RUSSIAN MARITIME REGISTER OF SHIPPING

CIRCULAR LETTER **No. 314-04-1553c** dated 27.04.2021

Re:

amendments to the Rules for the Classification and Construction of Sea-Going Ships in connection with coming into force of IACS Unified Requirements (UR) W27 (Corr.1 Rev.1 July 2020) and W24 (Rev.4 July 2020)

Item(s) of supervision:

ships under construction

Entry-into-force date: ~~Valid till:~~ ~~Validity period extended till:~~
01.07.2021

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

Number of pages: 1 + 24

Appendices:

Appendix 1: information on amendments introduced by the Circular Letter

Appendix 2: text of amendments to Part XIII "Materials"

Director General Konstantin G. Palnikov

Text of CL:

We hereby inform that, after their re-publication, the Rules for the Classification and Construction of Sea-Going Ships shall be amended at re-publication in 2021 as specified in the Appendices to the Circular Letter.

It is necessary to do the following:

1. Bring the content of the Circular Letter to the notice of the RS surveyors, as well as interested organizations and persons in the area of the RS Branch Offices' activity.
2. Apply the provisions of the Circular Letter during review and approval of the technical documentation on ships contracted for construction or conversion on or after 01.07.2021, in the absence of a contract, the keels of which are laid or which are at a similar stage of construction on or after 01.07.2021, as well as during review and approval of the technical documentation on ships, the delivery of which is on or after 01.07.2021.

List of the amended and/or introduced paras/chapters/sections:

Part XIII: Chapters 3.12 and 4.2

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Appendix 1 to Circular Letter
No. 314-04-1553c dated 27.04.2021

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

Nos.	Amended paras/chapters/sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
1	Chapter 3.12	Chapter has been revised considering IACS UR W27 (Corr.1 Rev.1 July 2020)	314-04-1553c of 27.04.2021	01.07.2021
2	Chapter 4.2	Chapter has been revised considering IACS UR W24 (Rev.4 July 2020)	314-04-1553c of 27.04.2021	01.07.2021

RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS, 2020,

ND No. 2-020101-124-E

PART XIII. MATERIALS

3 STEEL AND CAST IRON

1 **Chapter 3.12** is replaced by the following text:

"3.12 STEEL CASTINGS FOR PROPELLERS

3.12.1 General.

3.12.1.1 These requirements apply to inspection and repair procedures of steel castings for propellers, blades and bosses (hubs) during their manufacture.

These requirements may also be used for the repair of propellers damaged in service, subject to prior agreement with the Register.

The use of steel that is different in chemical composition, mechanical properties or heat treatment for propellers is permitted according to standards, specifications or other technical requirements recognized by the Register.

3.12.1.2 Propeller castings and their components (blades and bosses) shall be manufactured by the works recognized by the Register in accordance with 1.1.4 and 1.3.2. The manufacturing specification, description of the foundry facilities, specifications for material, the description of a technological process, repair and inspection shall be submitted to the Register at the time of approval. Castings supplied under the Register technical supervision shall be manufactured and tested in accordance with the requirements of this Chapter.

3.12.1.3 Recognizing the works, tests are conducted in accordance with 1.3.1.2 on the basis of the survey and tests program approved by the Register. The tests shall confirm the compliance of the chemical composition and the mechanical properties of castings material and their quality with these requirements. The scope of the approval test shall be agreed with the Register.

3.12.1.4 A foundry shall have an adequately equipped laboratory manned by experienced qualified personnel. The laboratory shall have at its disposal everything necessary for the performance of non-destructive testing. However, if the laboratory is unable to conduct tests and inspection, the data on an independent laboratory shall be submitted to the Register. The laboratory shall be recognized by the competent national body and/or Register.

3.12.1.5 Where the use of alternative alloys other than specified in this Chapter is proposed, particulars of chemical composition, mechanical properties and heat treatment shall be submitted to the Register for approval.

3.12.1.6 It is the manufacturer's responsibility to assure that effective quality, process and production controls during manufacturing are adhered to within the manufacturing specification.

3.12.2 Chemical composition.

The chemical composition of the steel for propellers shall meet the requirements of Table 3.12.2. The alloys in Table are subdivided into four main groups. Manufacture and application of steel castings for propellers whose chemical composition deviate from the typical values of the Chapter shall be specially approved by the Register.

Table 3.12.2

Chemical composition of steel castings for propellers[1]

Steel grade and type	C, max, %	Mn, max, %	Cr, %	Mo, max, %	Ni, %
Martensitic (12Cr1Ni)	0,15	2,0	11,5 — 17,0	0,5	≤ 2,0
Martensitic (13Cr4Ni)	0,06	2,0	11,5 — 17,0	1,0	3,5 — 5,0
Martensitic (16Cr5Ni)	0,06	2,0	15,0 — 17,5	1,5	3,5 — 6,0
Austenitic (19Cr11Ni)	0,12	1,6	16,0 — 21,0	4,0	8,0 — 13,0
[1] The minimum elements content not specified in Table shall meet the requirements of agreed national or international standards.					

The manufacturer shall maintain records of the chemical analyses of the production casts, which shall be made available to the RS surveyor so that they can satisfy themselves that the chemical composition of each casting is within the specified limits.

3.12.3 Mechanical properties and heat treatment.

3.12.3.1 The mechanical properties of steel during the testing of specimens prepared from samples cast-on to the boss or blade shall meet the requirements of Table 3.12.3.1. The thickness of test coupon shall be in accordance with agreed standards.

Table 3.12.3.1

Mechanical properties of steel castings for propellers

Steel grade and type	Yield stress $R_{p0,2}$, min, MPa	Tensile strength R_m, min, MPa	Elongation A_5, min, %	Reduction of area Z, min, %	Impact test[1] *KV*, min, J
Martensitic (12Cr1Ni)	440	590	15	30	20
Martensitic (13Cr4Ni)	550	750	15	35	30
Martensitic (16Cr5Ni)	540	760	15	35	30
Austenitic (19Cr5Ni)	180 ($R_{p1,0}$ 205)	440	30	40	–
[1] The impact test is not required for ice class ships of **Ice1**, **Ice2** and **Ice3**; for all other ice class ships and for icebreakers, steel castings shall be impact-tested at –10 °C.					

3.12.3.2 The level of mechanical properties of the separately cast samples metal is subject to the approval by the Register.

3.12.3.3 Heat treatment.

Castings of martensitic class steel shall be subjected to austenization and tempering. Austenitic class steels shall be subjected to solution treatment.

3.12.4 Sampling.

3.12.4.1 Samples may be taken immediately from a casting or gated to it. Test specimens, where possible, are taken from the cast-on sample in the area within 0,5*R* to 0,6*R* (where *R* is a propeller radius). The use of separately cast samples for machine specimens shall be specified in the approved documentation.

3.12.4.2 Separately cast samples shall be taken from the same ladle as the casting as the metal presented and heat treated in the same furnace charge.

In the initial survey of works in accordance with 3.12.1.2, tests may be conducted in the metal of both separately cast and cast-on samples or taken directly from a casting body.

3.12.4.3 Samples shall not be taken from a casting prior to a final heat treatment. Samples are prepared in accordance with the standards recognized by the Register.

3.12.4.4 Thermal methods shall not be used for sampling.

3.12.5 Scope of testing.

3.12.5.1 At least one tensile test specimen (refer to Table 2.2.2.3) and one set of impact test specimens (refer to 2.2.3) shall be taken from each cast presented. In tensile tests, the tensile strength, proof stress, elongation and reduction in area are determined. Test are conducted in compliance with the requirements of 2.2.

3.12.5.2 Test specimens shall generally be cut out from cast-on samples. If castings are roughly of the same size, less than 1 m in diameter made from metal of one cast and heat treated

in one furnace charge, one set of specimens for each 5 castings may be taken from separately cast samples of the relevant dimensions.

3.12.6 Severity zones (repair zones).

3.12.6.1 In order to define the criteria of assessment for propeller defects and to help reduce the risk of failure by fatigue cracking after repair, the blade surface is divided into three zones designated *A*, *B* and *C* (refer to Figs. 4.2.6.2-1 and 4.2.6.3). The definitions of repair zones are given in 4.2.6.2 and 4.2.6.3.

3.12.6.2 The definition of a skew angle — refer to 4.2.6.1 (Note) and Fig. 4.2.6.1.

3.12.7 Inspection.

3.12.7.1 Propeller castings shall be visually tested and measured by the manufacture at all the stages of their manufacture. The castings shall be subjected to a thorough 100 % visual testing in the finished condition. A general visual examination shall be carried out by the RS surveyor. A surface shall be free from the defects, which may result in propeller damages during operation. The Register representative can demand the performance of investigation of questionable surface sections including metal etching, particularly prior to repair welding.

Casting defects which may impair the serviceability of the castings, e.g. major non-metallic inclusions, shrinkage cavities, blow holes and cracks, are not permitted. They may be removed by one of the methods described in 3.12.9 and repaired within the limits and restrictions for the severity zones. Full description and documentation shall be available for the Register representative before commencement of works.

Minor casting defects which may still be visible after machining such as small sand and slag inclusions, small cold shuts and scabs shall be trimmed off by the manufacturer in accordance with 3.12.9.

3.12.7.2 The verification of dimensions, the dimensional and geometrical tolerances is the responsibility of the manufacturer. The report on the relevant examinations shall be submitted to the Register. At that, the Register may require the examination to be made in the presence of the RS surveyor.

In accordance with the requirements of the Register-approved documentation, all propellers shall be subjected to static balancing. Dynamic balancing is required for propellers running with a rotational speed of over 500 rpm.

3.12.8 Non-destructive testing.

Special requirements for testing laboratories carrying out penetrant testing (PT), ultrasonic testing (UT) and magnetic particle (MT) testing are specified in 10.3, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

3.12.8.1 All the castings of propellers shall be subjected to non-destructive testing. A manufacturer shall have available an appropriate system to record all the non-destructive testing results for each casting. The Register representative shall be familiarized with that system and the results of the testing carried out. The manufacturer duty shall confirm in the documentary form the true performance and the positive results of non-destructive testing methods.

