

The position of the samples to be taken in the length of the rolled product, “piece”, defined in 5C-8-6/2.1 (ABS), (top and/or bottom of the piece) and the direction of the test specimens with respect to the final direction of rolling of the material are indicated in 2-A4/Table 1.

The position of the samples in the width of the product is to be in compliance with 5C-8-6/2.2 (ABS).

5.11 Tests on Base Material

5.11.1 Type of Tests

The tests as indicated in 2-A4/Table 1 are to be carried out.

TABLE 1
Tests for Rolled Products Manufacturer Approval (2007)

Type of Test	Position of the samples and direction of the test specimen ⁽¹⁾	Remarks
Tensile test	Top and bottom transverse ⁽²⁾	ReH, Rm, A ₅ (%), RA(%) are to be reported
Tensile test (stress relieved) For TM steel only	Top and bottom transverse ⁽²⁾	Stress relieving at 600°C (2 min/mm) with minimum 1 hour)
Impact tests ⁽³⁾ on non aged specimens for grades:	Top and bottom – longitudinal	Testing temperature (0°C)
A, B, AH32, AH36, AH40		+20 0 -20
D, DH32, DH36, DH40		0 -20 -40
E, EH32, EH36, EH40		0 -20 -40 -60
FH32, FH36, FH40		-20 -40 -60 -80
A, B, AH32, AH36, AH40		+20 0 -20
D, DH32, DH36, DH40		0 -20 -40
E, EH32, E3H6, EH40		-20 -40 -60
FH32, FH36, FH40	-40 -60 -80	
Impact tests ⁽³⁾ on strain aged specimens ⁽⁵⁾ for grades:	Top - longitudinal	Testing temperature (0°C)
AH32, AH36, AH40		+20 0 -20
D, DH32, DH36, DH40		0 -20 -40
E, EH32, EH36, EH40		-20 -40 -60
FH32, FH36, FH40		+20 0 -80
Chemical analysis (%) ⁽⁶⁾	Top	Complete analysis including micro alloying elements
Sulphur prints	Top	
Micro examination	Top	
Grain size determination	Top	For fine grain steel only
Drop weight test ⁽⁴⁾	Top	For grades E, EH32, EH36, EH40, FH32, FH36, FH40 only
Through thickness tensile tests	Top and bottom	For grades with improved through thickness properties only

Notes:

- For hot rolled strips see 2-A4/5.11.2
- Longitudinal direction for sections and plates having width less than 600 mm
- One set of 3 Charpy V-notch impact specimens is required for each impact test
- Not required for sections and plates having width less than 600 mm
- (2007) Deformation 5% + 1 hour at 250°C. The impact energy value is reported for information only.
- Besides product analysis, ladle analysis is also required

5.11.2 Test Specimens and Testing Procedure

The test specimens and testing procedures are to be, as a rule, in accordance with Section 2-1-1 with particular attention to the following:

5.11.2(a) Tensile test

- For plates made from hot rolled strip, one additional tensile specimen is to be taken from the middle of the strip constituting the coil.
- For plates having thickness higher than 40mm, when the capacity of the available testing machine is insufficient to allow the use of test specimens of full thickness, multiple flat specimens, representing collectively the full thickness, can be used. Alternatively two round specimens with the axis located at one quarter and at mid-thickness can be taken.

5.11.2(b) Impact test

- For plates made from hot rolled strip, one additional set of impact specimens is to be taken from the middle of the strip constituting the coil.
- For plates having thickness higher than 40 mm, one additional set of impact specimens is to be taken with the axis located at mid-thickness.
- In addition to the determination of the energy value, also the lateral expansion and the percentage crystallinity are to be reported.

5.11.2(c) *Chemical analyses.* Both the ladle and product analyses are to be reported. The material for the product analyses should be taken from the tensile test specimen. In general, the content of the following elements is to be checked: C, Mn, Si, P, S, Ni, Cr, Mo, Al, N, Nb, V, Cu, As, Sn, Ti and, for steel manufactured from electric or open-hearth furnace, Sb and B.

5.11.2(d) *Sulphur prints* are to be taken from plate edges which are perpendicular to the axis of the ingot or slab. These sulfur prints are to be approximately 600 mm long, taken from the center of the edge selected, i.e., on the ingot centerline, and are to include the full plate thickness.

5.11.2(e) *Micrographic examination.* The micrographs are to be representative of the full thickness. For thick products in general, at least three examinations are to be made at surface, one quarter and mid-thickness of the product.

All photomicrographs are to be taken at $\times 100$ magnification and where ferrite grain size exceeds ASTM 10, additionally at $\times 500$ magnification. Ferrite grain size should be determined for each photomicrograph.

5.11.2(f) *Drop weight test.* The test is to be performed in accordance with ASTM E208. The NDTT is to be determined and photographs of the tested specimens are to be taken and enclosed with the test report.

5.11.2(g) *Through thickness tensile test.* The test is to be performed in accordance with 2-1-1/17.

The test results are to be in accordance, where applicable, with the requirements specified for the different steel grades in Part 2, Chapter 1.

5.11.3 Other Tests

Additional tests such as CTOD test, large scale brittle fracture tests (Double Tension test, ESSO test, Deep Notch test, etc.) or other tests may be required in the case of newly developed type of steel, outside the scope of Part 2, Chapter 1, or when deemed necessary by the Bureau.

5.13 Weldability Tests

5.13.1 General

Weldability tests are required for plates and are to be carried out on samples of the thickest plate. Tests are required for normal strength grade E and for higher strength steels.

5.13.2 Preparation and Welding of the Test Assemblies

In general the following tests are to be carried out:

- i)* One (1) butt weld test assembly welded with a heat input approximately 15 kJ/cm
- ii)* One (1) butt weld test assembly welded with a heat input approximately 50 kJ/cm.

The butt weld test assemblies are to be prepared with the weld seam transverse to the plate rolling direction, so that impact specimens will result in the longitudinal direction.

The edge preparation is preferably to be 1/2 V or K.

As far as possible, the welding procedure is to be in accordance with the normal welding practice used at the yards for the type of steel in question.

The welding parameters including consumables designation and diameter, pre-heating temperatures, interpass temperatures, heat input, number of passes, etc. are to be reported.

5.13.3 Type of Tests

From the test assemblies, the following test specimens are to be taken:

5.13.3(a) One (1) cross weld tensile test

5.13.3(b) A set of three (3) Charpy V-notch impact specimens transverse to the weld with the notch located at the fusion line and at a distance 2, 5 and minimum 20 mm from the fusion line. The fusion boundary is to be identified by etching the specimens with a suitable reagent. The test temperature is to be the one prescribed for the testing of the steel grade in question.

5.13.3(c) Hardness tests HV 5 across the weldment. The indentations are to be made along a 1 mm transverse line beneath the plate surface on both the face side and the root side of the weld as follows:

- Fusion line
- HAZ: at each 0.7 mm from fusion line into unaffected base material (6 to 7 minimum measurements for each HAZ)

The maximum hardness value is to be not higher than 350 HV.

A sketch of the weld joint depicting groove dimensions, number of passes, hardness indentations is to be attached to the test report, together with photomicrographs of the weld cross section.

5.13.4 Other Tests

Additional tests such as cold cracking tests (CTS, Cruciform, Implant, Tekken, Bead-on plate), CTOD, or other tests may be required in the case of newly developed type of steel, outside the scope of Part 2, Chapter 1, or when deemed necessary by the Bureau.

7 Results

Before the approval, all test results are evaluated for compliance with the Rules. Depending upon the finding, limitations or testing conditions, as deemed appropriate, may be specified in the approval document.

All information required under 2-A4/3, applicable to the products submitted to the tests, is to be collected by the manufacturer and incorporated into a single document including all test results and operation records relevant to steel making, casting, rolling and heat treatment of the tested products.

9 Certification

9.1 Approval

Upon satisfactory completion of the survey, approval will be granted by the Bureau.

9.3 List of Approved Manufacturers

The approved manufacturers are entered in a list containing the types of steel and the main conditions of approval.

11 Renewal of Approval (2007)

The validity of the approval is to be to the maximum of five years, renewable subject to an audit and assessment of the result of satisfactory survey during the preceding period. The Surveyor's report confirming no process changes, along with mechanical property statistical data for various approved grades, is to be made available to the ABS Engineering/Materials department for review and issuance of renewal letter/certificate. *

Where for operational reasons, the renewal audit cannot be carried out within the validity of approval, the manufacturer will still be considered as being approved if agreement to such extension of audit date is provided for in the original approval. In such instance, the extension of approval will be backdated to the original renewal date.

Manufacturers who have not produced the approved grades and products during the period preceding the renewal may be required to carry out approval tests, unless the results of production of similar grades of products during the period are evaluated by the Bureau and found acceptable for renewal.

Note: * The provisions for renewal of approval are also applicable to all grades and products which were approved by the Bureau prior to an implementation of 2-1-1/1.2 and this Appendix, regardless of any validity of prior approval. Such renewal is to be completed before 1 January 2008, that is, within five years after the 1 January 2003 effective date of this Rule change.

13 Withdrawal of the Approval

The approval may be withdrawn before the expiry of the validity period in the following cases:

- i) In-service failures traceable to product quality
- ii) Non conformity of the product revealed during fabrication and construction
- iii) Discovery of failure of the manufacturer's quality system
- iv) Changes made by the manufacturer, without prior agreement of the Bureau, to the extent of the approval defined at the time of the approval
- v) Evidence of major non conformities during testing of the products.

PART

2

Rules for Testing and Certification of Materials

APPENDIX **5 Procedure for the Approval of Manufacturers of Hull Structural Steels Intended for Welding with High Heat Input (2006)**

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APPENDIX 5 Procedure for the Approval of Manufacturers of Hull Structural Steels Intended for Welding with High Heat Input (2006)**1 Scope**

This Appendix specifies the weldability confirmation procedures of normal and higher strength hull structural steels stipulated in Sections 2-1-2 and 2-1-3 intended for welding with high heat input over 50 kJ/cm (127 kJ/in.).

The weldability confirmation procedure is to be generally applied at manufacturer's option and valid for certifying that the steel has satisfactory weldability for high heat input welding concerned under testing conditions.

Demonstration of conformance to the requirements of this Appendix approves a particular steel mill to manufacture grades of steel to the specific chemical composition range, melting practice, and processing practice for which conformance was established. The approval scheme does not apply to qualification of welding procedures to be undertaken by shipyards.

3 Application for Certification

The manufacturer is to submit to the Bureau a request for certification of the proposed weldability test program (see 2-A5/5.3 below) and technical documents relevant to:

- i)* Outline of steel plate to be certified
 - Grade
 - Thickness range
 - Deoxidation practice
 - Fine grain practice
 - Aim range of chemical composition
 - Aim maximum C_{eq} and P_{cm}
 - Production statistics of mechanical properties (tensile and Charpy V-notch impact tests), if any
- ii)* Manufacturing control points to prevent toughness deterioration in heat affected zones of high heat input welds, relevant to chemical elements, steel making, casting, rolling, heat treatment etc.
- iii)* Welding control points to improve joint properties on strength and toughness.

