amplitudes (measured in dB above 6 [mm] DAC) can 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). This is illustrated in Figure 6.3.8. The increase in dB to the indicated levels represent the equivalent FBH sizes (for 12 [mm] and 15 [mm]), and their respective corresponding ultrasonic response amplitudes.

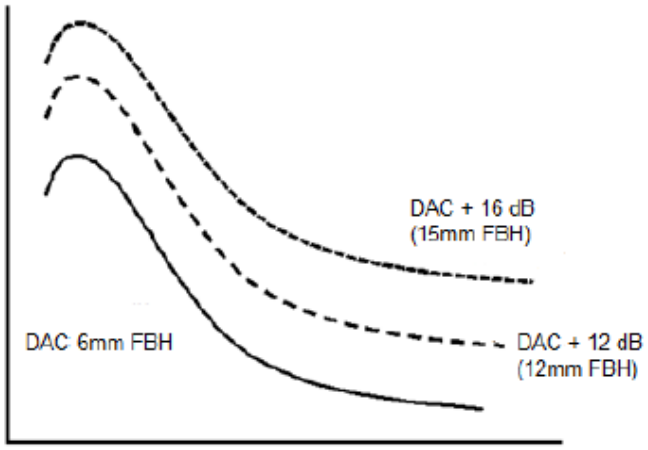


Fig. 6.3.8: DAC curve produced from 6.0mm FBH reflector and DAC curves adjusted to represent equivalent 12.0mm and 15.0mm FBH reflectors.

Explanatory Note for DAC and Fig. 6.3.8:

The bottom curve (DAC) represents a sensitivity based on 6mm FBH, and the two additional curves (DAC + 12 and DAC + 16dB) above this represent the equivalent sensitivities converted for larger FBH's (12mm and 15mm).

When scanning using these curves, and applying Table 2 acceptance criteria, for UT2, any indication below DAC +12mm should be disregarded, and any indication above DAC +16mm should be rejected.

Any indication between these two curves should be evaluated according to its size, as per Table 2.

Table 2 : Ultrasonic acceptance criteria for steel castings – using DGS or DAC system

Quality Level	Allowable disc shape according to DGS [1] [mm] or diameter of FBH according to DAC [2), 3)] Curve [mm]	Max. number of indications to be registered [4)]	Allowable size of all relevant indications [mm] [5), 6)]
UT1	> 6	0	0
UT2	12 – 15 > 15	5 0	50 0

Notes:

1) DGS : distance-gain-size
2) DAC : Distance Amplitude Correction
3) The corresponding DAC level to each of the FBH reflectors is at 100% DAC
4) Grouped in an area measuring 300 x 300 [mm]
5) Measured on the scanning surface.
6) The measured indication is regarded as the longest dimension, as measured in the scanning process.

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

6.3.10 For quality level UT 2, any discontinuity producing a signal amplitude in excess of the 15.0 [mm] DAC curve is to be regarded as unacceptable.

6.3.11 Any signal between 12 and 15 curve should be evaluated for length of defect, and referred to table 2 for acceptance.

7. Reporting

7.1 General

All reports of non-destructive examinations to include the following items:

1) Date of testing
2) Name(s) signature(s) and qualification level of inspection personnel
3) Type of casting
4) Product number and unique identification
5) Grade of steel
6) Heat treatment
7) Stage of testing
8) Locations for testing
9) Surface condition
10) Test standards used including reference to the appropriate tables for acceptance purposes
11) Calibration sensitivity
12) Results, including documentation regarding the repair and testing history (as appropriate)
13) Statement of acceptance / non-acceptance
14) Locations of reportable indications
15) Details of weld repairs including sketches (where applicable).

7.2 In addition to the items listed in 7.1, reports of surface detection inspections are to include at least the following items:

- for penetrant testing; the penetrant system used,

- for magnetic particle testing: method of magnetizing, test media and magnetic field strength and magnetic flux indicators (where appropriate).

- viewing conditions (as appropriate to the penetrant or magnetic technique and media used)

- testing details and procedure number

- details of any test restrictions

7.3 In addition to the items listed in 7.1, reports of ultrasonic inspection should include at least the following items:

- flaw detector probe type, size, angle and frequency (and any adaptions to probes for curved surfaces), , calibration and reference blocks, sensitivity method (including reflector size, transfer correction), maximum scanning rate (mm/s) and couplant.