3.12.8.2 Penetrant and magnetic particle testing.

3.12.8.2.1 Liquid penetrant testing procedure shall be submitted to the Register and shall meet the requirements of ISO 3452-1:2013 or an RS-agreed standard. The acceptance criteria are specified in 3.12.8.2.3. For all propellers, cast blades and bosses, the surfaces covered by severity zones *A*, *B* and *C* shall be liquid penetrant tested. Testing of zone *A* shall be undertaken in the presence of the RS surveyor, whilst testing of zone *B* and *C* may be witnessed by the RS surveyor upon request of the Register.

If repairs have been made either by grinding or by welding, the repaired areas shall additionally be subjected to the liquid penetrant testing independent of their location. Weld repairs shall, independent of repair location, always be assessed according to zone *A*.

3.12.8.2.2 Magnetic particle method may be applied instead of penetrant testing when testing martensitic steels.

Magnetic particle testing procedure shall comply with ISO 9934-1:2016 or the agreed standard. The procedure shall be submitted to the Register for approval.

3.12.8.2.3 Acceptance criteria for liquid penetrant testing and magnetic particle testing.

3.12.8.2.3.1 Definitions of liquid penetrant testing:

I n d i c a t i o n is the presence of detectable bleed-out of the penetrant liquid from the material discontinuities appearing at least 10 min after the developer has been applied.

Relevant indication is indication which has any dimension greater than 1,5 mm when categorization of indications is performed.

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

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

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

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

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

Illustration of liquid penetrant indications is given in Fig. 3.12.8.2.3.1.

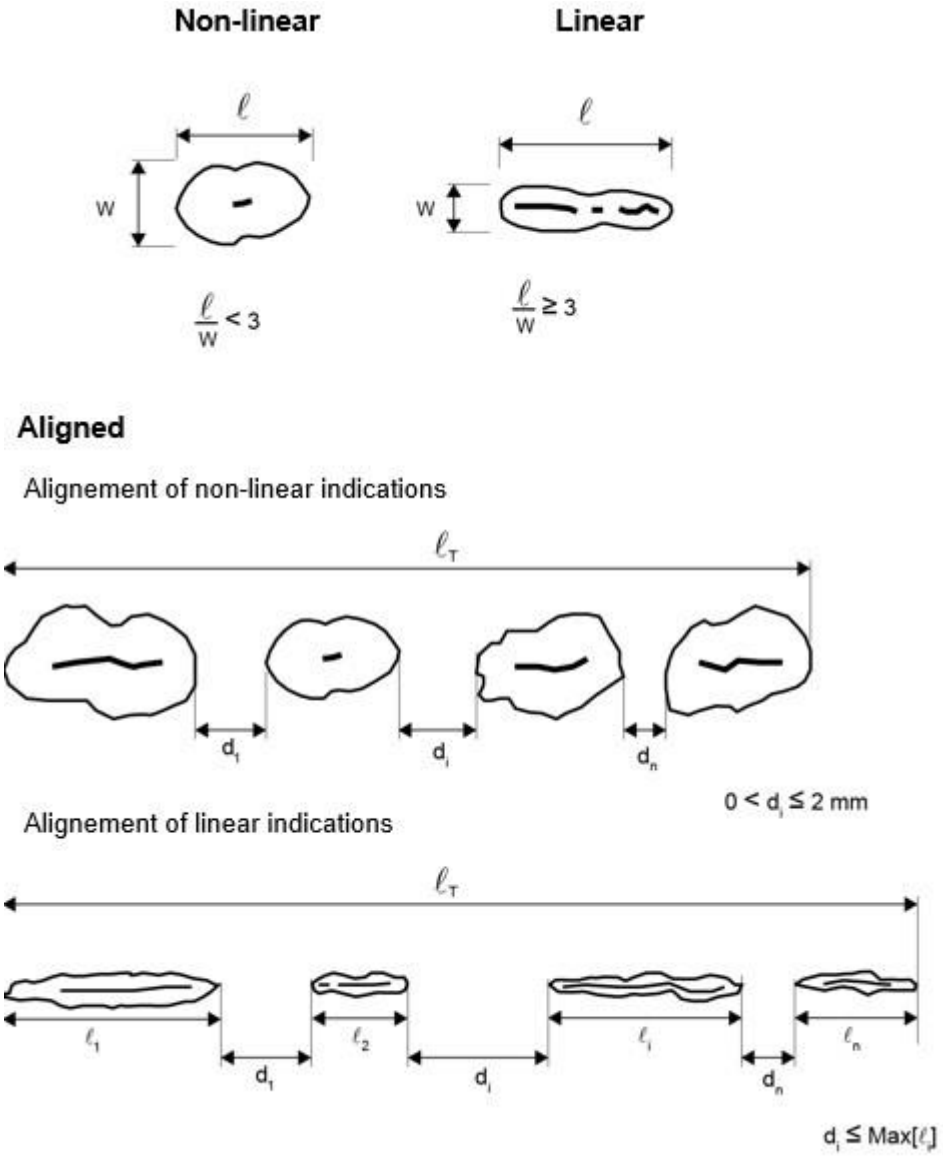

Fig. 3.12.8.2.3.1

3.12.8.2.3.2 Acceptance criteria.

Reference area is of 100 cm^2 and may have square or rectangular shape with the major dimension not exceeding 250 mm. In evaluation of surface quality by penetrant testing, the entire controlled surface is conventionally divided in reference areas of 100 cm^2 each. Segmentation shall be the most unfavourable in relation to indications, i.e. the shape and dimensions of each reference area shall be chosen so that it covers the maximum number of defects without their distribution among adjacent reference areas.

The relevant indications, with respect to their shape, dimensions and number, shall meet the requirements of Table 3.12.8.2.3.2-1.

Table 3.12.8.2.3.2-1

Allowable number and size of indications depending on severity zone

Severity zone	Total number of indications, max	Indication type	Number of indications of each type, max	Indication size, mm, max
A	7	non-linear	5	4
		linear	2	3
		aligned	2	3
B	14	non-linear	10	6
		linear	4	
		aligned	4	
C	20	non-linear	14	8
		linear	6	6
		aligned	6	6

Notes: 1. Singular non-linear indications less than 2 mm in zone *A* and less than 3 mm in other zones may be disregarded.

2. The total number of non-linear indications may be increased to the total allowable number of all type indications, represented by the absence of linear or aligned indications.

3.12.8.3 Radiographic and ultrasonic testing.

When required by the Register or when deemed necessary by the manufacturer, further non-destructive testing (e.g. radiographic and/or ultrasonic testing) shall be carried out. The evaluation and acceptance criteria shall be agreed between the manufacturer, the customer and the Register and shall meet the requirements of standards agreed by the Register.

Ultrasonic testing may not be practical in some cases, depending on the shape, type and thickness, as well as grain-growth direction of the casting, negatively impacting absorption of ultrasound.

3.12.9 Repair of defects.

3.12.9.1 Surface discontinuities, which impair propellers performance, shall be repaired by mechanical methods, e.g. by grinding, chipping and milling. Complete elimination of the defective material shall be verified by liquid penetrant testing or magnetic particle testing. The use of welding to repair defects is allowed only in justified cases to be agreed with the Register representative.

The repair of defects shall be carried out after producing the documentation with the full description of works to be conducted, to the Register representative. The relevant repair zones, dimensions and location of defects, methods of their repair and inspection shall be specified.

After milling or chipping, grinding shall be applied for such defects, which shall not be welded. The grinding shall be carried out in such a manner that the contour of the ground depression is as smooth as possible to avoid stress concentration and/or minimize cavitation corrosion. The metal for welding shall be properly selected and shall have the shape and dimensions needed for welding. The welding of areas less than 5 cm^2 shall be avoided.

3.12.9.2 Repair of defects in zone *A*.

In zone *A*, repair welding is not allowed. Grinding in zone *A* may be carried out to the extent, which maintains the blade thickness of the drawing approved by the Register. The possible repair of defects by methods not specified here shall be approved as part of the submitted documentation.

In some cases, the propeller designer may submit technical documentation to propose a modified zone *A* based on the technical documentation submitted to the Register for review. The documentation shall contain detailed hydrodynamic load and stress analysis in the propeller.

3.12.9.3 Repair of defects in zone *B*.

The defects that are not deeper than $dB = t/40$ (t = minimum local thickness) or 2 mm (whichever is greater) may be removed by grinding. The defects, which are deeper than allowable for removal by grinding, may be repaired by welding.

3.12.9.4 Repair of defects in zone *C*.

In zone *C*, repair welds are generally permitted.

3.12.9.5 Repair welding.

3.12.9.5.1 General provisions and documentation.

The welding procedure and welding consumables used for defects repair shall be recognized by the Register in accordance with the requirements of Part XIV "Welding".

The manufacturer shall maintain records of defects based on which any scope of repair, heat treatment type and mode may be traced for each casting. Full details on casting subject to survey by the Register shall be submitted to the RS surveyor.

Prior to the beginning of works on the repair of defects by welding, the detailed specification of a welding procedure, which shall include data on the welding position, welding process parameters, welding consumables, preheating, follow-up heat treatment and inspection of welding operations conducted shall be submitted to the Register for approval.

3.12.9.5.2 Welding repair procedure.

3.12.9.5.2.1 The approval of a welding procedure is carried out in accordance with the requirements of Section 6, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships following the Register-approved program.

Defects shall be repaired in accordance with the approved welding procedures and by welders qualified to an agreed standard. Welding Procedure Qualification Tests shall be carried out under technical supervision of the RS surveyor and shall meet the requirements of 3.12.9.5.3.

Defects to be repaired by welding shall be ground to sound material.

The welding grooves shall be prepared in such a manner which will allow a good fusion of the groove bottom.

The resulting ground areas shall be examined in the presence of the RS surveyor by liquid penetrant testing. The results shall demonstrate the complete elimination of defective material.