5 Confirmation tests

5.1 Range of Certification

Range of certification for steel grades is to be in accordance with the following, unless otherwise agreed by the Bureau:

- i) Approval tests on the lowest and highest toughness levels cover the intermediate toughness level.
- ii) Approval tests on normal strength level cover that strength level only.
- iii) For high tensile steels, approval tests on one strength level cover strength level immediately below.
- iv) Tests may be carried out separately provided the same manufacturing process is applied.
- v) Certification and documentation of confirmation tests performed by another Classification Society may be accepted at the discretion of the Bureau.

5.3 Weldability Test Program

The extent of the test program is specified in 2-A5/5.9, but it may be modified according to the contents of certification. In particular, additional test assemblies and/or test items may be required in the case of newly developed types of steel, welding consumable and welding method, or when deemed necessary by the Bureau. Where the content of tests differs from those specified in 2-A5/5.9, the program is to be confirmed by the Bureau before the tests are carried out.

5.5 Test Plate

The test plate is to be manufactured by a process approved by the Bureau in accordance with the requirements of Part 2, Appendix 4. For each manufacturing process route, two test plates with different thickness are to be selected. The thicker plate (t) and thinner plate (less than or equal to $t/2$) are to be proposed by the manufacturer.

Minor changes in manufacturing processing (e.g. within the TMCP process) may be considered for acceptance without testing, at the discretion of the Bureau.

5.7 Test Assembly

One butt weld assembly welded with heat input over 50 kJ/cm is generally to be prepared with the weld axis transverse to the plate rolling direction.

Dimensions of the test assembly are to be amply sufficient to take all the required test specimens specified in 2-A5/5.5.

The welding procedures should be as far as possible in accordance with the normal practices applied at shipyards for the test plate concerned, and including the following:

- Welding process
- Welding position
- Welding consumable (manufacturer, brand, grade, diameter and shield gas)
- Welding parameters including bevel preparation, heat input, preheating temperatures, interpass temperatures, number of passes, etc.

5.9 Examinations and Tests for the Test Assembly

The test assembly is to be examined and tested in accordance with the following, unless otherwise agreed by the Bureau.

- i) *Visual examination.* Overall welded surface is to be uniform and free from injurious defects such as cracks, undercuts, overlaps, etc.
- ii) *Macroscopic test.* One macroscopic photograph is to be representative of transverse section of the welded joint and is to show absence of cracks, lack of penetration, lack of fusion and other injurious defects.
- iii) *Microscopic test.* Along mid-thickness line across transverse section of the weld, one micrograph with $\times 100$ magnification is to be taken at each position of the weld metal centerline, fusion line and at a distance 2, 5, 10 and a minimum 20 mm (0.8 in.) from the fusion line. The test result is provided for information purpose only.
- iv) *Hardness test.* Along two lines across transverse weld section 1 mm beneath plate surface on both face and root side of the weld, indentations by HV5 are to be made at weld metal centerline, fusion line and each 0.7 mm (0.28 in.) position from fusion line to unaffected base metal (minimum 6 to 7 measurements for each heat affected zone). The maximum hardness value should not be higher than 350 HV.
- v) *Transverse tensile test.* Two transverse (cross weld) tensile specimens are to be taken from the test assembly. Test specimens and testing procedures are to comply with the requirements of Section 2-4-3.

The tensile strength is to be not less than the minimum required value for the grade of base metal.

- vi) *Bend test.* Two transverse (cross weld) test specimens are to be taken from the test assembly and bent on a mandrel with diameter of quadruple specimen thickness. Bending angle is to be at least 120 degrees. Test specimens are to comply with the requirements of Section 2-4-3.

For plate thickness up to 20 mm (0.8 in.), one face-bend and one root-bend specimens or two side-bend specimens are to be taken. For plate thickness over 20 mm (0.8 in.), two side-bend specimens are to be taken. After testing, the test specimens shall not reveal any crack nor other open defect in any direction greater than 3 mm (0.12 in.).

- vii) *Impact test.* Charpy V-notch impact specimens (three specimens for one set) are to be taken within 2 mm (0.08 in.) below plate surface on face side of the weld with the notch perpendicular to the plate surface.

One set of the specimens transverse to the weld is to be taken with the notch located at the fusion line and at a distance 2, 5 and a minimum 20 mm (0.8 in.) from the fusion line. The fusion boundary is to be identified by etching the specimens with a suitable reagent. The test temperature is to be the one prescribed for the testing of the steel grade in question.

For steel plate with thickness greater than 50 mm (2.0 in.) or one side welding for plate thickness greater than 20 mm (0.8 in.), one additional set of the specimens is to be taken from the root side of the weld with the notch located at each of the same positions as for the face side.

The average impact energy at the specified test temperature is to comply with the requirements of 2-1-2/Table 4 or 2-1-3/Table 4, depending on the steel grade and thickness. Only one individual value may be below the specified average value provided it is not less than 70% of that value. Additional tests at the different testing temperatures may be required for evaluating the transition temperature curve of absorbed energy and percentage crystallinity at the discretion of the Bureau.

- viii) *Other tests.* Additional tests, such as wide-width tensile test, HAZ tensile test, cold cracking tests (CTS, Cruciform, Implant, Tekken, and Bead-on plate), CTOD or other tests may be required at the discretion of the Bureau (see 2-A5/5.3).

7 Results

The manufacturer is to submit to the Bureau the complete test report including all the results and required information relevant to the confirmation tests specified in 2-A5/5.

The contents of the test report are to be reviewed and evaluated by the Bureau in accordance with this weldability confirmation scheme.

9 Certification

The Bureau will issue a certificate where the test report is found to be satisfactory. The following information is to be included on the certificate:

- i)* Manufacturer
- ii)* Grade designation with notation of heat input (refer to 2-A5/11)
- iii)* Deoxidation practice
- iv)* Fine grain practice
- v)* Condition of supply
- vi)* Plate thickness tested
- vii)* Welding process
- viii)* Welding consumable (manufacturer, brand, grade).
- ix)* Actual heat input applied.

11 Grade Designation

Upon issuance of the certificate, the notation indicating the value of heat input applied in the confirmation test may be added to the grade designation of the test plate, e.g. “E36-W300” [in the case of heat input 300 kJ/cm (762 kJ/in.) applied]. The value of this notation is to be not less than 50 and every 10 added.

Rules for Testing and Certification of Materials

APPENDIX **6 Guide for Nondestructive Examination of Marine Steel Castings (2005)**

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PART

2

APPENDIX **6 Guide for Nondestructive Examination of Marine Steel Castings**

SECTION **1 General**

Note: The requirements in this Appendix have been adopted from the IACS Recommendation No. 69. “Guidelines for Non-destructive Examination of Marine Steel Castings”. However, in order to be consistent with existing ABS publications, some specific text from the above referenced Guidelines has been modified. This Appendix incorporates the ABS *Guide for Nondestructive Examination of Marine Steel Castings*, which is effective as of 1 January 2005.

1 Scope

1.1

This Guide contains general guidance for the nondestructive examination methods, the extent of examination and the minimum recommended quality levels to be complied with for marine steel castings, unless otherwise approved or specified.

1.3

This document contains guidelines on “Surface Inspections” (Section 2-A6-2) by visual examination, magnetic particle testing and liquid penetrant testing and “Volumetric Inspection” (Section 2-A6-3) by ultrasonic testing and radiographic testing.

1.5

Although no detailed guidelines are given for machinery components, the requirements in this Guide may apply correspondingly considering their materials, kinds, shapes and stress conditions being subjected.

1.7

Castings should be examined in the final delivery condition. For specific requirements, see 2-A6-2/9.3 and 2-A6-3/7.3.

1.9

Where intermediate inspections have been performed the manufacturer is to furnish the documentation of the results upon request of the Surveyor.

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PART

2

APPENDIX **6 Guide for Nondestructive Examination of Marine Steel Castings**

SECTION **2 Surface Inspection**

1 General

1.1

Surface inspections in this Guide are to be carried out by visual examination and magnetic particle testing or liquid penetrant testing.

1.3

The testing procedures, apparatus and conditions of magnetic particle testing and liquid penetrant testing are to comply with a recognized national or international standard.

1.5

Personnel engaged in visual examination are to have sufficient knowledge and experience. Personnel engaged in magnetic particle testing or liquid penetrant testing are to be qualified in accordance with the *ABS Guide for Nondestructive Inspection of Hull Welds*. The qualification is to be verified by the certificates.

3 Products

3.1

Steel castings are to be subjected to a 100% visual examination of all accessible surfaces by the Surveyor.

3.3

Surface inspections by magnetic particle and/or liquid penetrant methods apply to the hull steel castings indicated in Annex 1 of this Appendix.

5 Location for Surface Inspections

5.1

Surface inspections are to be carried out in the following locations:

- At all accessible fillets and changes of section
- At positions where surplus metal has been removed by flame cutting, scarfing or arc-air gouging
- In way of fabrication weld preparation, for a band width of 30 mm
- In way of weld repairs

5.3

The following quality levels are considered for magnetic particle testing (MT) and/or liquid penetrant testing (PT):

- Level MT1/PT1 – fabrication weld preparation and weld repairs.
- Level MT2/PT2 – other locations shown in 2-A6-2/5.1.

The required quality level is to be shown on the manufacturer's drawings.

7 Surface Condition

The surfaces of castings to be examined are to be free from scale, dirt, grease or paint and are to be shot blasted or ground.

9 Surface Inspection

9.1

Magnetic particle inspection will be carried out with the following exceptions, when liquid penetrant testing will be permitted:

- Austenitic stainless steels
- Interpretation of open visual or magnetic particle indications
- At the instruction of the Surveyor

9.3

Unless otherwise specified in the order, the magnetic particle test is to be performed on a casting in the final delivery condition and final thermally treated condition or within 0.3 mm of the final machined surface condition for AC techniques (0.8 mm for DC techniques).

9.5

Unless otherwise agreed, the surface inspection is to be carried out in the presence of the Surveyor.

9.7

For magnetic particle testing, attention is to 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 are not permitted on finished machined items.

9.9

When indications are detected as a result of the surface inspection, the acceptance or rejection is to be decided in accordance with 2-A6-2/11.

11 Acceptance Criteria and Rectification of Defects

11.1 Acceptance Criteria – Visual Inspection

All castings are to be free of cracks, crack-like indications, hot tears, laps, seams, folds or other injurious indications. Thickness of the remains of sprues, heads or burrs is to be within the casting dimensional tolerance. Additional magnetic particle, liquid penetrant and ultrasonic testing may be required for a more detailed evaluation of surface irregularities at the request of the surveyor.

11.3 Acceptance Criteria – Magnetic Particle Testing and Liquid Penetrant Testing

11.3.1

The following definitions relevant to indications apply:

- *Linear indication.* An indication in which the length is at least three times the width.
- *Nonlinear indication.* An indication of circular or elliptical shape with a length less than three times the width.
- *Aligned indication.* Three or more indications in a line, separated by 2 mm or less edge-to-edge.
- *Open indication.* An indication visible after removal of the magnetic particles or that can be detected by the use of contrast dye penetrant.
- *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 contrast dye penetrant.
- *Relevant indication.* 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 are to be considered relevant.