8. Rectification of Defects

8.1 Indications that exceed the requirements of Table 1 and Table 2, should be classed as defects, and are to be repaired or rejected as appropriate.

8.2 Complete removal of the defect is to be proved by magnetic particle testing or penetrant testing, as appropriate.

8.3 Defects and unacceptable indications are to be repaired as indicated below

8.3.1 Defective parts of material may be removed by grinding or by chipping and grinding or by arc air-gouging. Thermal methods of metal removal should only be allowed before the final heat treatment. All grooves to have a bottom radius of approximately three times the groove depth and should be smoothly blended to the surface area with a finish equal to that of the adjacent surface.

8.3.2 Weld repairs should be suitably classified. Major repairs are those:

- where the depth is greater than 25% of the wall thickness or 25 [mm] whichever is less,
- where the total weld area on a casting exceeds 2% of the casting surface noting that where a distance between two welds is less than their average width, they are to be considered as one weld.

Major repairs require the approval of IRS before the repair is carried out. The repair is to be carried out before final furnace heat treatment.

8.3.3 Minor repairs are those:

- where the total weld area (length x width) exceeds 500 [mm^2].

Minor repairs do not usually require the approval of IRS but to be recorded on a weld repair sketch as a part of the manufacturing procedure documents. These repairs should be carried out before final furnace heat treatment.

8.3.4 Cosmetic repairs are:

- all other welds.

Cosmetic repairs do not require the approval of IRS but to be recorded on a weld repair sketch. These repairs may be carried out after final furnace heat treatment but are subject to a local stress relief heat treatment.

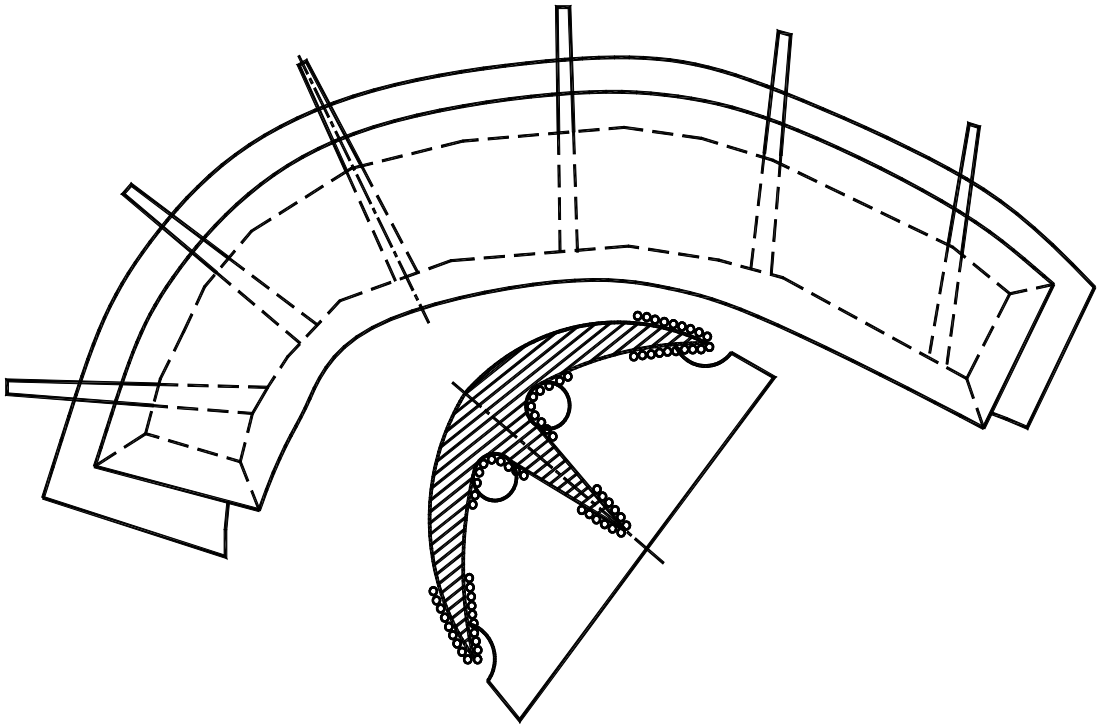
8.3.5 Castings in carbon or carbon manganese steel may require pre-heating prior to welding and also a post weld stress relieving heat treatment depending upon their chemical composition and the

dimensions and position of the weld repairs. Post weld heat treatment to be carried out at a temperature of not less than 550°C.