3.12.9.5.2.2 Welding shall be done under controlled conditions free from draughts and adverse weather.

3.12.9.5.2.3 Metal arc welding with electrodes or filler wire used in the procedure tests shall be used. The welding consumables shall be stored and handled in accordance with the manufacturer's recommendations.

3.12.9.5.2.4 Slag, undercuts and other defects shall be removed before depositing the next run.

3.12.9.5.2.5 The martensitic steels shall be furnace re-tempered after weld repair. Methods of local stress relieving for minor repairs shall be agreed as part of the repair documentation.

3.12.9.5.2.6 On completion of heat treatment the weld repairs and adjacent material shall be ground smooth. All weld repairs shall be liquid penetrant tested.

3.12.9.5.3 Welding procedure qualification test for repair.

3.12.9.5.3.1 General.

Requirements for qualification tests of welding procedures intended for the repair of cast steel propellers are specified below.

For the welding procedure approval, the welding procedure qualification tests shall be carried out with satisfactory results.

The qualification tests shall be carried out with the same welding process, filler metal, preheating and stress-relieving treatment as those intended applied by the actual repair work. Welding procedure specification (WSP) shall refer to (or contain) the test results achieved during welding procedure qualification testing.

Welding procedures approved by the Register for the specified manufacturer may be applied for all workshops under the same repair procedure and quality management system.

3.12.9.5.3.2 Welding of samples.

The approval of a welding procedure shall be based on the welding of samples consisting of cast samples with size sufficient to ensure a reasonable heat distribution. Minimum sample dimensions shall comply with Fig. 3.12.9.5.3.2-1.

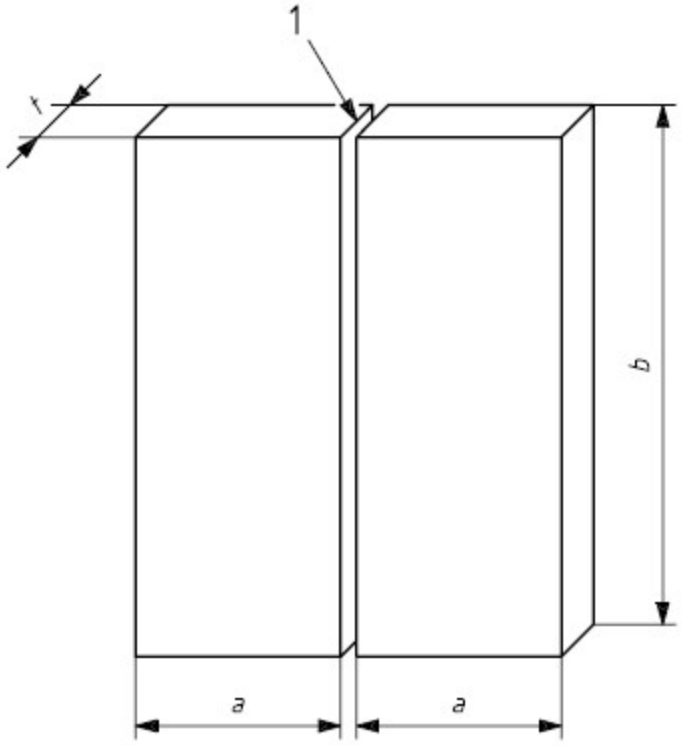

Fig. 4.2.8.5.1-1
1 — joint preparation and fit-up as detailed in the preliminary welding procedure specification;
a — minimum width of the sample 150 mm;
b — minimum length of the sample 350 mm;
t — sample thickness.

The dimensions, shape of the groove, preparation and welding of test pieces shall be carried out in accordance with the general condition of the firm's repair welding work which shall be presented to the RS surveyor upon request.

Welding of the test assemblies and testing of test specimens shall be witnessed by the RS surveyor.

3.12.9.5.3.3 Examination and tests of the welded joint.

Test assembly received from sample shall be examined in accordance with Table 3.12.9.5.3.3-1. Specimen cutout procedure is given on the Fig. 3.12.9.5.3.3-1.

Table 3.12.9.5.3.3-1

Type of tests and extent of testing

Type of test	**Extent of testing**
Visual testing	100 % in accordance with 3.12.9.5.3.4
Liquid penetrant testing[1]	100 % in accordance with 3.12.9.5.3.4
Transverse tensile test	Two specimens in accordance with 3.12.9.5.3.5
Bend test	Two root and two face specimens in accordance with 3.12.9.5.3.6[2]
Macro examination	Three specimens in accordance with 3.12.9.5.3.7
Impact test	Two sets of specimens in accordance with 3.12.9.5.3.8
Hardness test	In accordance with 3.12.9.5.3.9
[1] Magnetic particle testing may be used in lieu of liquid penetrant testing for martensitic stainless steels. [2] For samples with *t* ≥12mm, the face and root bend may be substituted by 4 side bend test specimens.	

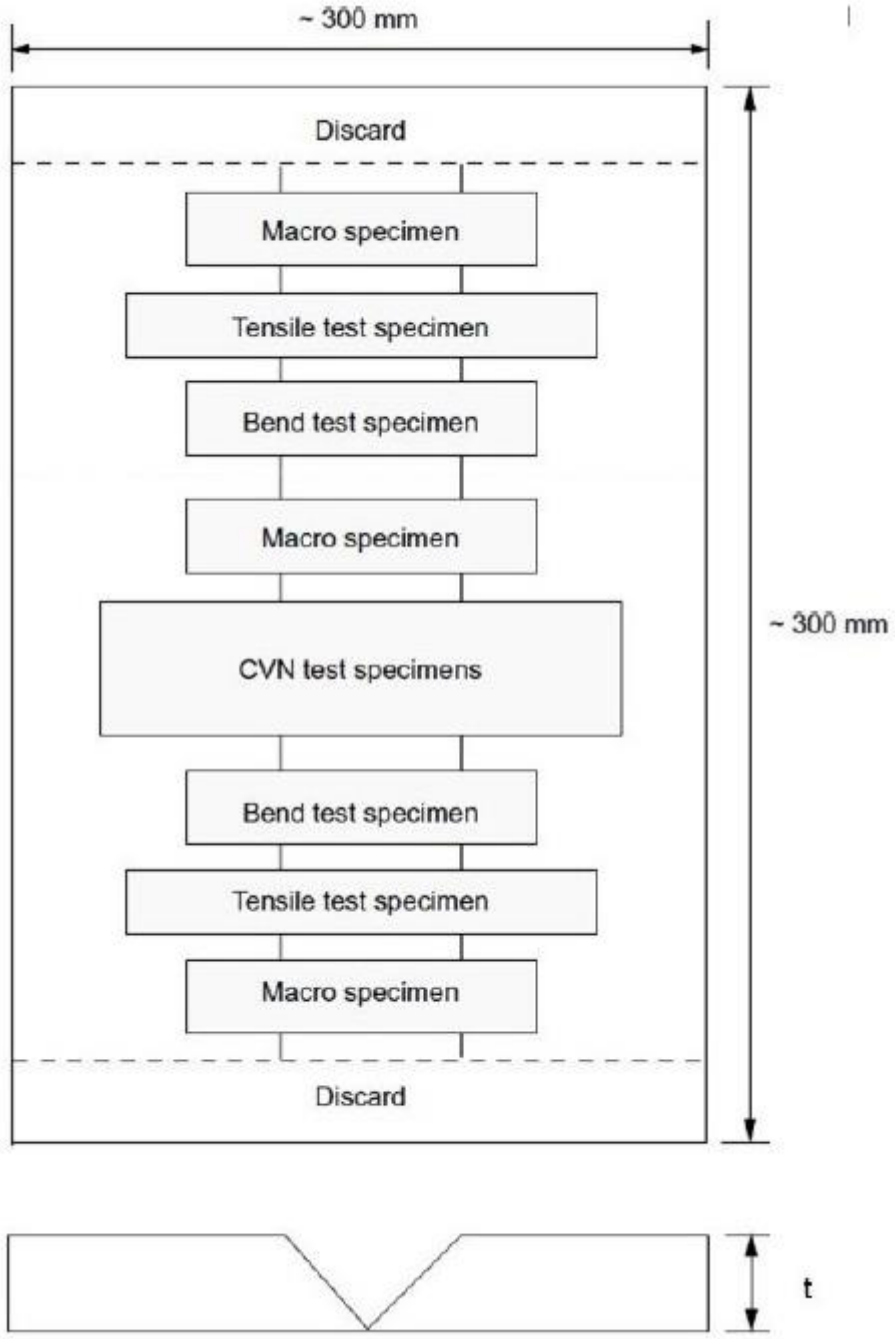

Fig. 3.12.9.5.3.3-1

3.12.9.5.3.3.1 Examination and non-destructive testing.

Test assembly shall be examined by visual and liquid penetrant testing or magnetic particle testing after welding and prior to the cutting of test specimen. In case, that any post-weld heat treatment is required or specified, non-destructive testing shall be performed after heat treatment.

No cracks are permitted. Procedure for detection of imperfections by liquid penetrant testing or magnetic particle testing is specified in 3.12.8.2.3.

3.12.9.5.3.3.2 Tensile testing.

Tests are carried out on two transverse specimens, which thickness in equal to that of a sample, the width is 30 mm and the parallel test length is equal to the weld width plus 6 mm to each side (refer to 4.2.3.2.2, Part XIV "Welding"). Alternatively, tensile test specimens manufactured in accordance with the agreed standards may be used. Mechanical properties shall meet those required for the base metal.

The fracture area, weld metal, heat-affected zone or base metal shall be in a test report.

3.12.9.5.3.3.3 Bend testing.

The tests are conducted on two transverse specimens from root and from its opposite surface of butt joint (4 samples in total) made in accordance with the requirements of 2.2.5.1. The test is

conducted on a mandrel four thickness in diameter except for austenitic steels, in which case the mandrel diameter shall be equal to three thicknesses.