11.3.2

For the purpose of evaluating indications, the surface is to be divided into reference band length of 15 cm for level MT1/PT1 and into reference areas of 225 cm² for level MT2/PT2. The band length and/or area is to be taken in the most unfavorable location relative to the indication being evaluated.

11.3.3

The allowable number and size of indications in the reference band length and/or area is given in 2-A6-2/Table 1. Cracks and hot tears are not acceptable.

11.5 Rectification of Defects

Defects and unacceptable indications are to be repaired as indicated below and detailed in 2-A6-2/11.5.2.

11.5.1

Defective parts of material may be removed by grinding, or by chipping and grinding, or by arc air-gouging and grinding. All grooves are 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 the adjacent surface.

11.5.2

Repairs by welding are defined as follows:

Major repairs:

- Where the depth is greater than 25% of the wall thickness or 2.5 cm whichever is the less, or
- Where the weld area (length X width) exceeds 1250 cm² (*Note:* where a distance between two welds is less than their average width, they are considered as one weld), or
- Where the total weld area on a casting exceeds 2% of the casting surface.

Minor repairs:

- Where the total weld area (length X width) exceeds 5 cm².

Cosmetic repairs:

- All other welds.

11.5.2(a) Major repairs are to be approved before the repair is carried out. The repair should be carried out before final furnace heat treatment.

11.5.2(b) Minor repairs do not require approval before the repair is carried out but should 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.

11.5.2(c) Cosmetic repairs do not require approval before the repair is carried out but should 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. Thermal methods of metal removal should only be allowed before the final heat treatment. After final heat treatment only grinding or chipping and grinding should be allowed. Weld repairs should be suitably classified.

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

13 Record

13.1

Test results of surface inspections are to be recorded at least with the following items:

- i) Date of testing
- ii) Names and qualification level of inspection personnel
- iii) Kind of testing method
 - For liquid penetrant testing: test media combination
 - For magnetic particle testing: method of magnetizing, test media and magnetic field strength
- iv) Kind of product
- v) Product number for identification
- vi) Grade of steel
- vii) Heat treatment
- viii) Stage of testing

- ix) Locations for testing
- x) Surface condition
- xi) Test standards used
- xii) Testing condition
- xiii) Results
- xiv) Statement of acceptance/non acceptance
- xv) Details of weld repair including sketch

TABLE 1
Allowable Number and Size of Indications
in a Reference Band Length/Area

<i>Quality Level</i>	<i>Max. Number of Indications</i>	<i>Type of Indication</i>	<i>Max. Number for Each Type</i>	<i>Max. Dimension (mm) ⁽²⁾</i>
MT1/PT1	4 in a 15 cm length	Linear	4 ⁽¹⁾	5
		Nonlinear	4 ⁽¹⁾	3
		Aligned	4 ⁽¹⁾	3
MT2/PT2	20 in a 225 cm ² area	Linear	10	7
		Nonlinear	6	5
		Aligned	6	5

Notes

- 1 30 mm min. between relevant indications.
- 2 In weld repairs, max. dimension < 2 mm.

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PART

2

APPENDIX **6 Guide for Nondestructive Examination of Marine Steel Castings**

SECTION **3 Volumetric Inspection**

1 General

1.1

Volumetric inspection in this Guide is to be carried out by ultrasonic testing using the contact method with straight beam and/or angle beam technique.

1.3

The testing procedures, apparatus and conditions of ultrasonic testing are to comply with the recognized national or international standards. Generally, the DGS (distance-gain size) procedure is to be applied using straight beam probes and/or angle beam probes with 1 to 4 MHz and an inspection should be carried out using a twin crystal 0° probe for near surface scans (25 mm) plus a 0° probe for the remaining volume. Fillet radii should be examined using 45°, 60° or 70° probes.

1.5

Radiographic testing is to be carried out in accordance with an approved plan.

1.7

Personnel engaged in ultrasonic or radiographic testing is to be qualified in accordance with the ABS *Guide for Nondestructive Inspection of Hull Welds*. The qualification is to be verified by certificates.

3 Products

3.1

Volumetric inspection by ultrasonic or radiographic testing apply to the hull steel castings indicated in Annex 1 of this Appendix.

5 Location for Volumetric Inspection

5.1

Volumetric inspection is to be carried out according to the inspection plan. The inspection plan should specify the extent of the examination, the examination procedure, the quality level or, if necessary, levels for different locations of the castings. The inspection plan is to be approved.

5.3

Ultrasonic testing is to be carried out in the following locations:

- In way of all accessible fillets and changes of section
- In way of fabrication weld preparation for a distance of 50 mm from the edge
- At all locations to be subject to subsequent machining (including bolt holes)
- In way of weld repairs where original defect was detected by ultrasonic testing

5.5

The following quality levels are considered for ultrasonic testing (UT):

Level UT1:

- Fabrication weld preparation for a distance of 50 mm
- 50 mm depth from the final machined surface including bolt holes
- Fillet radii for a depth of 50 mm and within distance of 50 mm from the radius end

Level UT2:

- Other locations.

The required quality levels are to be shown on the manufacturer's drawings.

7 Surface Condition

7.1

The surfaces of castings to be examined are to be such that adequate coupling can be established between the probe and the casting and that excessive wear of the probe can be avoided. The surfaces are to be free from scale, dirt, grease or paint.

7.3

The ultrasonic testing is to be carried out after the steel castings have been machined to a condition suitable for this type of testing and after the final heat treatment. Black castings are to be inspected after removal of the oxide scale by either flame descaling or shot blasting methods.

9 Acceptance Criteria

Acceptance criteria of volumetric inspection by ultrasonic testing are shown in 2-A6-3/Table 1.

11 Record

Test results of volumetric inspection are to be recorded at least with the following items:

- i) Date of testing
- ii) Names and qualification level of inspection personnel
- iii) Kind of testing method
- iv) Kind of product
- v) Product number for identification
- vi) Grade of steel
- vii) Heat treatment
- viii) Stage of testing
- ix) Locations for testing
- x) Surface condition
- xi) Test standards used
- xii) Testing condition
- xiii) Results
- xiv) Statement of acceptance/non acceptance

TABLE 1
Acceptance Criteria for Steel Castings

<i>Quality Level ⁽¹⁾</i>	<i>Allowable Disk Shape According to DGS ⁽²⁾</i>	<i>Max. Number of Indications to be Registered</i>	<i>Allowable Length of Linear Indications (mm)</i>
UT1	6	3	10
UT2	12	5	50

Notes

- 1 For the castings subject to cyclic bending stresses, e.g., rudder horn, rudder castings and rudder stocks, the outer one third of thickness is to comply with the acceptance criteria for level UT 1.
- 2 DGS: distance – gain size.

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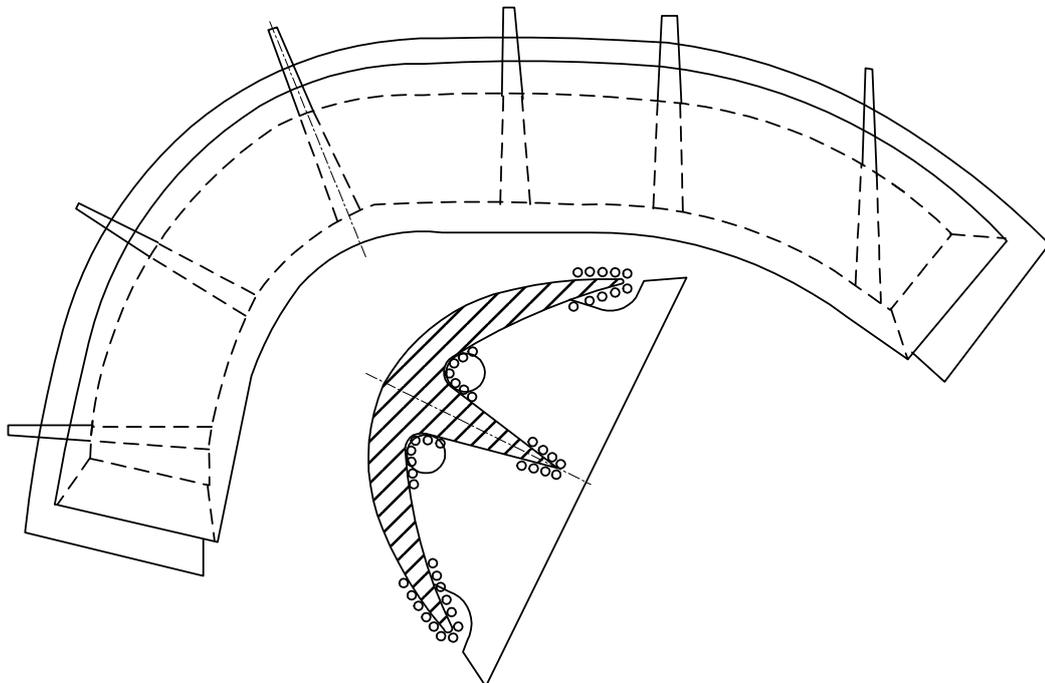
PART

2

APPENDIX **6** **Guide for Nondestructive Examination of Marine Steel Castings**

ANNEX **1** **General Location for the Type of Nondestructive Examinations of Typical Hull Steel Castings**

FIGURE 1
Stern Frame

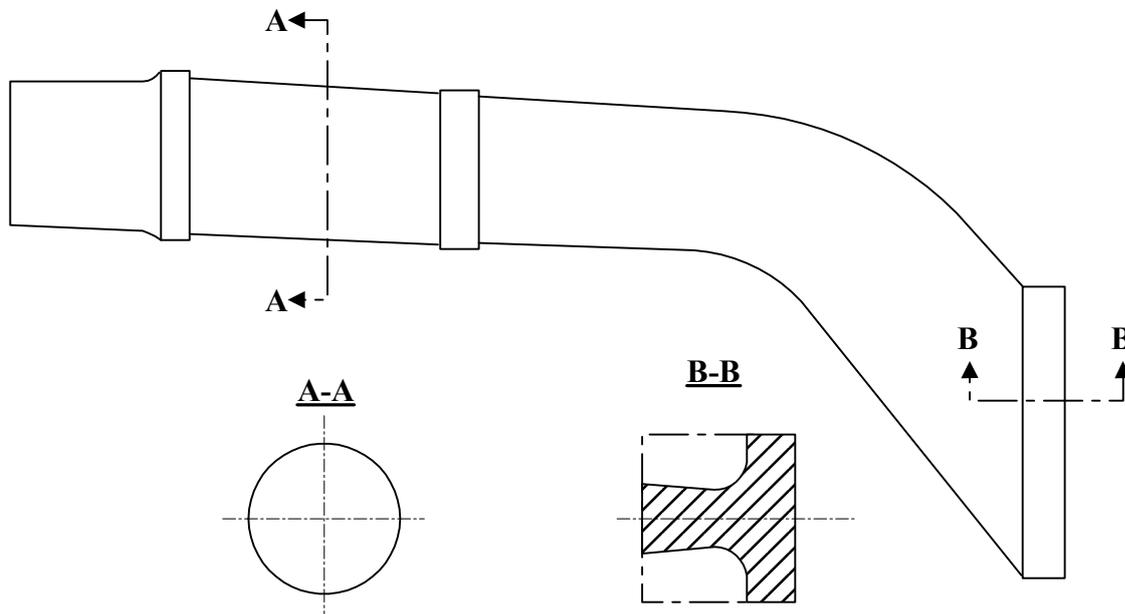


Notes:

Location of nondestructive examination:

- 1 All surfaces: Visual examination
- 2 Location indicated with (OOO): Magnetic particle testing and ultrasonic testing
- 3 The detailed extents of examinations and quality levels are given in Sections 2-A6-2 and 2-A6-3.