8.3.6 Castings subject to the removal of defects may be supplied without welding under the specific conditions:

- on un-machined surfaces where the depth of defect removal is not over 15 [mm] or 10% of wall thickness, whichever is less and the length of the removed part is not over 100 [mm].

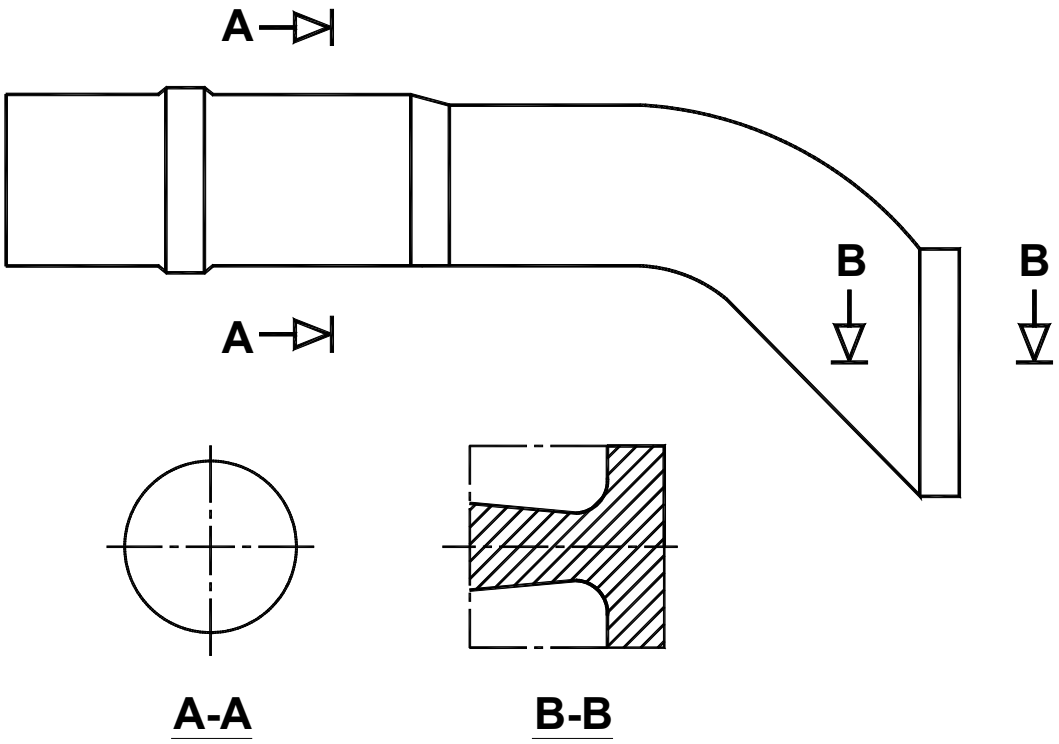
8.3.7 Parts which are repaired should be examined by the same method as at initial inspection as well as by additional methods as recommended by the Surveyor.



Notes : Location of non-destructive examination

1) **All surfaces : Visual examination**
2) **Location indicated with (OOO) : Magnetic particle and Ultrasonic testing**
3) **The detailed extents of examinations and quality levels are given in Section 4 and 6.**