The bending angle shall be 180°. After the tests, the specimen surface shall be free from tension fractures and cracks of more than 3 mm long. Defects appearing at the corners of a test specimen during testing shall be investigated separately.

For thickness 12 mm and over, four side bend specimens may alternatively be tested.

3.12.9.5.3.3.4 Macro examination.

Macro examination is carried out on two macro-sections etched on one side to clearly reveal the weld metal, the fusion line, and the heat affected zone. Cracks, pores, slag inclusions and other imperfections greater than 3 mm are not permitted.

3.12.9.5.3.3.5 Impact testing.

The tests are required for cases when a base metal was subjected to these tests. Where necessary, impact tests are conducted on specimens made in accordance with 2.2.3 and Fig. 2.2.3.1-2.

The tests shall be conducted on one set of specimens notched in the weld centre and on another one notched in the HAZ (i.e. the mid-point of the notch shall be at 1 mm to 2 mm from the fusion line to the base metal).

The temperature and results of the tests shall meet those required for the base metal.

3.12.9.5.3.3.6 Hardness testing

The macro-section representing the start of welding shall be used for Vickers hardness testing (HV 10). Indentations shall traverse 2 mm below the surface. Three measurements each are, as a minimum, made on the weld metal, heat-affected zone, at both sides of a weld and in the base metal. The measurements shall be presented for information in a test report.

3.12.9.5.3.3.7 Re-testing.

In case of unsatisfactory results of the above-mentioned tests, repeat testing may be conducted in accordance with 6.5, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

3.12.9.5.3.4 Test records.

3.12.9.5.3.4.1 Welding conditions for test assemblies and test and examination results shall be recorded in welding procedure qualification records. Welding Procedure Approval Test Certificate (form 7.1.33, pages 3 — 9) or other specification regulated by the relevant standards may be used as a record form.

3.12.9.5.3.4.2 A statement of the results of assessing each test piece, including repeat tests, shall be made for each welding procedure qualification records. The relevant items listed for the WPS shall be included in the test report.

3.12.9.5.3.4.3 The welding procedure qualification records shall be signed and stamped by the RS surveyor attending the tests.

3.12.9.5.3.5 Range of approval.

3.12.9.5.3.5.1 General.

Requirements specified in 3.12.9.5.3.5 shall be fulfilled independently of each other.

Welding procedure approved by the Register for the specified manufacturer may be applied for all workshops having the same repair procedure and quality management system.

3.12.9.5.3.5.2 Base metal.

Range of approval of welding procedure is limited to steel grade tested.

3.12.9.5.3.5.3 Thickness.

The qualification of a WPS carried out on a weld assembly of thickness *t* is valid for the thickness range given in accordance with Table 3.12.9.5.3.5.3-1.

Table 3.12.9.5.3.5.3-1

Range of qualification for thickness

Thickness of the test piece, *t* (mm)	**Range of approval**
$15 < t \leq 30$	3 mm to 2*t*
$30 < t$	0,5*t* to 2*t*, or 200 mm, whichever is greater

3.12.9.5.3.5.4 Welding process parameters.

Approval for a test made in any position is restricted to that position.

The approval is only valid for the welding process used in the welding procedure test. Single run test results are not valid for multi-run butt weld test applied in accordance with this Chapter.

The approval is only valid for the filler metal used when taking the sample specimens.

The upper limit of heat input approved is 15 % greater than that used in welding the test piece. At that, the lower limit of heat input approved shall be 15 % lower than that used in welding the test piece.

The approved minimum preheating temperature shall not be less than that obtained when taking the test piece.

The approved maximum interpass temperature shall not be higher than that obtained in welding the test piece.

The heat treatment used for test pieces shall be specified in WPS. Holding time at a specified temperature may be adjusted as a function of thickness.

3.12.10 Identification and marking.

3.12.10.1 Identification.

The manufacturer shall adopt a system for the identification of all castings enabling the material to be traced to its original cast. The RS surveyor shall be given full facilities for so tracing the castings in accordance with the applied system, when required.

3.12.10.2 Marking.

A casting shall be properly marked prior to its presentation in the finished condition to the Register representative. In addition to specified in 1.4, the marking shall include the following data:

casting number and other designations allowing tracing all the stages of manufacture;

grade of cast material or corresponding abbreviated designation;

number of the Register Certificate;

skew angle (for high-skew propellers);

ice class symbol, where applicable;

date of casting acceptance.

The Register stamp shall be put on following the final survey and the acceptance of a casting.

3.12.10.3 Manufacturer's Certificate.

The Manufacturer's Certificate for a casting shall be submitted to the Register representative simultaneously with the presentation of the casting in the finished condition or in good time. The Certificate shall be verified by the quality service of a works and witnessed by the person authorized for this by the works. The Certificate shall contain the following data:

manufacturer's name and order number;

shipbuilding project number, if known;

description of the casting with drawing number;

propeller diameter, number of blades, pitch and directions of turning;

final weight;

grade and type of alloy, number of a cast and chemical composition;

identification number;

heat treatment schedule;

results of mechanical tests;

result of non-destructive testing and details of test procedure, when applicable.

3.12.10.4 The Register Certificate.

Each casting or the batch of small castings shall be accompanied with the Register Certificate. In addition to the special number, the requisites of the Register representation or location, the place and date of issue, the Register Certificate is, as a minimum, to contain the following data:

manufacturer's name and order number;

shipbuilding project number, if known;

number of the certificate of quality of the casting manufacturer;

final weight;

identification number and casting number;

drawing number.

The Manufacturer's Certificate shall be the mandatory appendix to the Register Certificate. Test protocols witnessed by the Register representative may also be part of the appendix to the Register Certificate on the purchaser's demand.".

2 **Chapter 4.2** is replaced by the following text:

"4.2 PROPELLER CASTINGS

4.2.1 General.

4.2.1.1 The present requirements apply to the manufacture, inspection and repair procedures of new cast copper alloy propellers, blades and bosses (hubs).

The present requirements may also be used for the repair of propellers damaged in service, subject to prior agreement with the Register.

4.2.1.2 All propellers and their components shall be cast by foundries approved by the Register in compliance with 1.3.1.2. At the time of approval specifications of the propeller materials, manufacturing procedures, repair, non-destructive testing and a description of the foundry facilities, including the maximum capacity of the ladles shall be submitted to the Register. The castings supplied under the Register technical supervision shall be manufactured and tested in accordance with the requirements of this Chapter.

4.2.1.3 The approval tests shall be carried out in compliance with 1.3.5 under the program approved by the Register. The purpose of the tests shall verify that the castings and their quality, including chemical composition and mechanical properties, comply with these requirements.

4.2.1.4 The foundry shall have an adequately equipped laboratory, manned by experienced personnel, for the testing of moulding materials, chemical analyses, mechanical testing, microstructural testing of metallic materials and non-destructive testing. Where testing activities are assigned to other laboratory, such laboratory shall be recognized by an authorized national body and/or Register.

4.2.1.5 The pouring shall be carried out into dried moulds using degassed liquid metal. The pouring shall be controlled as to avoid turbulences of flow. Special devices and/or procedures shall prevent slag flowing into the mould.

4.2.1.6 Subsequent stress relieving heat treatment may be performed to reduce the residual stresses. For this purpose, the manufacturer shall submit a specification containing the details of the heat treatment to the Register for approval (refer to Tables 4.2.8.5.1-1 and 4.2.8.5.1-2).

4.2.1.7 Where the use of alloys alternative to those specified in this Chapter is proposed, particulars of chemical composition, mechanical properties and heat treatment shall be submitted to the Register for approval.

4.2.1.8 It is the manufacturer's responsibility to assure that effective quality, process and production controls during manufacturing are adhered to.

4.2.2 Chemical composition and metallurgical characteristics

The chemical composition of typical copper-base alloys for propellers shall comply with the requirements of Table 4.2.2.

Table 4.2.2

Alloy type	Cu	Al	Mn	Zn	Fe	Ni	Sn	Pb
CU1	52 — 62	0,5 — 3,0	0,5 — 4,0	35 — 40	0,5 — 2,5	max 1,0	max 1,5	max 0,5
CU2	50 — 57	0,5 — 2,0	1,0 — 4,0	33 — 38	0,5 — 2,5	3,0 — 8,0	max 1,5	max 0,5
CU3	77 — 82	7,0 — 11,0	0,5 — 4,0	max 1,0	2,0 — 6,0	3,0 — 6,0	max 0,1	max 0,03
CU4	70 — 80	6,5 — 9,0	8,0 — 20,0	max 6,0	2,0 — 5,0	1,5 — 3,0	max 1,0	max 0,05
Note. Chemical composition shall be determined for the metal of each ladle.								

Note. The main constituents of the microstructure in the copper-base alloys types CU1 and CU2 are alpha and beta phase.

Important properties such as ductility and resistance to corrosion fatigue are strongly influenced by the relative proportion of beta phase (too high percentage of beta phase having a negative effect on these properties). To ensure adequate cold ductility and corrosion fatigue resistance, the proportion of beta phase shall be kept low. The concept of the zinc equivalent shall be used as control since it summarizes the effect of the tendency of various chemical elements to produce beta phase in the structure.

The manufacturer shall maintain records of the chemical analyses of the production casts, which shall be made available to the RS surveyor.

The structure CU1 and CU2 type alloys shall contain an alpha phase component of at least 25 %. The content of alpha phase shall be measured by the manufacturer. The zinc equivalent defined by the following formula shall not exceed a value of 45 %:

zinc equivalent (%) = $100 - \frac{100\,\%\,\mathrm{Cu}}{100+A}$, %,

where $A = \%Sn + 5 \times \%al - 0.5 \times \%Mn - 0.1 \times \%Fe - 2.3 \times \%Ni$

The negative sign in front of the elements Mn, Fe and Ni signifies that these elements tend to reduce the proportion of beta phase.

The micro structure of alloy types CU1 and CU2 shall be verified by determining the proportion of alpha phase. For this purpose, at least one specimen shall be taken from each heat. The proportion of alpha phase shall be determined as the average value of 5 counts.