FIGURE 2
Rudder stock

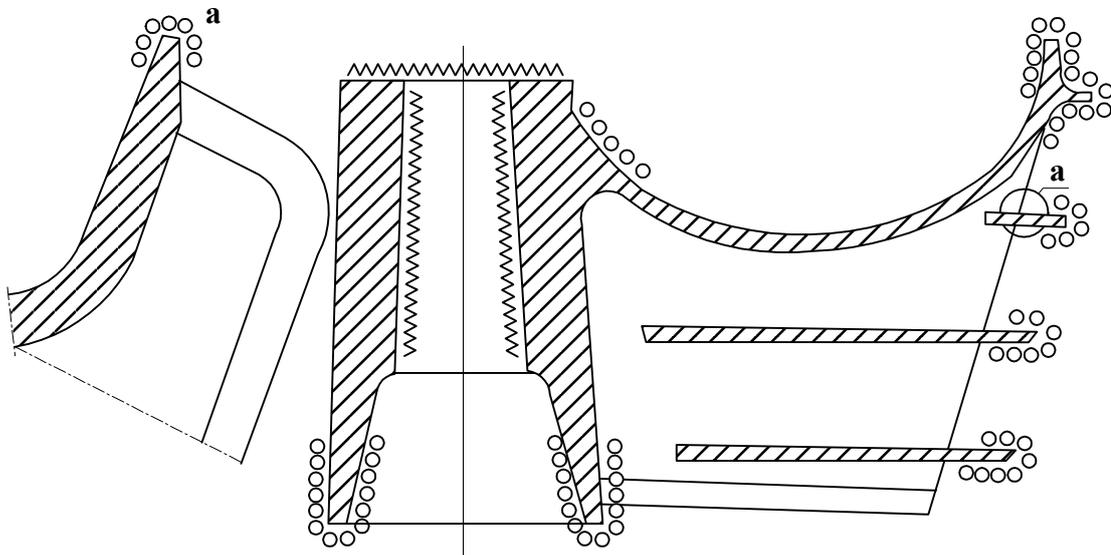


Notes:

Location of nondestructive examination:

- 1 All surfaces: Visual examination.
 Magnatic particle testing and Ultrasonic testing.
- 2 The detailed extents of examinations and quality levels are given in Sections 2-A6-2 and 2-A6-3.

FIGURE 3
Stern Boss

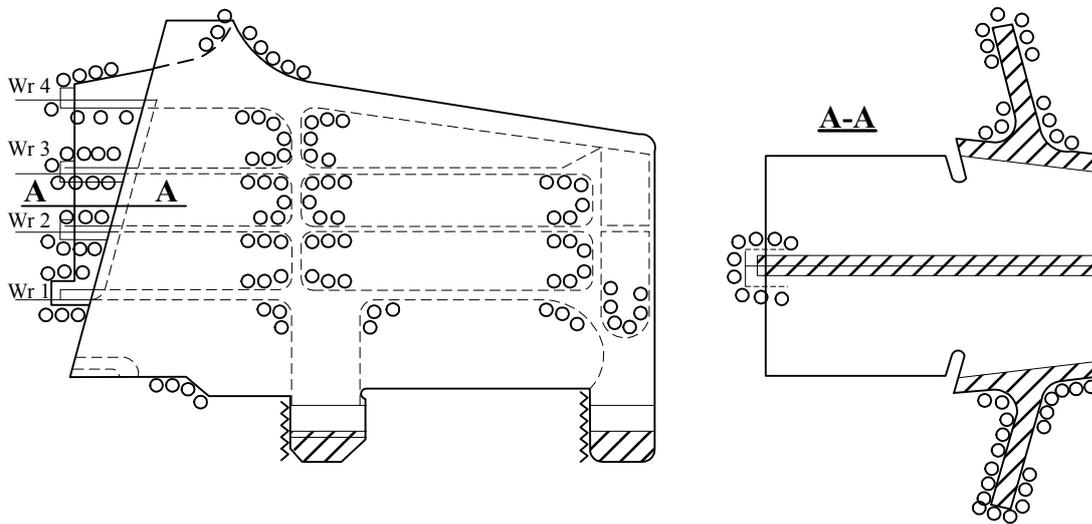


Notes:

Location of nondestructive examination:

- | | | |
|---|--|--|
| 1 | All surfaces: | Visual examination |
| 2 | Location indicated with (OOO): | Magnetic particle testing and Ultrasonic testing |
| 3 | Location indicated with (^^^): | Ultrasonic testing |
| 4 | The detailed extents of examinations and quality levels are given in Sections 2-A6-2 and 2-A6-3. | |

FIGURE 4
Rudder Hangings

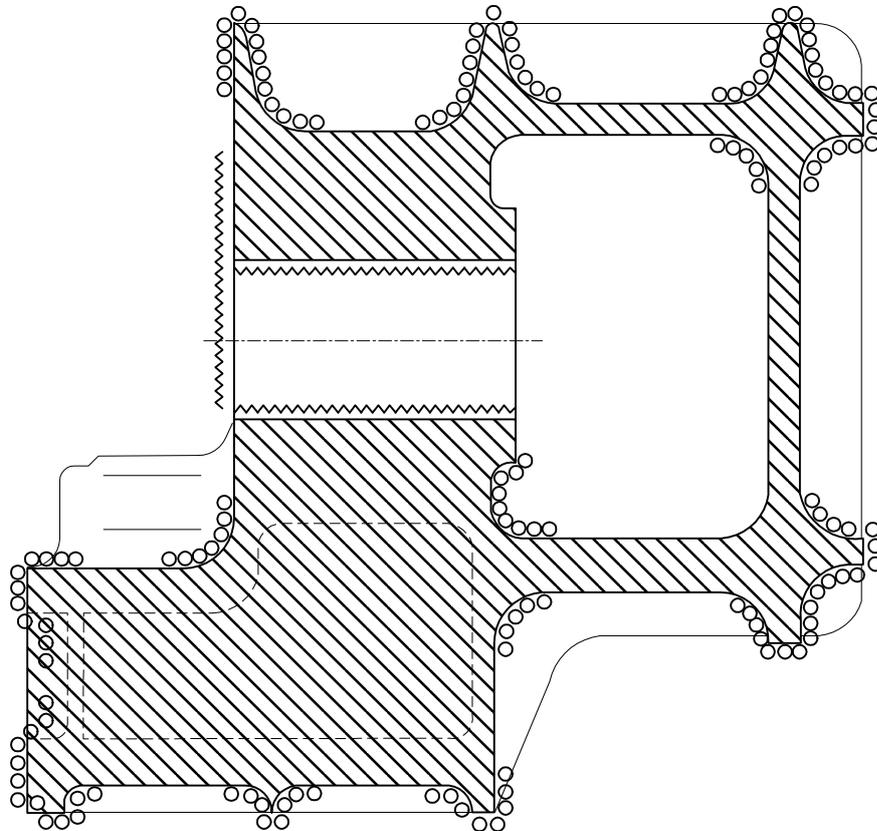


Notes:

Location of nondestructive examination:

- | | | |
|---|--|--|
| 1 | All surfaces: | Visual examination |
| 2 | Location indicated with (OOO): | Magnetic particle testing and Ultrasonic testing |
| 3 | Location indicated with (^^^): | Ultrasonic testing |
| 4 | The detailed extents of examinations and quality levels are given in Sections 2-A6-2 and 2-A6-3. | |

FIGURE 5
Rudder (Upper Part)

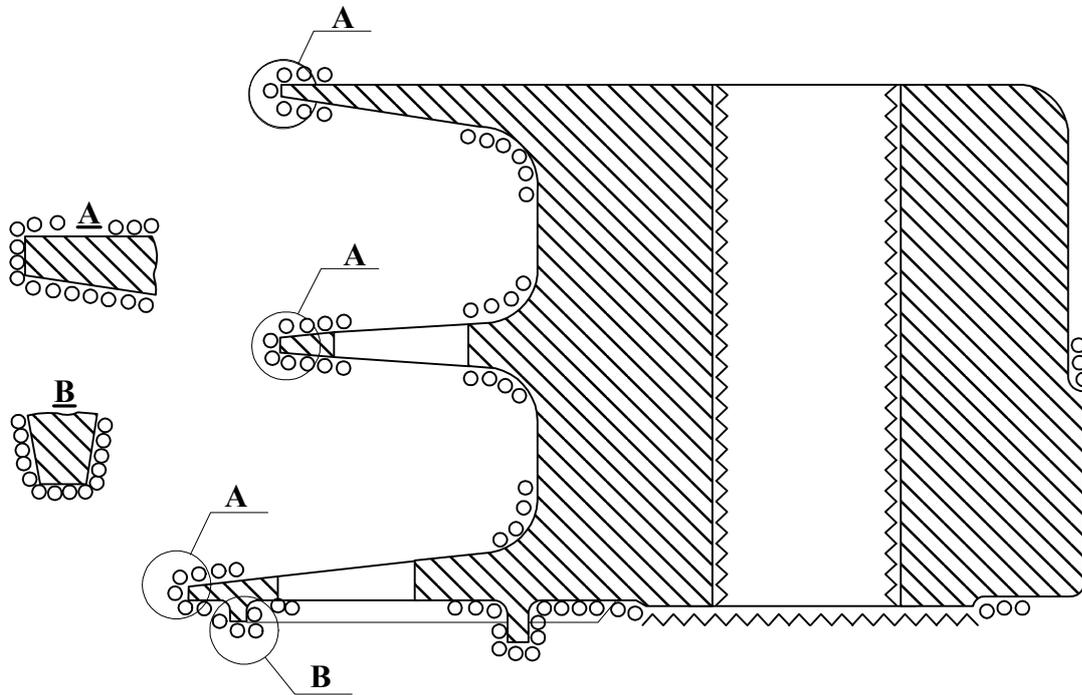


Notes:

Location of nondestructive examination:

- | | | |
|---|--|--|
| 1 | All surfaces: | Visual examination |
| 2 | Location indicated with (OOO): | Magnetic particle testing and Ultrasonic testing |
| 3 | Location indicated with (^^^): | Ultrasonic testing |
| 4 | The detailed extents of examinations and quality levels are given in Sections 2-A6-2 and 2-A6-3. | |

FIGURE 6
Rudder (Lower Part)



Notes:

Location of nondestructive examination:

- | | | |
|---|--|--|
| 1 | All surfaces: | Visual examination |
| 2 | Location indicated with (OOO): | Magnetic particle testing and Ultrasonic testing |
| 3 | Location indicated with (^^^): | Ultrasonic testing |
| 4 | The detailed extents of examinations and quality levels are given in Sections 2-A6-2 and 2-A6-3. | |

Rules for Testing and Certification of Materials**APPENDIX 7 Guide for Nondestructive Examination of Hull and Machinery Steel Forgings (2005)****CONTENTS**

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PART

2

APPENDIX **7** **Guide for Nondestructive Examination of Hull and Machinery Steel Forgings**

SECTION **1** **General**

Note: This Appendix incorporates the ABS *Guide for Nondestructive Examination of Marine Steel Castings*, which is effective as of 1 January 2005. The requirements in the Guide have been adopted from the IACS Recommendation No. 68. “Guidelines for Non-destructive Examination of Hull and Machinery Steel Forgings”. However, in order to be consistent with existing ABS publications, some specific text from the above referenced Guidelines has been modified.