Fig.1 : Stern Frame

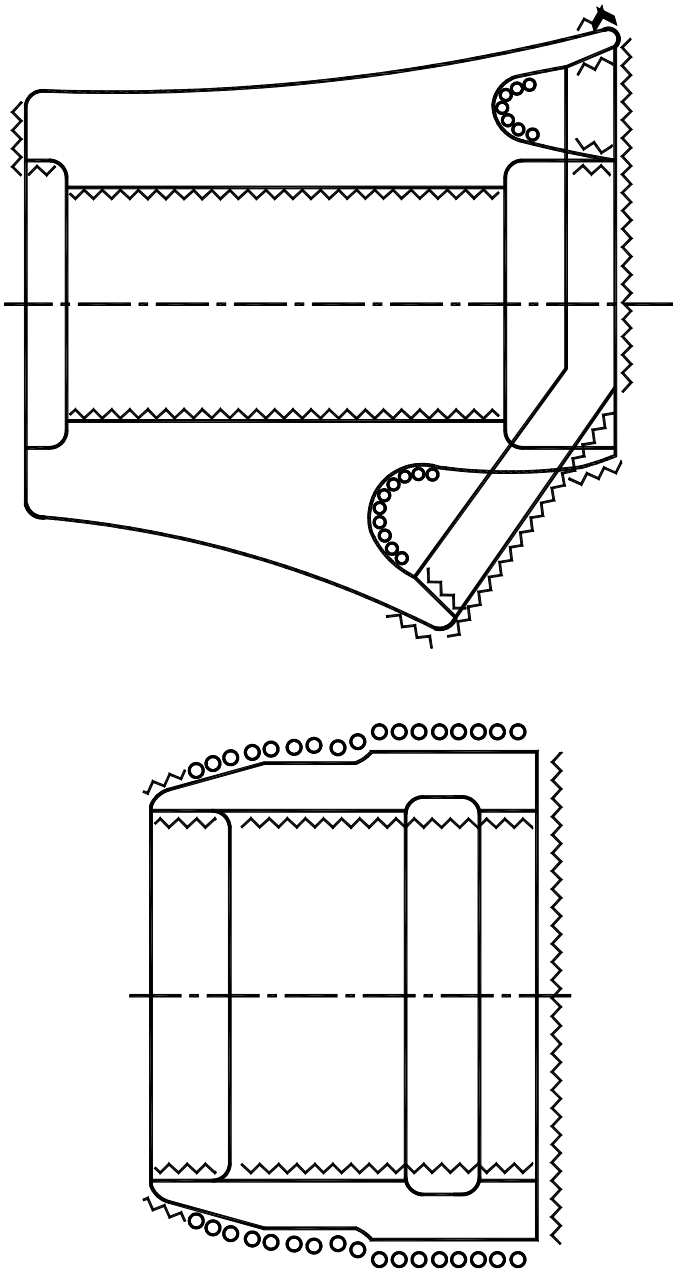


Notes : Location of non-destructive examination

1) **All surfaces :** **Visual examination**
Magnetic particle and Ultrasonic testing.

2) **The detailed extents of examinations and quality levels are given in Section 4 and 6.**