4.2.3 Mechanical properties.

Mechanical properties of standardized alloys as applied to test specimens taken from separately cast samples shall comply with Table 4.2.3.

Table 4.2.3

Mechanical properties of copper-base alloys for propellers (separately cast samples)

Alloy type	Yield stress $R_{p0,2}$, min, MPa	Tensile strength R_m, min, MPa	Elongation A_5, min, %
CU1	175	440	20
CU2	175	440	20
CU3	245	590	16
CU4	275	630	18

These properties are a measure of the mechanical quality of each heat; and they are generally not representative of the mechanical properties of the propeller casting itself, which may be up to 30 % lower than that of separately cast samples.

The requirements for mechanical properties of cast-on specimens or those cut out from the casting are specified in accordance with the approved documentation.

Copper alloys with mechanical characteristics different from those given in Table 4.2.3 may be allowed only after their approval by the Register in compliance with 1.3.2.

4.2.4 Sampling.

Separately cast samples for determining the mechanical properties of propeller alloys shall be taken from each ladle and shall have the dimensions as shown in Fig. 4.2.4. Samples may be prepared in accordance with the standards approved by the Register. For the purpose of approval of a foundry the tests indicated in Table 4.2.1.3 may be carried out on separately cast samples and specimens of cast-on metal or casting metal.

4.2.5 Tensile tests and specimens.

Out of each sample at least one cylindrical specimen is machined to undergo the tensile test (refer to Table 2.2.2.3). The tensile strength, proof stress and elongation shall be determined by tensile test.

Generally, the specimens shall be taken from separately cast samples (refer to 4.2.4). The samples shall be cast in moulds made of the same material as the mould for propeller. They shall be cooled down under the same conditions as the propeller. If propellers are subjected to a heat treatment the samples shall be heat treated together with them.

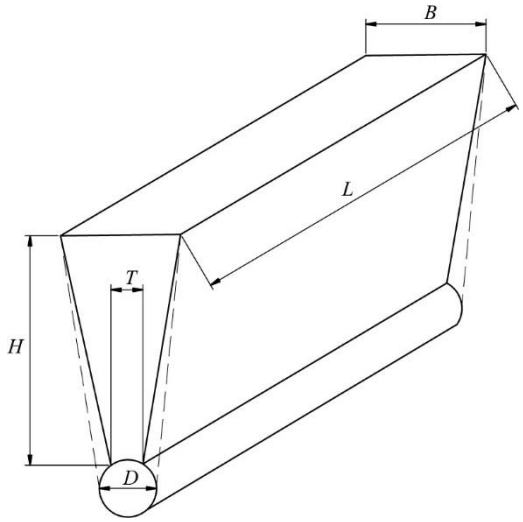

Fig. 4.2.4
Separately cast sample with dimensions in mm: H = 100, B =50, L > 150, T = 15, D = 25

Where use of cast-on samples specimens is approved by the Register, they shall, wherever possible, be located on the blades in an area lying between 0,5R and 0,6R, where R is the radius of the propeller. The sample material shall be removed from the casting by non-thermal procedures, for CU1 and CU2 type alloys the proportion of alpha phase is additionally determined. For this purpose, at least one specimen shall be taken from each cast. The proportion of alpha phase shall be determined as the average value of 5 counts. The requirements of 4.2.2.1 shall also be complied with.

4.2.6 Severity zones (repair zones).

4.2.6.1 In order to relate the degree of inspection to the criticality of defects in propeller blades and to help reduce the risk of failure by fatigue cracking after repair, propeller blades are divided into the three severity zones designated *A*, *B* and *C* (refer to Figs. 4.2.6.2-1 and 4.2.6.3).

N o t e . Propellers are divided into high skew propellers, i.e. propellers with a skew angle greater than 25°, and low skew propellers with a skew angle of up to 25°.

The skew of the propeller is defined as the angle, in projected view of the blade, between a line drawn through the blade tip and the shaft centreline and a second line through the shaft centreline, which acts as a tangent to the locus of the mid-points of the helical blade section (refer to Fig. 4.2.6.1).

4.2.6.2 Severity zones for low-skew propeller blades.

Z o n e *A* is in the area on the pressure side of the blade, from and including the fillet to 0,4R, and bounded on either side by lines at a distance 0,15 times the chord length C_r from the leading edge and 0,2 times C_r from the trailing edge, respectively, as shown in Fig. 4.2.6.2-1 (C_r is the chord width of the blade on radius 0,4R).

Where the boss radius (R_b) exceeds 0,27R, the other boundary of zone *A* shall be increased to 1,5 R_b.

Z o n e *A* also includes the parts of the separate cast propeller boss, which lie in the area of the windows as described in Fig. 4.2.6.2-2, and the flange and fillet area of controllable pitch and built-up propeller blades as described in Fig. 4.2.6.2-3.

Z o n e *B* is the area on the pressure and suction sides of the blade. On the pressure side zone *B* is the remaining area up to 0,7R (the area within the boundaries of 0,4R and 0,7R plus areas on the leading and trailing edges bounded by lines 0,15C_r and 0,2C_r, respectively, and the line over the blade length with a radius of 0,4R) as described in Fig. 4.2.6.2-1.

On the suction side zone *B* is the area from the fillet to 0,7R.

Z o n e *C* is the area outside 0,7R on both pressure and suction sides of the blade (between 0,7R and R) as described in Fig. 4.2.6.2-1. It also includes all the surfaces of the boss other than those designated zone *A* above.

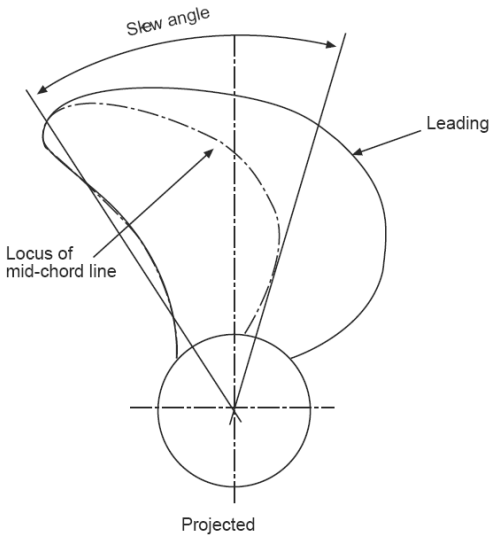

Fig. 4.2.6.1
Definition of skew angle

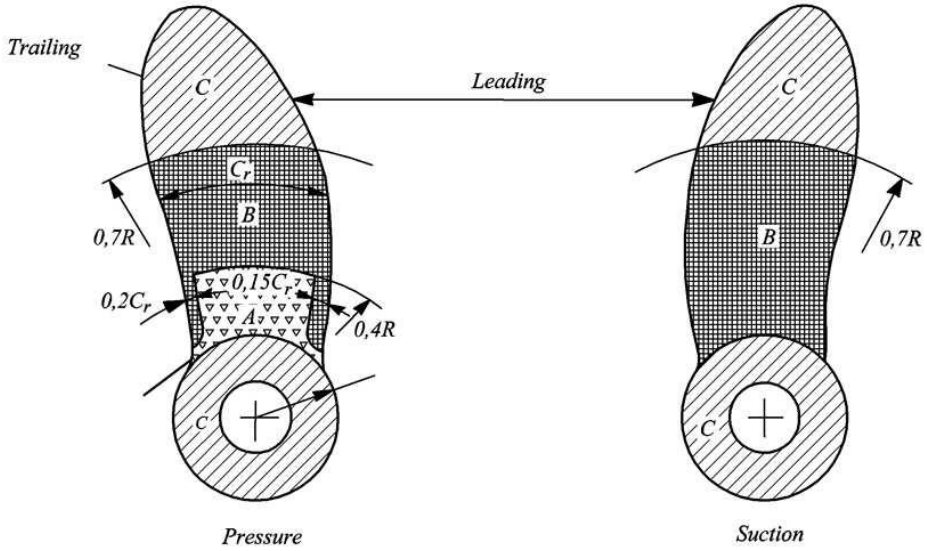

Fig. 4.2.6.2-1
Severity zones for integrally cast low skew propellers, where *R* — propeller radius; *Cr* — chord width at any radius