1 **Scope**

1.1

This Guide complements the ABS requirements for “Hull and machinery steel forgings” and “Parts of internal combustion engines for which non-destructive tests are required”, and contains general guidance for the nondestructive examination methods, the extent of examination and the minimum recommended quality levels to be complied with unless otherwise approved or specified.

1.3

This document contains guidelines on “Surface Inspections” (Section 2-A7-2) by visual examination, magnetic particle testing and liquid penetrant testing and “Volumetric Inspection” (Section 2-A7-3) by ultrasonic testing.

1.5

For steel forgings (e.g., components for couplings, gears, boilers and pressure vessels) other than those specified in this Guide, the requirements in this Guide may apply correspondingly considering their materials, kinds, shapes and stress conditions being subjected.

1.7

Forgings should be examined in the final delivery condition. For specific requirements, see 2-A7-2/9.3 and 2-A7-3/7.3.

1.9

Where intermediate inspections have been performed, the manufacturer is to furnish a documentation of the results upon the request of the Surveyor.

1.11

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

PART

2

APPENDIX **7** **Guide for Nondestructive Examination of Hull and Machinery Steel Forgings**

SECTION **2** **Surface Inspection**

1 **General**

1.1

Surface inspections in this Guide are to be carried out by visual examination and magnetic particle testing or liquid penetrant testing.

1.3

The testing procedures, apparatus and conditions of magnetic particle testing and liquid penetrant testing are to comply with a recognized national or international standard.

1.5

Personnel engaged in visual examination are to have sufficient knowledge and experience. Personnel engaged in magnetic particle testing or liquid penetrant testing are to be qualified in accordance with the *ABS Guide for Nondestructive Inspection of Hull Welds*. The qualification is to be verified by certificates.

3 **Products**

3.1

The steel forgings intended for hull and machinery applications such as rudder stocks, pintles, propeller shafts, crankshafts, connecting rids, piston rods, gearing, etc. are to be subjected to a 100% visual examination by the Surveyor. For mass produced forgings the extent of examination is to be established at the discretion of the attending Surveyor.

3.3

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

- i)* Crankshafts with minimum crankpin diameter not less than 100 mm
- ii)* Propeller shafts, intermediate shafts, thrust shafts and rudder stocks with minimum diameter not less than 100 mm
- iii)* Connecting rods, piston rods and crosshead with minimum diameter not less than 75 mm or equivalent cross section
- iv)* Bolts with minimum diameter not less than 50 mm, which are subjected to dynamic stresses such as cylinder cover bolts, tie rods, crankpin bolts, main bearing bolts, propeller blade fastening bolts

5 Zones for Surface Inspections

Magnetic particle, or where permitted, liquid penetrant testing, is to be carried out in the zones I and II as indicated in 2-A7-2/Figures 1 to 4.

7 Surface Condition

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

9 Surface Inspection

9.1

Where indicated by Section 2, Figures 1 to 4, magnetic particle inspections are to be carried out with the following exceptions, when liquid penetrant testing will be permitted:

- Austenitic stainless steels
- Interpretation of open visual or magnetic particle indications
- At the instruction of the Surveyor

9.3

Unless otherwise specified in the order, the magnetic particle test is to be performed on a forging in the final machined surface condition and final thermally treated condition or within 0.3 mm of the final machined surface condition for AC techniques (0.8 mm for DC techniques).

9.5

Unless otherwise agreed, the surface inspection is to be carried out in the presence of the Surveyor. The surface inspection is to be carried out before the shrink fitting, where applicable.

9.7

For magnetic particle testing, attention is to 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 are not permitted on finished machined items.

9.9

When indications are detected as a result of the surface inspection, the acceptance or rejection is to be decided in accordance with 2-A7-2/11.

11 Acceptance Criteria and Rectification of Defects

11.1 Acceptance Criteria Visual Inspection

All forgings are to be free of cracks, crack-like indications, laps, seams, folds or other injurious indications. At the request of the Surveyor, additional magnetic particle, liquid penetrant and ultrasonic testing may be required for a more detailed evaluation of surface irregularities.

The bores of hollow propeller shafts are to be visually examined for imperfections uncovered by the machining operation. Machining marks are to be ground to a smooth profile.

11.3 Acceptance Criteria Magnetic Particle Testing and Liquid Penetrant Testing

11.3.1

The following definitions relevant to indications apply:

- *Linear indication.* An indication in which the length is at least three times the width.
- *Nonlinear indication.* An indication of circular or elliptical shape with a length less than three times the width.
- *Aligned indication.* Three or more indications in a line, separated by 2 mm or less edge-to-edge.
- *Open indication.* An indication visible after removal of the magnetic particles or that can be detected by the use of contrast dye penetrant.
- *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 contrast dye penetrant.
- *Relevant indication.* 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 are to be considered relevant.

11.3.2

For the purpose of evaluating indications, the surface is to be divided into reference areas of 225 cm². The area is to be taken in the most unfavorable location relative to the indication being evaluated.

11.3.3

The allowable number and size of indications in the reference area is given in 2-A7-2/Table 1 for crankshaft forgings and in 2-A7-2/Table 2 for other forgings, respectively. Cracks are not acceptable. Irrespective of the results of nondestructive examination, the Surveyor may reject the forging if the total number of indications is excessive.

TABLE 1
Crankshaft Forgings

Allowable Number and Size of Indications in a Reference Area of 225 cm²

<i>Inspection Zone</i>	<i>Max. Number of Indications</i>	<i>Type of Indication</i>	<i>Max. Number for Each Type</i>	<i>Max. Dimension (mm)</i>
I (Critical Fillet Area)	0	Linear	0	---
		Nonlinear	0	---
		Aligned	0	---
II (Important Fillet Area)	3	Linear	0	---
		Nonlinear	3	3.0
		Aligned	0	---
III (Journal Surfaces)	3	Linear	0	---
		Nonlinear	3	5.0
		Aligned	0	---

TABLE 2
Steel Forgings Excluding Crankshaft Forgings

Allowable Number and Size of Indications in a Reference Area of 225 cm²

<i>Inspection Zone</i>	<i>Max. Number of Indications</i>	<i>Type of Indication</i>	<i>Max. Number for Each Type</i>	<i>Max. Dimension (mm)</i>
I	3	Linear	0 ⁽¹⁾	---
		Nonlinear	3	3.0
		Aligned	0 ⁽¹⁾	---
II	10	Linear	3 ⁽¹⁾	3.0
		Nonlinear	7	5.0
		Aligned	3 ⁽¹⁾	3.0

Note:

- 1 Linear or aligned indications are not permitted on bolts, which receive a direct fluctuating load, e.g. main bearing bolts, connecting rod bolts, crosshead bearing bolts, cylinder cover bolts.

11.5 Rectification of Defects

11.5.1

Defects and unacceptable indications are to be rectified as indicated below and detailed in 2-A7-2/11.5.2 thru 2-A7-2/11.5.6.

11.5.1(a) Defective parts of material may be removed by grinding, or by chipping and grinding. All grooves are 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 the adjacent surface.

11.5.1(b) To depress is to flatten or relieve the edges of a non-open indication with a fine pointed abrasive stone with the restriction that the depth beneath the original surface is to be 0.08 mm minimum to 0.25 mm maximum and that the depressions be blended into the bearing surface. A depressed area is not considered a groove and is made only to prevent galling of bearings.

11.5.1(c) Non-open indications evaluated as segregation need not be rectified.

11.5.1(d) Complete removal of the defect is to be proved by magnetic particle testing or penetrant testing, as appropriate.

11.5.1(e) Repair welding is not permitted for crankshafts. Repair welding of other forgings is subjected to prior approval on a case-by-case basis.

11.5.2 Zone I in Crankshaft Forgings

Neither indications nor repair are permitted in this zone.

11.5.3 Zone II in Crankshaft Forgings

Indications are to be removed by grinding to a depth no greater than 1.5 mm. Indications detected in the journal bearing surfaces are to be removed by grinding to a depth no greater than 3.0 mm. The total ground area is to be less than 1% of the total bearing surface area concerned. Non-open indications, except those evaluated as segregation, are to be depressed but need not be removed.

11.5.4 Zone I in Other Forgings

Indications are to be removed by grinding to a depth no greater than 1.5 mm. However, grinding is not permitted in way of finished machined threads.

11.5.5 Zone II in Other Forgings

Indications are to be removed by grinding to a depth no greater than 2% of the diameter or 4.0 mm, whichever is smaller.

11.5.6 Zones Other than I and II in All Forgings

Defects detected by visual inspection are to be removed by grinding to a depth no greater than 5% of the diameter or 10 mm, whichever is smaller. The total ground area is to be less than 2% of the forging surface area.