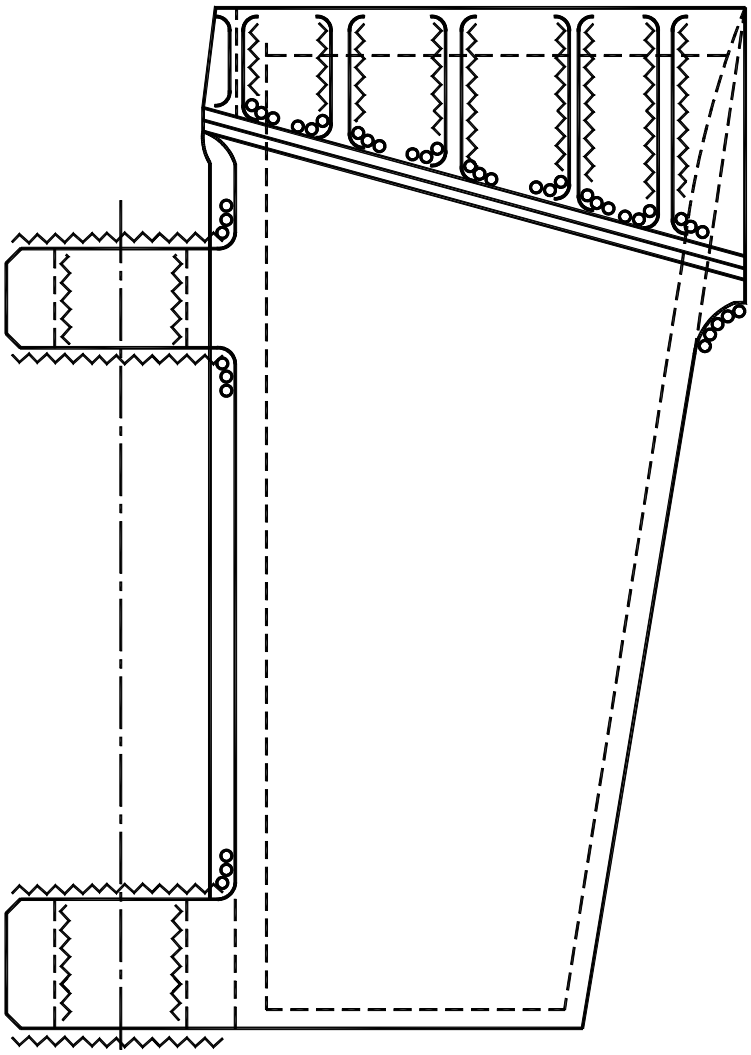
Fig.2 : Rudder stock



Notes : Location of non-destructive examination

1) **All surfaces : Visual examination**
2) **Location indicated with (OOO) : Magnetic particle and Ultrasonic testing**
3) **Location indicated with (∿∿∿) : Ultrasonic testing**
4) **The detailed extents of examinations and quality levels are given in Section 4 and 6.**

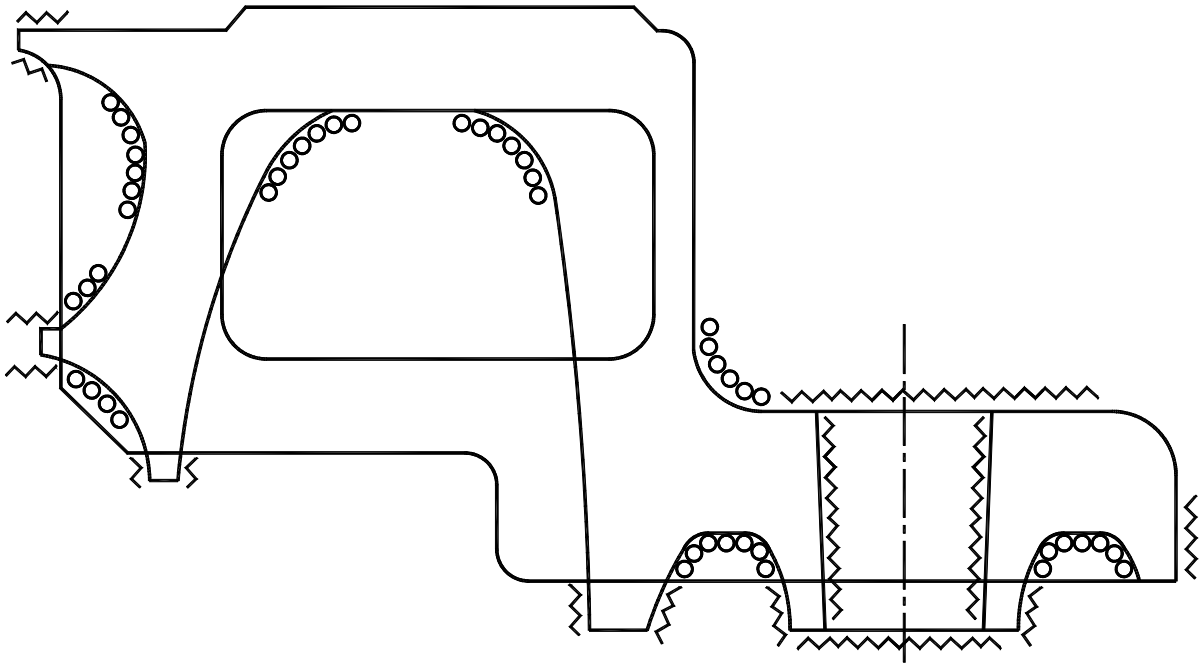
Fig.3 : Stern Boss



Notes : Location of non-destructive examination

1) **All surfaces : Visual examination**
2) **Location indicated with (OOO) : Magnetic particle and Ultrasonic testing**
3) **Location indicated with (∿∿∿) : Ultrasonic testing**
4) **The detailed extents of examinations and quality levels are given in Section 4 and 6.**