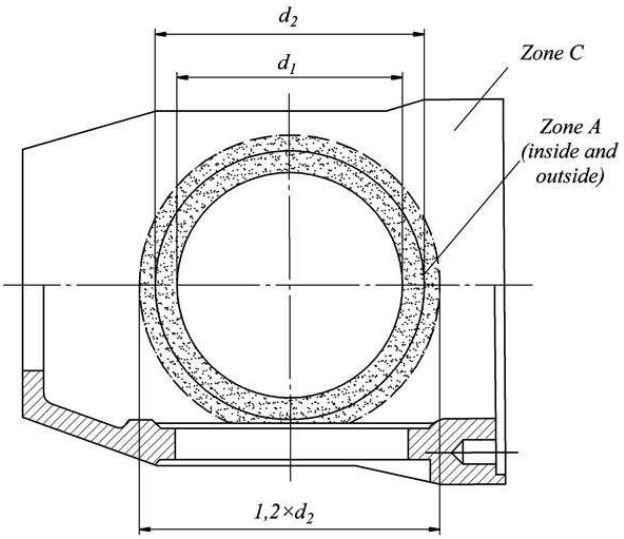

Fig. 4.2.6.2-2
Severity zones for controllable pitch propeller boss

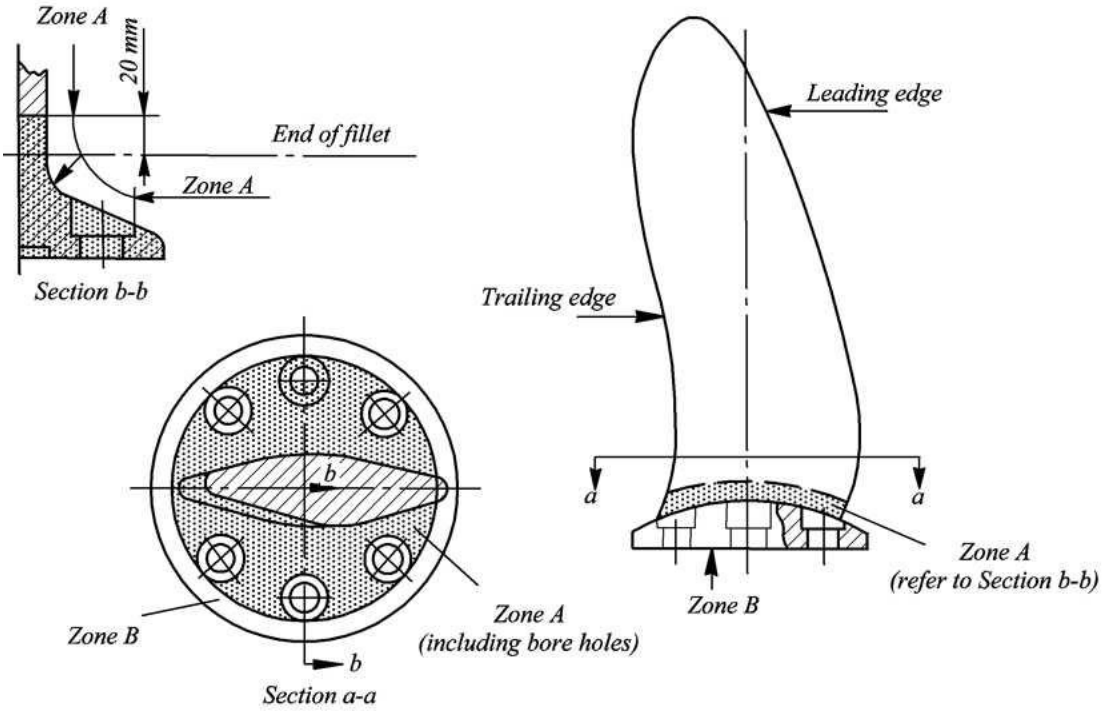

Fig. 4.2.6.2-3
Severity zones for controllable pitch and built-up propeller

4.2.6.3 Severity zones for high-skew propellers.

Z o n e *A* is the area on pressure and suction sides of the blade as described in Fig. 4.2.6.3.

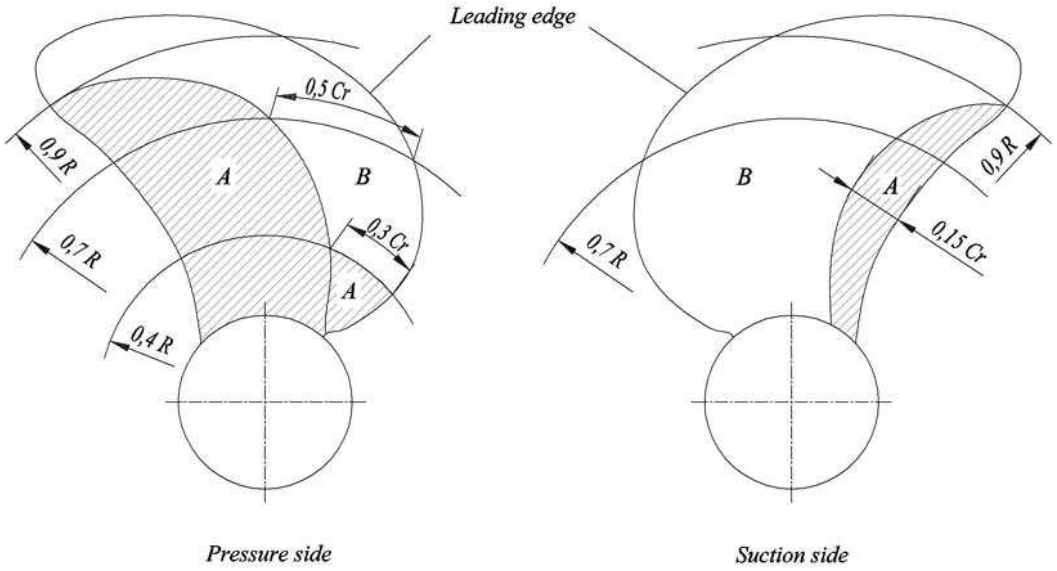

Fig. 4.2.6.3
Severity zones in blades with skew angles greater than 25°

On the pressure face zone *A* is contained within the blade root-fillet and a line running from the junction of the leading edge with the root fillet to the trailing at 0,9*R* and at passing through the mid-point of the blade chord at 0,7*R* and a point situated at 0,3 of the chord length from the leading edge at 0,4*R*. Zone *A* also includes an area between the above line and the edge from the root to the chord at 0,4*R*.

Zone *A* includes an area along the trailing edge on the suction side of the blade from the root to 0,9*R* and with its inner boundary at 0,15 of the chord lengths from the trailing edge.

Z o n e *B* is the area of the pressure and suction sides of the blade as described in Fig 4.2.6.3.

Zone *B* includes the blade surfaces not included in zone A.

4.2.6.4 Zone *A* is a region characterized by the highest operating stresses and the greatest thicknesses, and therefore it requires the highest degree of inspection and performance of all repair works.

Zone *B* is also a region where the operating stresses may be high, and therefore welding shall preferably be avoided in repair works.

Zone *C* is a region, in which the operating stresses are low and where the blade thicknesses are relatively small. Repair welding is safer and is permitted in accordance with a procedure approved by the Register.

4.2.7 Inspection.

4.2.7.1 Propeller castings shall be visually tested at all stages of manufacture. The castings shall be subjected to a 100 % visual inspection and measurement in the finished condition by the manufacturer. At the final stage of manufacture the inspection shall include the bore. The castings subject to inspection shall be fettled and their surface prepared for non-destructive testing. Final visual examination shall be carried out by the RS representative. The surface shall be free from defects which may interfere with the use of castings.

N o t e . Casting defects, which may impair the serviceability of the castings, e.g. major non-metallic inclusions, shrinkage cavities, blow holes and cracks, are not permitted. These defects may be completely removed by one of the methods described in 4.2.8 and repaired within the limits and restrictions for the severity areas. Full description and documentation shall be presented to the surveyor to the Register before commencement of works.

4.2.7.2 The verification of dimensions, the dimensional and geometrical tolerances is the responsibility of the manufacturer. The report on the relevant examinations shall be submitted to the Register. At that, the Register may require checks to be made in the presence of the RS surveyor.

Static balancing shall be carried out on all the propellers in accordance with the documentation approved by the Register. Dynamic balancing is necessary for propellers running above 500 rpm.

4.2.7.3 Non-destructive testing.

Special requirements for testing laboratories carrying out penetrant testing (PT), ultrasonic testing (UT) and magnetic particle (MT) testing are given in 10.3, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

4.2.7.3.1 Penetrant testing.

4.2.7.3.1.1 Liquid penetrant testing procedure shall be submitted to the Register and shall meet the requirements of ISO 3452-1:2013 or an RS-agreed standard. The examination criteria are specified in 4.2.7.3.1.2.2.

The severity zone *A* shall be subjected to a liquid penetrant testing in the presence of the RS surveyor.

Zones *B* and *C* shall be subjected to a liquid penetrant testing. The RS surveyor may require tests of zones *B* and *C* to be made in their presence.

If repairs have been made either by grinding, straightening or by welding the repaired areas shall additionally be subjected to the liquid penetrant testing independent of their location and/or severity zone.

4.2.7.3.1.2 Examination criteria for liquid penetrant testing

4.2.7.3.1.2.1 Definitions.

I n d i c a t i o n is the presence of detectable bleed-out of the penetrant from the material discontinuities appearing at least 10 min after the developer has been applied.

R e l e v a n t i n d i c a t i o n is an indication which has any dimension greater than 1,5 mm when categorization of indications is performed.

N o n - l i n e a r i n d i c a t i o n is an indication with a largest dimension less than three times its smallest dimension (i.e. $l < 3w$).

L i n e a r i n d i c a t i o n is an indication with a largest dimension three or more times its smallest dimension (i.e. $l \geq 3w$).

A l i g n e d i n d i c a t i o n (refer to Fig. 4.2.7.3.1.2.1) is considered to be a unique indication and its length is equal to the overall length of the alignment. The aligned indication may have the following structure:

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

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

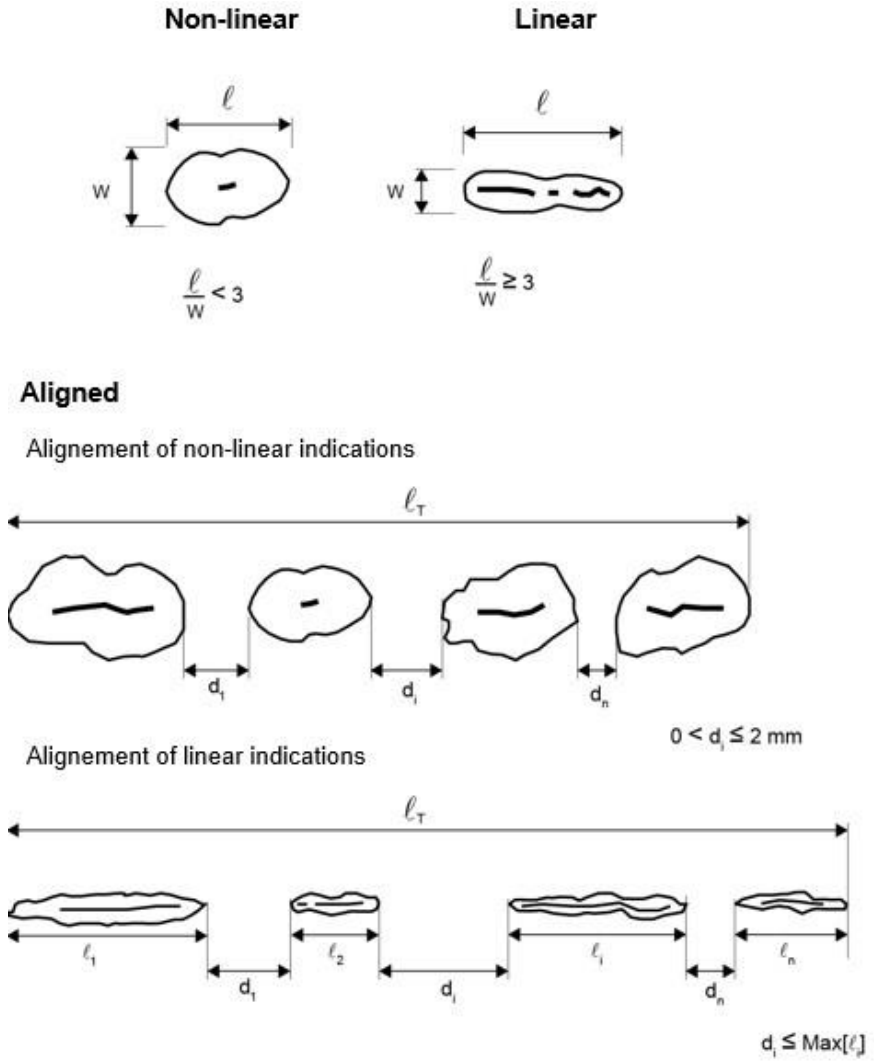

Fig. 4.2.7.3.1.2.1

4.2.7.3.1.2.2 Acceptance criteria.

The entire surface to be inspected shall be divided into reference area of 100 m^2. Each reference area may be square or rectangular with the major dimension not exceeding 250 mm.

The area shall be taken in the most unfavourable locations relative to the indication being evaluated i.e. the shape and dimensions of each reference area are chosen so that they cover the maximum number of defects without their distribution to an adjacent reference area.

The indications detected in each of such areas are, with respect to their size and number, shall not exceed the values given in Table 4.2.7.3.1.2.2.

Table 4.2.7.3.1.2.2

Allowable number and size of relevant indications in a reference area of 100 cm², depending on the severity zones

Severity zones	Max. total number of indications, max	Type of indication	Max. number of each type of indications, max	Dimensions *a* or *l*, mm
A	7	non-linear	5	4
		linear	2	3
		aligned	2	3
B	14	non-linear	10	6
		linear	4	6
		aligned	4	6
C	20	non-linear	14	8
		linear	6	6
		aligned	6	6

Notes: 1. Singular non-linear indications less than 2 mm for zone *A* and less than 3 mm for the other zones are not considered relevant.

2. The total number of circular indications may be increased to the maximum total number represented by the absence of linear/aligned indications. The total number of circular indications may also be increased due to the absence of part of linear and/or aligned indications retaining the total number of allowable indications.

Areas, which are prepared for welding, shall, independent of their location, always be assessed according to zone *A*. The same applies to the welded areas after being finished machined and/or grinded.

4.2.7.3.2 Radiographic and ultrasonic testing.

When required by the Register or when deemed necessary by the manufacturer, further non-destructive testing (e.g. radiographic and/or ultrasonic testing) shall be carried out. In these cases, the acceptance criteria shall be agreed as part of the documentation of the manufacturer and comply with the RS-agreed standards.

Ultrasonic testing is not practical in some cases, depending on the shape, type, thickness, and grain growth direction of the casting negatively impacting absorption of ultrasound.

When the ultrasonic testing is applied, effective ultrasound penetration into the casting shall be practically demonstrated to the Register. As a rule, this is determined by way of back-wall reflection, and/or target features within the casting.

4.2.8 Repair of defects.

4.2.8.1 Discontinuities of the surface causing indications when penetrant testing is carried out and not meeting the requirements of Table 4.2.7.3.1.2.2, such as cracks, shrinkage cavities, sand, slag and other non-metallic inclusions, blow holes, etc., which may impair the safe service of the propeller, shall be eliminated and/or welded.

Dimensions, number and location of defects allowable without repairs, as well as of those subject to repair shall be specified in the product documentation submitted to the Register for approval.

In general, the repairs shall be carried out by mechanical means, e.g. by grinding, chipping or milling. Welding may be applied if the requirements stated here are complied with. Welding may be applied subject to the agreement of with Register in accordance with 4.2.8.3 and 4.2.8.4.

After milling or chipping grinding shall be applied for such defects, which shall not be welded. Grinding shall be carried out in such a manner that the contour of the ground depression is as smooth as possible in order to avoid stress concentrations or to minimize cavitation corrosion. Complete elimination of the defective material shall be verified by liquid penetrant testing.

The manufacturer shall maintain records of inspections, welding, and any subsequent heat treatment, traceable to each casting.

Before welding is started, full details of the extent and location of the repair, the proposed welding procedure, heat treatment and subsequent inspection procedures shall be submitted to the Register for approval.

Welding of areas less than 5 cm² shall be avoided.

4.2.8.2 Repair of defects in zone *A*.

In zone *A*, repair welding is not allowed.

Grinding shall be carried out to an extent, which maintains the blade thickness of the drawing approved by the Register.

In special cases the propeller designer may submit technical documentation to propose a modified zone *A* based on technical documentation submitted for consideration by the Register. The documentation shall contain detailed hydrodynamic load and stress analysis in propeller.

4.2.8.3 Repair of defects in zone *B*.

Defects that are not deeper than *dB*=*t*/40 mm (*t*=minimum local thickness, in mm, according to the Rules) or 2 mm (whichever is greater) shall be removed by grinding. Those defects, which are deeper than allowable for removal by grinding, may be repaired by welding.

4.2.8.4 Repair of defects in zone *C*.

In zone *C*, repair welds are generally permitted.

4.2.8.5 Repair welding.

4.2.8.5.1 General.

The welding procedure and welding consumables used in repair welding shall be recognized by the Register as required by Part XIV "Welding".

Before welding is started, manufacturer shall submit to the Register a detailed welding procedure specification covering the weld preparation, welding parameters, filler metals, preheating and post weld heat treatment and inspection procedures.

Defects shall be repaired in accordance with the approved welding procedure by welders who are qualified to a recognized standard. Welding Procedure Qualification Tests shall be carried out under technical supervision of the RS surveyor and shall meet the requirements of 4.2.8.5.

The welding grooves shall be prepared in such a manner which will allow a good fusion of the groove bottom.

For the welding procedure approval the welding procedure qualification tests shall be carried out with satisfactory results. The qualification tests shall be carried out with the same welding process, filler metal, preheating and stress-relieving treatment as those intended applied by the actual repair work. Welding procedure specification (WPS) shall refer to (or contain) the test results achieved during welding procedure qualification testing. Documents referenced in the welding procedure specification shall be submitted to the RS surveyor upon request.

Welding procedure approved by the Register for the specified manufacturer may be applied for all workshops having the same repair procedure and quality management system.

The approval of the welding procedure shall be based on welding of samples consisting of cast samples and with sizes sufficient to ensure a reasonable heat distribution. Minimum sample sizes shall comply with those specified for Fig. 4.2.8.5.1-1.

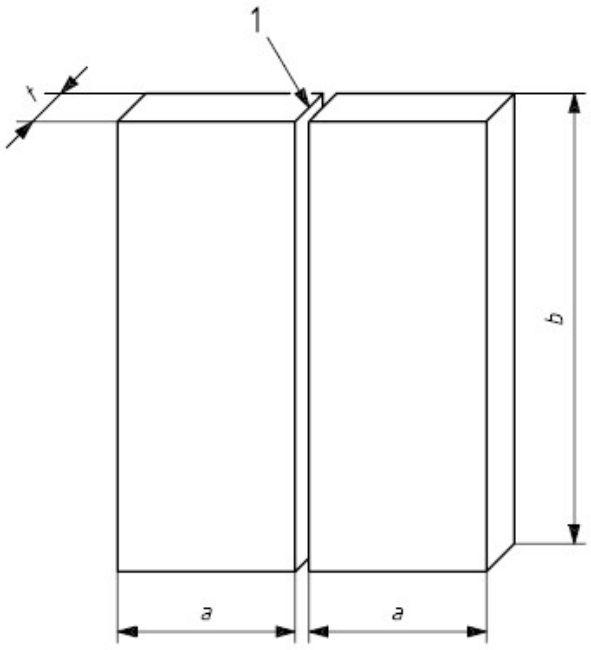

Fig. 4.2.8.5.1-1

1 — Joint preparation and fit-up as detailed in the preliminary welding procedure specification;

a — minimum width of the sample 150 mm;

b — minimum length of the sample 300mm;

t — minimum thickness of the sample 30 mm.

Preparation and welding of test pieces shall be carried out in accordance with the applied procedures of the firm that shall be submitted to the RS surveyor upon request.

Welding of the test assemblies and testing of test specimens shall be carried out under technical supervision of the RS surveyor.

Two transverse round tensile test specimens shall be taken from samples as shown in Fig. 2.2.2.3, *b* and three macro-etch specimens shall be prepared. As an alternative, tensile test specimens may be prepared in compliance with the methods approved by the Register or the agreed standards.