13 Record

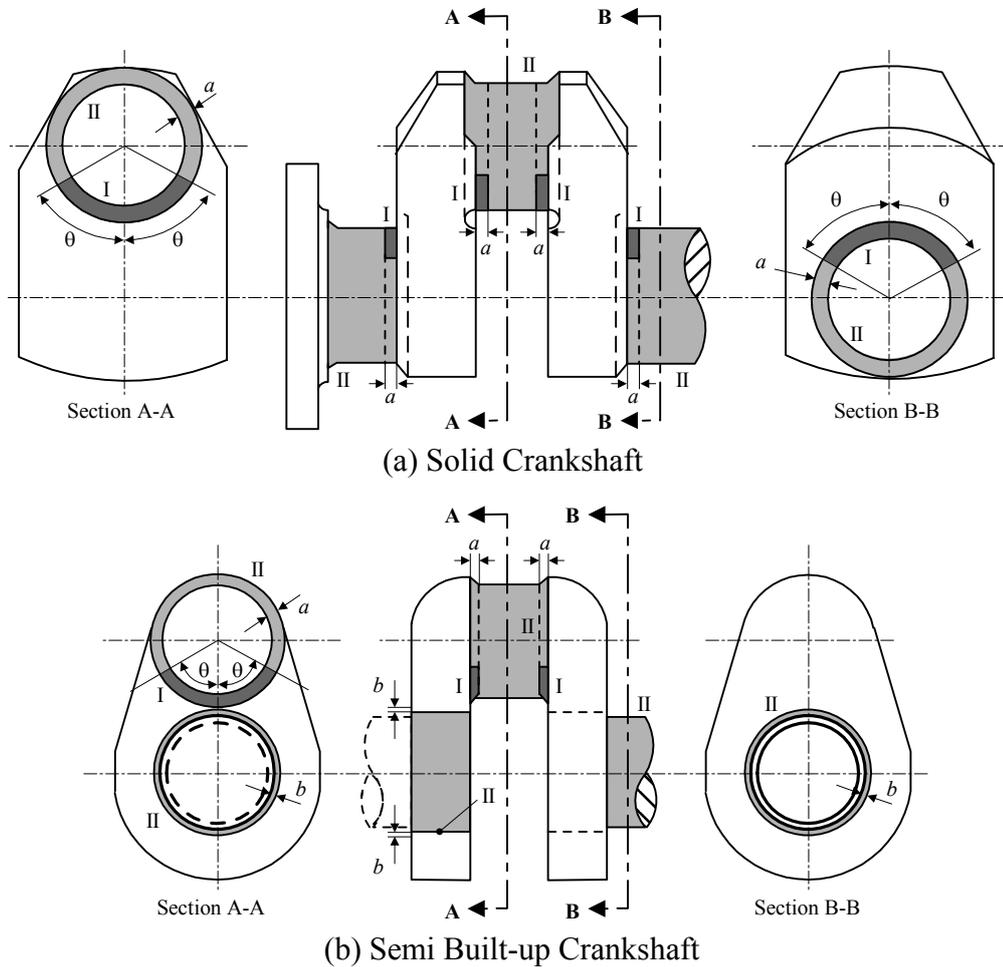
13.1

Test results of surface inspections are to be recorded at least with the following items:

- i) Date of testing
- ii) Names and qualification level of inspection personnel
- iii) Kind of testing method
 - For liquid penetrant testing: test media combination
 - For magnetic particle testing: method of magnetizing, test media and magnetic field strength
- iv) Kind of product
- v) Product number for identification
- vi) Grade of steel
- vii) Heat treatment
- viii) Stage of testing
- ix) Position (zone) of testing
- x) Surface condition

- xi)* Test standards used
- xii)* Testing condition
- xiii)* Results
- xiv)* Statement of acceptance/non acceptance
- xv)* Details of weld repair including sketch

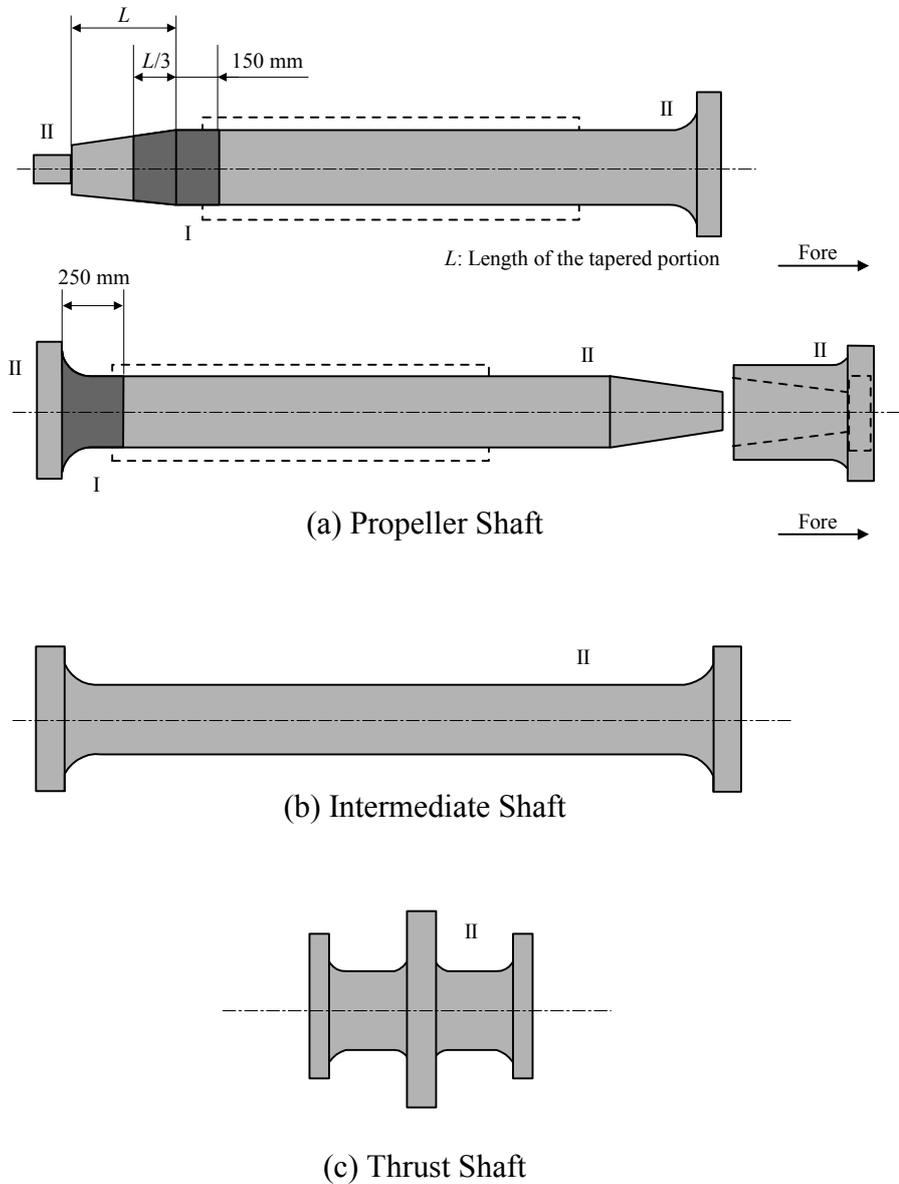
FIGURE 1
Zones for Magnetic Particle/Liquid Penetrant Testing
on Crankshafts



Notes

1	Where the crankpin or journal has oil holes, the circumferential surfaces of the oil holes are to be treated as Zone I. (See the figure in the right.)	<p>d_b: oil hole bore diameter</p>
2	In the above figures, “ θ ”, “ a ” and “ b ” mean: $\theta = 60^\circ$ $a = 1.5 r$ $b = 0.05 d$ (: circumferential surfaces of shrinkage fit) where r = fillet radius d = journal diameter	
3	Identification of the Zones (Similar in 2-A7-2/Figures 1 through 4): 	

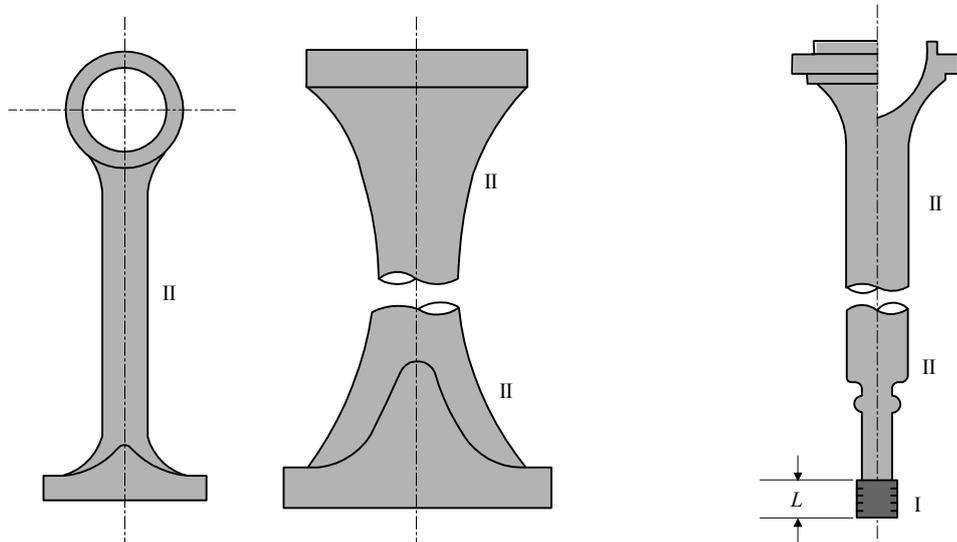
FIGURE 2
Zones for Magnetic Particle/Liquid Penetrant Testing on Shafts



Note

For propeller shaft, intermediate shafts and thrust shafts, all areas with stress raisers such as radial holes, slots and key ways are to be treated as Zone I.

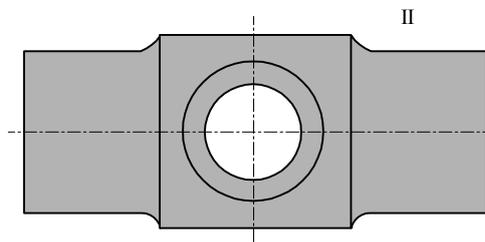
FIGURE 3
Zones for Magnetic Particle/Liquid Penetrant Testing
on Machinery Components



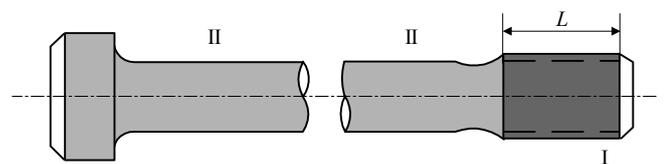
Note: Threads, holes and their circumstances are to be treated as Zone I

(a) Connecting Rod

(b) Piston Rod



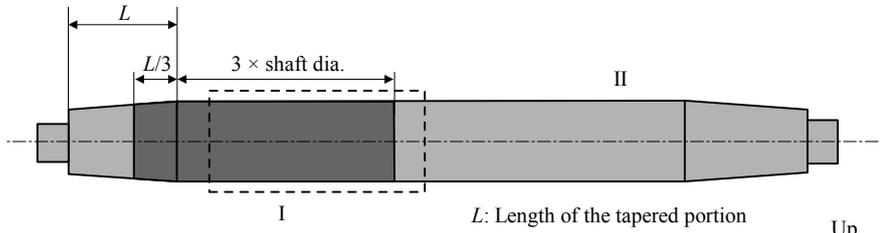
(c) Cross Head



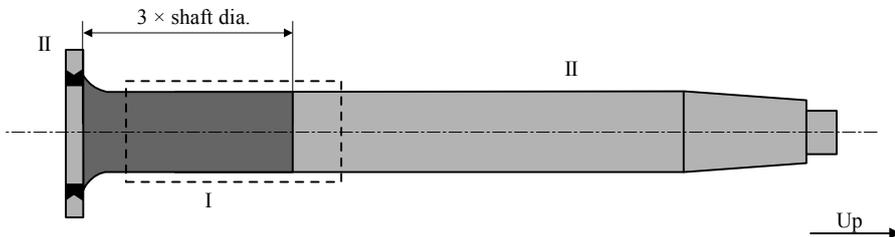
L: Length of thread

(d) Bolt

FIGURE 4
Zones for Magnetic Particle/Liquid Penetrant Testing
on Rudder Stocks

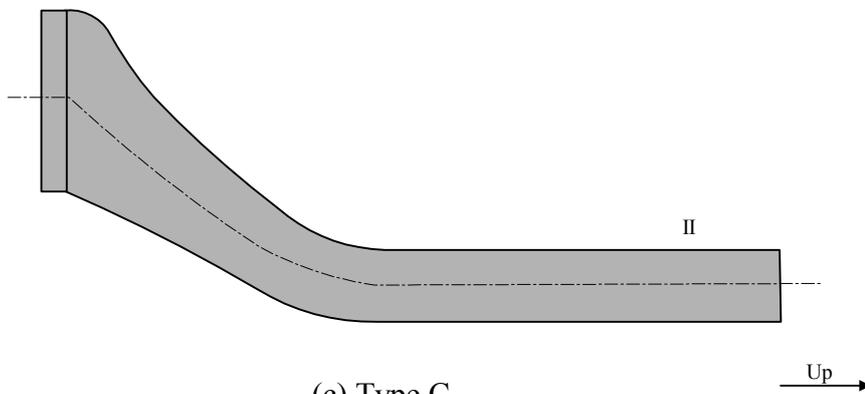


(a) Type A



Note: Welded areas are to be treated as Zone I

(b) Type B



(c) Type C

PART

2

APPENDIX **7** **Guide for Nondestructive Examination of Hull and Machinery Steel Forgings**

SECTION **3** **Volumetric Inspection**

1 **General**

1.1

Volumetric inspection in this Guide is to be carried out by ultrasonic testing using the contact method with straight beam and/or angle beam technique.