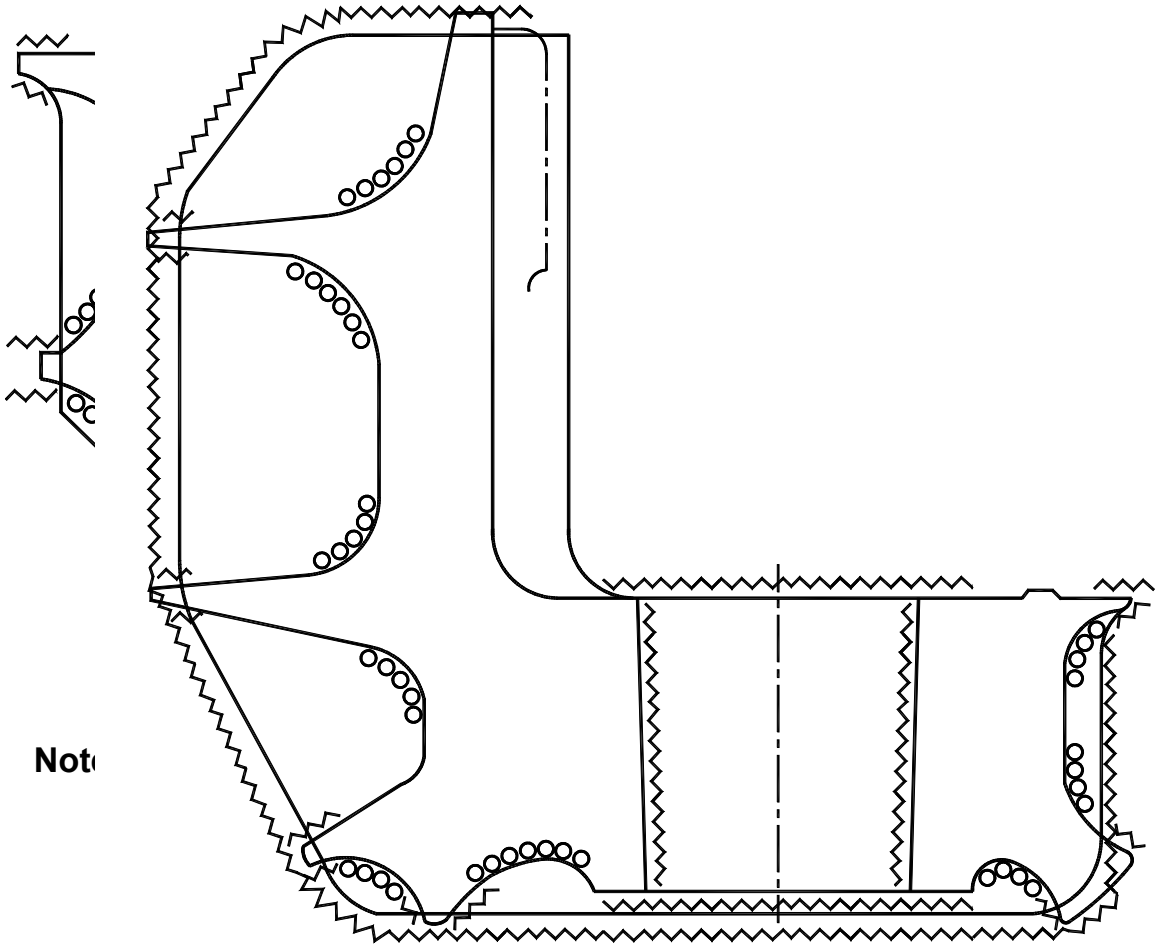
Fig. 4 : Rudder Horn



Notes : Location of non-destructive examination

1) **All surfaces : Visual examination**
2) **Location indicated with (OOO) : Magnetic particle and Ultrasonic testing**
3) **Location indicated with (∿∿∿) : Ultrasonic testing**
4) **The detailed extents of examinations and quality levels are given in Section 4 and 6.**

Fig. 5 : Rudder (Upper Part)



Notes : Location of non-destructive examination

1) **All surfaces : Visual examination**
2) **Location indicated with (OOO) : Magnetic particle and Ultrasonic testing**
3) **Location indicated with (∿∿∿) : Ultrasonic testing**
4) **The detailed extents of examinations and quality levels are given in Section 4 and 6.**

Fig. 6 : Rudder (Lower Part)

End of Classification Note