Welding specification to be submitted to the Register for approval shall be made taking into account the following requirements and recommendations:

defects shall be repaired by mechanical means in accordance with 4.2.8.1 — 4.2.8.4, using penetrant testing for determination of the complete removal of the defects. The examination shall be carried out in the presence of the RS surveyor;

selection of welding consumables, selection of preheat temperature and heat treatment temperature for stress relief shall be made in compliance with the requirements of Table 4.2.8.5.1-1. It shall be noted that with the exception of alloy CU3 all weld repairs shall be stress relief heat treated, in order to avoid stress corrosion cracking;

Table 4.2.8.5.1-1

Recommended fillet metals and heat treatments

Alloy type	Filler metal	Preheat temperature, °C, min	Interpass temperature, °C, max	Stress relief temperature, °C	Hot straightening temperature, °C
CU1	Al-bronze[1]	150	300	350 — 550	500 — 800
	Mn-bronze				
CU2	Al-bronze	150	300	350 — 550	500 — 800
	Ni-Mn-bronze				
CU3	Al-bronze	50	250	450 — 500	700 — 900
	Ni-Al-bronze[2]				
	Mn-Al-bronze				
CU4	Mn-Al-bronze	100	300	450 — 600	700 — 850

[1] Ni-Al-bronze and Mn-Al-bronze are acceptable.
[2] Stress relieving is not required.

where stress relief heat treatment of alloy CU3 propeller castings is required after major repairs in zone *B* and/or zone *A* or if a welding consumable susceptible to stress corrosion cracking is used, the propeller shall be either stress relief heat treated in the temperature 450 to 500 °C or annealed in the temperature range 650 to 800 °C, depending on the extent of repair (refer to Table 4.2.8.5.1-1);

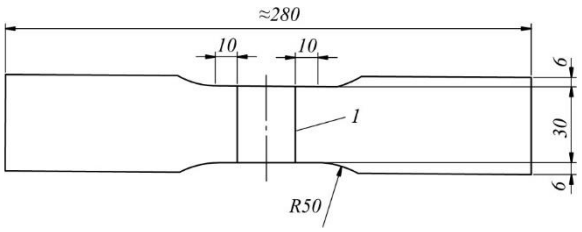

Fig. 4.2.8.5.1-2
Tensile test specimen:
1 — weld edge

the defects shall be repaired as far as possible in the down-hand position, using arc welding with coated electrodes or "wire — shielded gas" combination.

Metal arc welding shall be used for all types of welding repair on cast copper alloy propellers.

Where the down-hand position is impossible for repairs, only "wire — shielded gas" combination shall be used;

N o t e . Use of argon-shielded tungsten welding is not recommended due to the higher specific heat input of this process.

the time of conditioning for stress relief heat treatment of copper alloy propellers is determined in accordance with Table 4.2.8.5.1-2. The cooling rate shall not exceed 50 °C/h until the temperature of 200 °C is reached.

Table 4.2.8.5.1-2

Time of conditioning for stress relief heat treatment of copper alloy propellers

Stress relief temperature, °C	CU1 and CU2		CU3 and CU4	
	hours per 25 mm thickness	max. recommended total time, hours	hours per 25 mm thickness	max. recommended total time, hours
350	5	15	–	–
400	1	5	–	–
450	0,5	2	5	15
500	0,25	1	1	5
550	0,25	0,5	0,5[1]	2[1]
600	–	–	0,25[1]	1[1]
[1] 550 and 600 °C only applicable to CU4 alloys.				

4.2.8.5.2 Testing.

4.2.8.5.2.1 Test assembly shall be examined non-destructively in accordance with the requirements of Table 4.2.8.5.2.1-1. The location pattern on specimens is shown on Fig. 4.2.8.5.2.1-1.

Table 4.2.8.5.2.1-1

Type of tests and extent of testing

Type of test[1]	**Extent of testing**
Visual testing	100% as per 4.2.8.5.2.2
Liquid penetrant testing	100% as per 4.2.8.5.2.2
Transverse tensile test	Two specimens as per 4.2.8.5.2.3
Macro examination	Three specimens as per 4.2.8.5.2.4
[1] Bend or fracture test shall be agreed with the Register.	

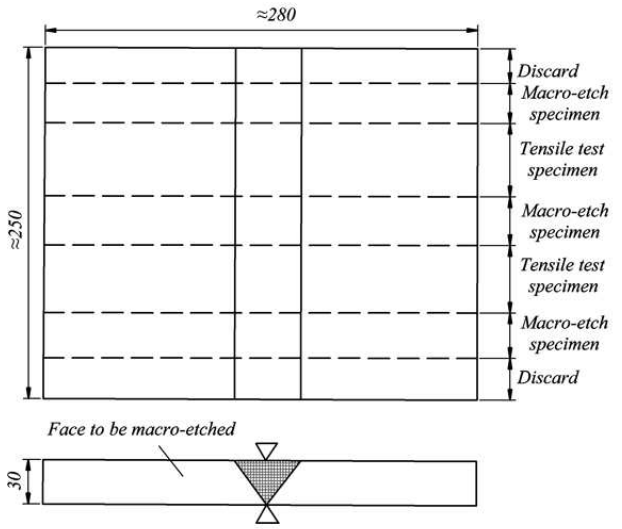

Fig. 4.2.8.5.2.1-1
Location of specimens

4.2.8.5.2.2 Examination and non-destructive testing of specimens

Test assembly shall be examined by complete visual and liquid penetrant testing after welding and prior to the cutting of test specimen. In case, that any post-weld heat treatment is required or specified, visual examination and liquid penetrant testing shall be performed after heat treatment.

No cracks are permitted. Procedure for detection of imperfections and control criteria by liquid penetrant testing are specified in 4.2.7.3.1.

4.2.8.5.2.3 Tensile testing.

Two tensile tests shall be prepared in accordance with 2.2.2.8 for butt weld. Alternative specimens may be applied if it is agreed with the Register. These specimens shall comply with the agreed standards. The requirements for the values of tensile strength are given in Table 4.2.8.5.2.3-1.

Table 4.2.8.5.2.3-1

Required tensile strength values for copper-base alloys welded joints

Alloy type	Tensile Strength, MPa
CU1	370
CU2	410
CU3	500
CU4	550

4.2.8.5.2.4 Macroscopic examination.

Macroscopic examination shall be carried out on three test specimens prepared and etched on one side to clearly reveal the weld metal, the fusion line and the heat affected zone.

A suitable etchant for this purpose is:

5 g iron (III) chloride

30 ml hydrochloric acid (cone)

100 ml water.

The test specimens shall be examined for imperfections present in the weld metal and the heat affected zone. Cracks and lack of fusion are not permitted. Pores and slag inclusions, greater than 3 mm are not permitted as well.

4.2.8.5.2.5 Re-testing.

In case of unsatisfactory results of one of the tests, the repeated tests shall be conducted in accordance with 6.5, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

4.2.8.5.2.6 Test record.

4.2.8.5.2.6.1 Welding conditions for test assemblies and test and examination results shall be recorded in welding procedure qualification records. Welding Procedure Approval Test Certificate (form 7.1.33, pages 3 — 9) or other specification regulated by the relevant standards may be used as a record form.

4.2.8.5.2.6.1.2 A statement of the results of assessing each test piece, including repeat tests, shall be made for each welding procedure qualification records. The relevant items listed for the WPS shall be included in the test report.

4.2.8.5.2.6.1.3 The welding procedure qualification records shall be signed and stamped by the RS surveyor attending the tests.

4.2.8.5.3 Range of approval.

4.2.8.5.3.1 General.

Requirements specified in 4.2.8.5.3 shall be met independently of each other.

Changes outside of the ranges specified shall require a new welding procedure test.

Welding procedure approved by the Register for a specified manufacturer may be applied for all workshops or sites under the same repair procedure and quality management system.

4.2.8.5.3.2 Base metal.

Results of qualification tests of welding procedure shall cover types of alloys in accordance with Table 4.2.8.5.3.2.

Table 4.2.8.5.3.2

Range of qualification for base metal

Copper alloy material grade used for qualification	Range of approval
CU1	CU1
CU2	CU1, CU2
CU3	CU3
CU4	CU4

4.2.8.5.3.3 Parameters of welding procedure.

The approval of WPS carried out on a weld assembly of thickness *t* equal or less than 30 mm applies to material thickness of equal or more than 3 mm.

Approval for a test made in any position is restricted to that position.

The approval is only valid for the welding used in the welding procedure test. Single run test results are not valid for multi-run butt weld test applied in accordance with this Chapter.

The approval is only valid for the filler metal used in the welding procedure test.

The upper limit of heat input approved is 25 % greater than that used in welding the test piece. At that, the lower limit of heat input approved is 25 % lower than that used in welding the test piece.

The approved minimum preheating temperature shall not be less than that obtained when taking the test piece.

The approved maximum interpass temperature shall not be higher than that obtained in welding the test piece.

The heat treatment used in the qualification test shall be specified in WPS. Holding time at a specified temperature may be adjusted as a function of thickness.

4.2.8.6 Straightening.

For hot and cold straightening, static loading only shall be used.

Straightening of a bent propeller blade or pitch modification shall be carried out after heating the bent region and approximately 500 mm wide zones on either side of it. The temperature range shall comply with the requirements of Table 4.2.8.5.1-1; the heating shall be slow and uniform.

The concentrated flame such as oxy-acetylene and oxy-propane shall not be used.

Weld repaired areas of propeller may be subject to hot straightening, provided it can be demonstrated that weld properties are not impaired by the hot straightening operations.

Cold straightening shall be used for minor repairs of tips and edges only. Cold straightening on CU1 and CU2 as well as CU4 bronze shall be always followed by a stress relieving heat treatment in accordance with Table 4.2.8.5.1-1.

4.2.9 Identification and marking.

4.2.9.1 Identification.

The manufacturer's shall employ a monitoring system, which enables all castings to be traced back to their heat. The confirmation of the availability of such system at manufacturer's shall be given during the manufacturer's survey. System data shall be provided upon request of the RS surveyor.

4.2.9.2 Marking.

Marking of propellers shall be made in compliance with the requirements of 1.4. Besides, marking shall contain the following data:

type/grade of cast material or corresponding abbreviated designation;

manufacturer's mark;

heat number, casting number or another mark enabling the manufacturing process to be traced back;

date of final inspection;

number of the Register Certificate;

skew angle for high-skew propellers;

ice class symbol, where applicable.

4.2.9.3 The Manufacturer's Certificate for each propeller and its components casting to be submitted to the RS surveyor shall contain the following details:

purchaser and order number;

shipbuilding project number, if known;

description of the casting with drawing number;

diameter, number of blades, pitch, direction of turning;

grade of alloy and chemical composition of each heat;

heat and casting number;

final weight;

results of non-destructive tests, if used;

portion of alpha phase for CU1 and CU2 alloys;

results of the mechanical tests;

casting identification number;

skew angle for high-skew propellers.".