1.3

The testing procedures, apparatus and conditions of ultrasonic testing are to comply with the recognized national or international standards. Generally the DGS (distance-gain size) procedure is to be applied using straight beam probes and/or angle beam probes with 2 to 4 MHz and inspection should be carried out using a twin crystal 0o probe for near surface scans (25 mm) plus a 0° probe for the remaining volume. Fillet radii should be examined using 45°, 60° or 70° probes.

1.5

Personnel engaged in ultrasonic testing is to be qualified in accordance with the ABS *Guide for Nondestructive Inspection of Hull Welds*. The qualification is to be verified by certificates.

3 **Products**

3.1

Volumetric inspections by ultrasonic testing generally apply to the following steel forgings:

- i)* Crankshaft with minimum crankpin diameter not less than 150 mm
- ii)* Propeller shafts, intermediate shafts, thrust shafts and rudder stocks with minimum diameter not less than 200 mm
- iii)* Connecting rods, piston rods and crosshead with minimum diameter not less than 200 mm or equivalent cross section

5 Zones for Volumetric Inspection

Ultrasonic testing is to be carried out in the zones I to III as indicated in 2-A7-3/Figures 1 to 4. Areas may be upgraded to a higher zone at the discretion of the Surveyors.

7 Surface Condition

7.1

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

7.3

The ultrasonic testing is to 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 and prior to surface hardening. Black forgings are to be inspected after removal of the oxide scale by either flame descaling or shot blasting methods.

9 Acceptance Criteria

Acceptance criteria of volumetric inspection by ultrasonic testing are shown in 2-A7-3/Tables 1 and 2.

11 Record

Test results of volumetric inspection are to be recorded at least with the following items:

- i)* Date of testing
- ii)* Names and qualification level of inspection personnel
- iii)* Kind of testing method
- iv)* Kind of product
- v)* Product number for identification
- vi)* Grade of steel
- vii)* Heat treatment
- viii)* Stage of testing
- ix)* Position (zone) of testing
- x)* Surface condition
- xi)* Test standards used
- xii)* Testing condition
- xiii)* Results
- xiv)* Statement of acceptance/non acceptance

TABLE 1
Acceptance Criteria for Crankshafts

<i>Type of Forging</i>	<i>Zone</i>	<i>Allowable Disk Shape According to DGS⁽¹⁾</i>	<i>Allowable Length of Indication</i>	<i>Allowable Distance Between Two Indications⁽²⁾</i>
Crankshaft	I	$d \leq 0.5 \text{ mm}$	---	---
	II	$d \leq 2.0 \text{ mm}$	$\leq 10 \text{ mm}$	$\geq 20 \text{ mm}$
	II	$d \leq 4.0 \text{ mm}$	$\leq 15 \text{ mm}$	$\geq 20 \text{ mm}$

Notes:

- 1 DGS: distance-gain size
- 2 In case of accumulations of two or more isolated indications which are subjected to registration, the minimum distance between two neighboring indications is to be at least the length of the bigger indication.

This applies as well to the distance in axial direction as to the distance in depth. Isolated indications with less distances are to be determined as one single indication.

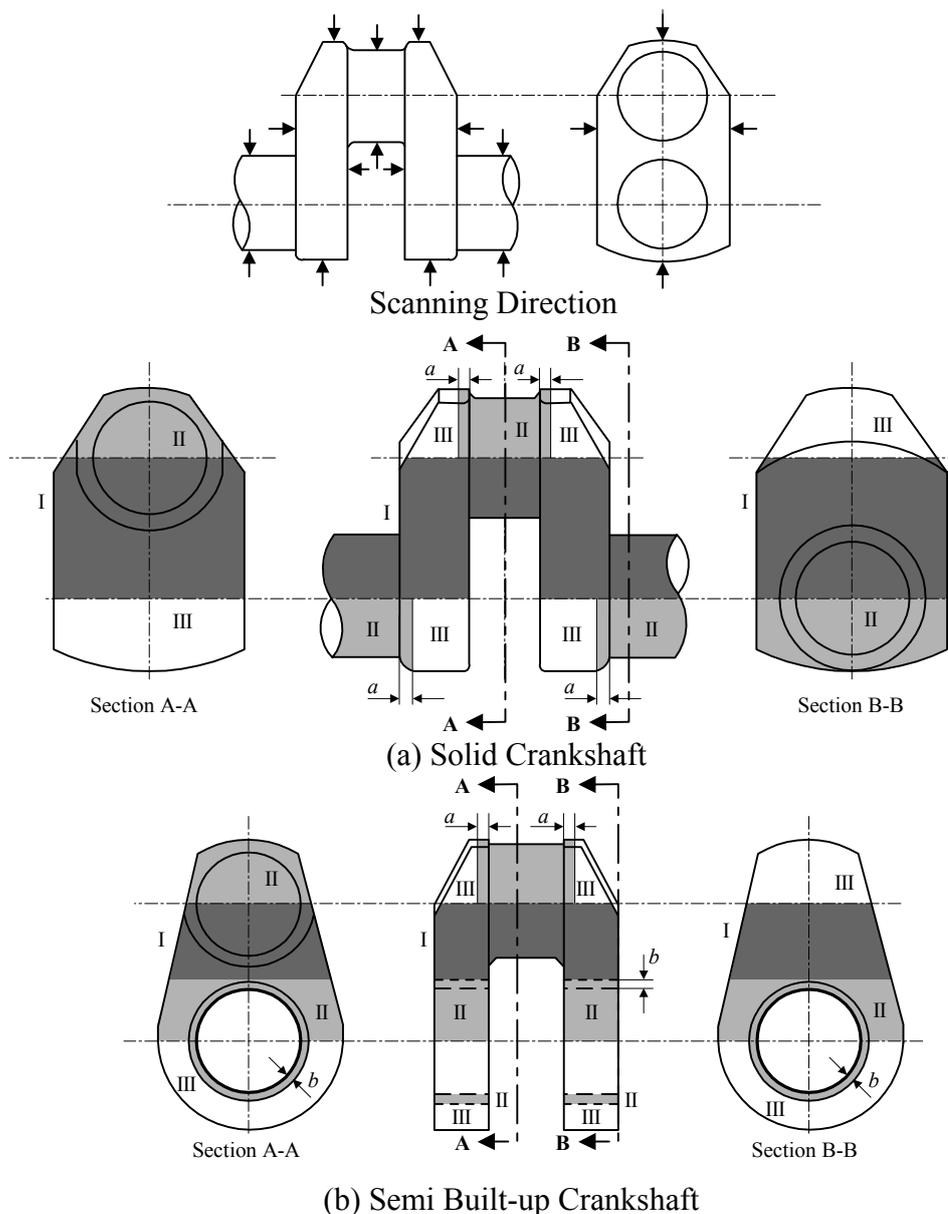
TABLE 2
Acceptance Criteria for Shafts and Machinery Components

<i>Type of Forging</i>	<i>Zone</i>	<i>Allowable Disk Shape According to DGS^(1,2)</i>	<i>Allowable Length of Indication</i>	<i>Allowable Distance Between Two Indications⁽³⁾</i>
Propeller Shaft	II	outer: $d \leq 2 \text{ mm}$	$\leq 10 \text{ mm}$	$\geq 20 \text{ mm}$
Intermediate Shaft		inner: $d \leq 4 \text{ mm}$	$\leq 15 \text{ mm}$	$\geq 20 \text{ mm}$
Thrust Shaft	III	outer: $d \leq 3 \text{ mm}$	$\leq 10 \text{ mm}$	$\geq 20 \text{ mm}$
Rudder Stock		inner: $d \leq 6 \text{ mm}$	$\leq 15 \text{ mm}$	$\geq 20 \text{ mm}$
Connecting Rod	II	$d \leq 2 \text{ mm}$	$\leq 10 \text{ mm}$	$\geq 20 \text{ mm}$
Piston Rod	III	$d \leq 4 \text{ mm}$	$\leq 10 \text{ mm}$	$\geq 20 \text{ mm}$
Crosshead				

Notes

- 1 DGS: distance-gain size
- 2 The “outer part” means the part beyond one third of the shaft radius from the center, the “inner part” means the remaining core area.
- 3 In case of accumulations of two or more isolated indications which are subjected to registration, the minimum distance between two neighboring indications is to be at least the length of the bigger indication.

FIGURE 1
Zones for Ultrasonic Testing on Crankshafts

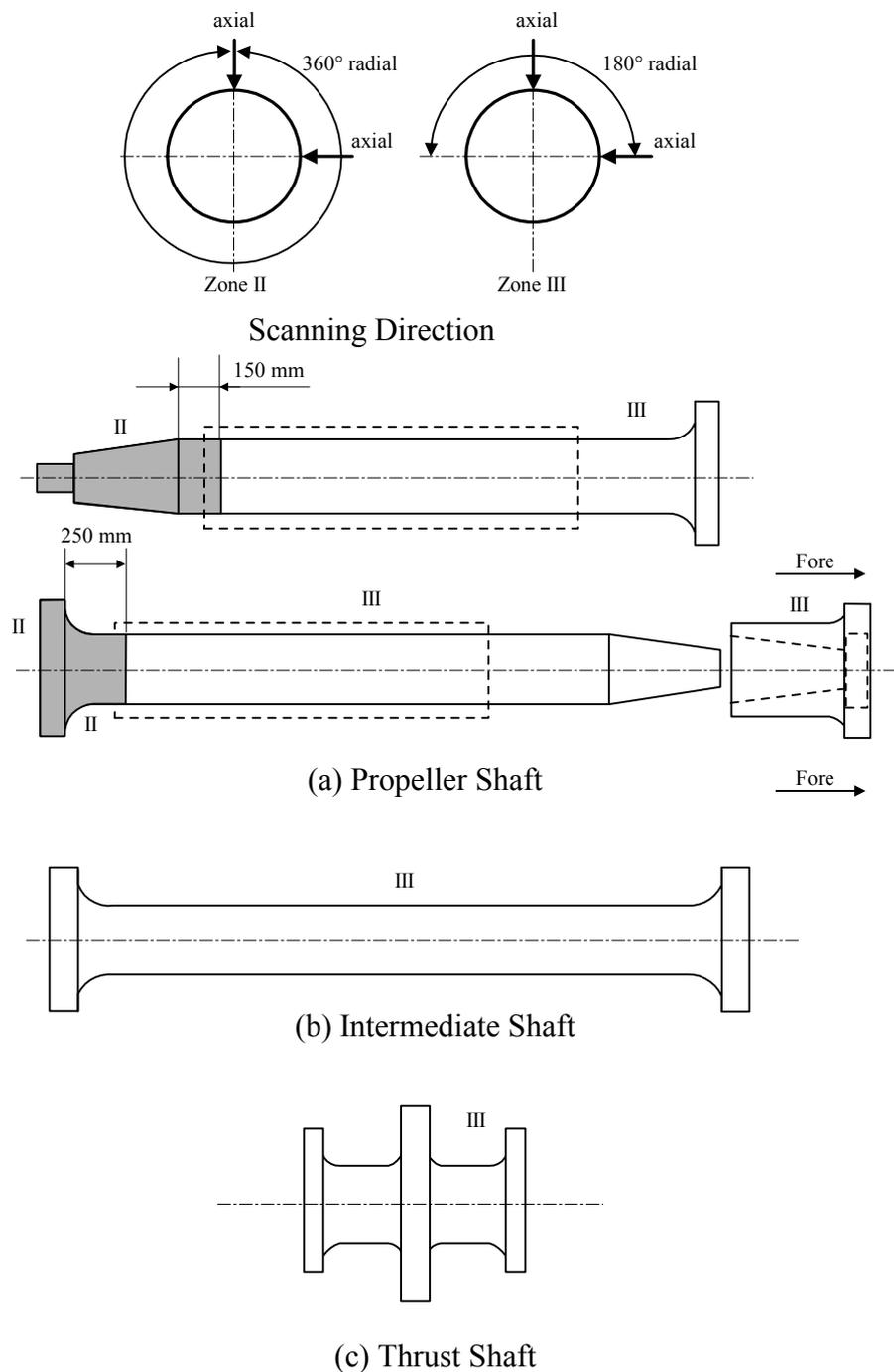


Notes

- 1 In the above figures, "a" and "b" mean:
 $a = 0.1d$ or 25 mm, whichever greater
 $b = 0.05d$ or 25 mm, whichever greater (: circumstances of shrinkage fit)
 where d = pin or journal diameter.
2. Core areas of crank pins and/or journals within a radius of $0.25d$ between the webs may generally be coordinated to Zone II.
- 3 Identification of the Zones (Similar in 2-A7-3/Figures 1 through 4):

- Zone I
- Zone II
- Zone III

FIGURE 2
Zones for Ultrasonic Testing on Shafts



Notes

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

FIGURE 3
Zones for Ultrasonic Testing on Machinery Components

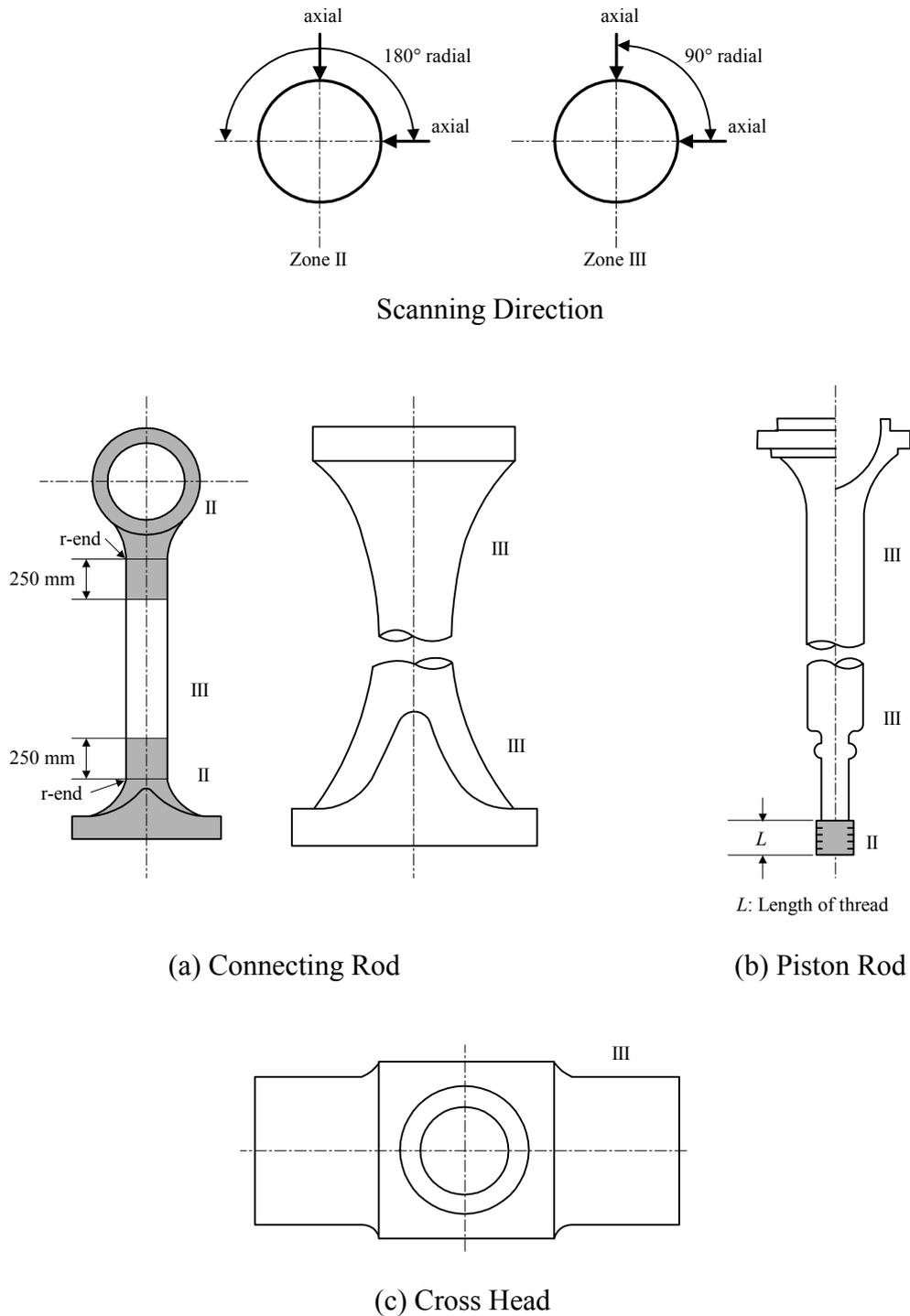
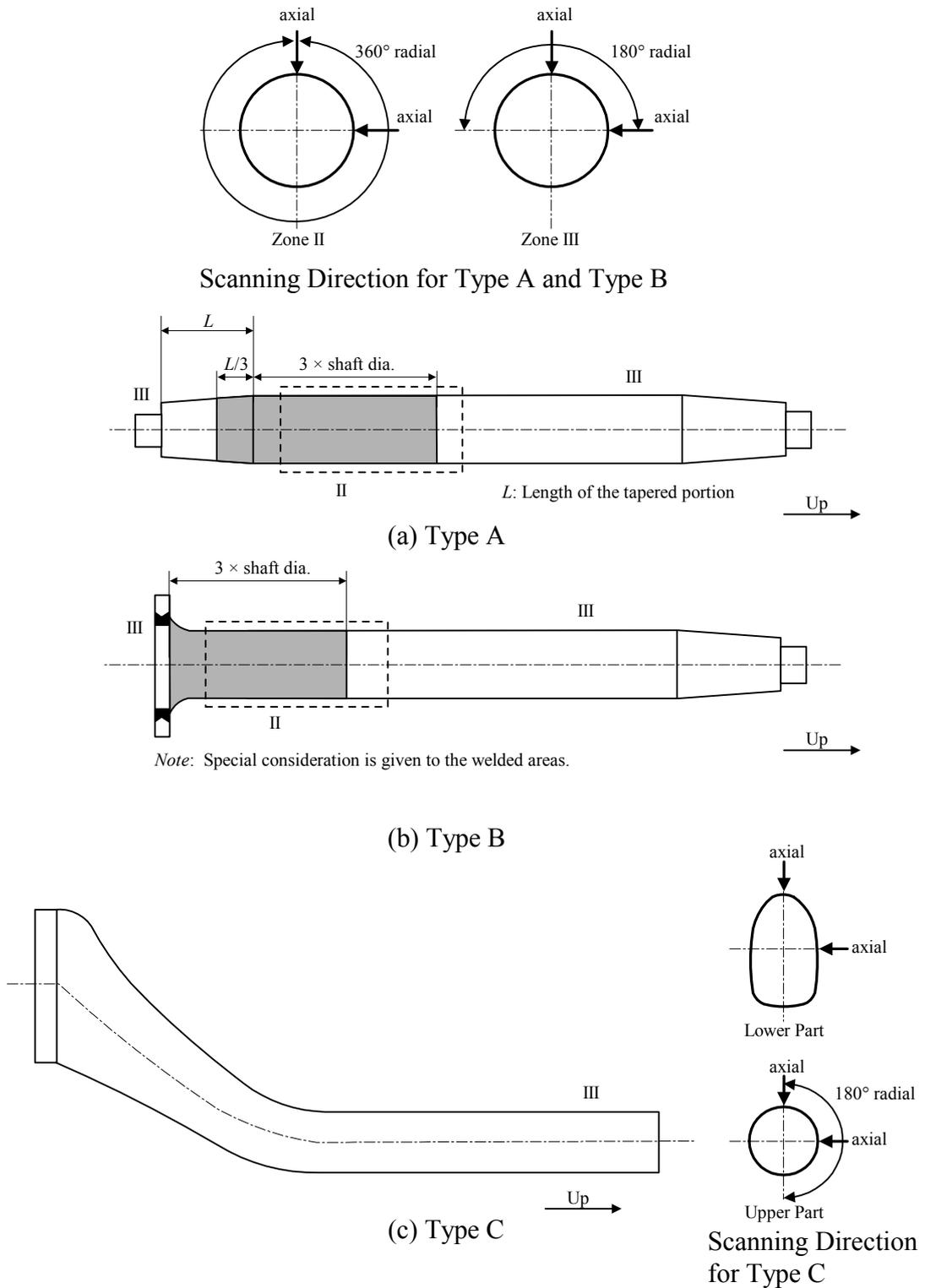


FIGURE 4
Zones for Ultrasonic Testing on Rudder Stocks



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