
W27 Cast Steel Propellers

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1. Scope

1.1 These unified requirements are applicable to the manufacture of cast steel propellers, blades and bosses.

1.2 Where the use of alternative alloys is proposed, particulars of chemical composition, mechanical properties and heat treatment are to be submitted for approval.

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

2. Foundry approval

All propellers, blades and bosses are to be manufactured by foundries approved by the Classification Society. The scope of the procedure tests involved in the approval is to be agreed.

3. General characteristics of castings

All castings are to have a workmanlike finish and are to be free from imperfections that could be considered to impair in-service performance.

4. Chemical composition

Typical cast steel propeller alloys are grouped into four types depending on their chemical composition as given in Table 1.

5. Heat treatment

Martensitic castings are to be austenitized and tempered. Austenitic castings should be solution treated.

6. Mechanical properties

6.1 The mechanical properties are to meet the requirements in Table 2. These values refer to the test specimens machined from integrally cast test bars attached to the hub or on the blade.

6.2 Where possible, the test bars attached on blades are to be located in an area between 0.5 to 0.6R, where R is the radius of the propeller.

6.3 The test bars are not to be detached from the casting until the final heat treatment has been carried out. Removal is to be by non-thermal procedures.

6.4 Separately cast test bars may be used subject to prior approval of the Classification Society. The test bars are to be cast from the same heat as the castings represented and heat treated with the castings represented.

6.5 At least one set of mechanical tests is to be made on material representing each casting in accordance with UR W2.

6.6 As an alternative to 6.5, where a number of small propellers of about the same size, and less than 1m in diameter, are made from one cast and heat treated in the same furnace charge, a batch testing procedure may be adopted using separately cast test samples of suitable dimensions. At least one set of mechanical tests is to be provided for each multiple of five castings in the batch.



W27 7. Visual inspection

7.1 All finished castings are to be 100% visually inspected by the Surveyor. The Surveyor may require areas to be etched for the purpose of investigating weld repairs.

7.2 Castings are to be free from cracks, hot tears or other imperfections which, due to their nature, degree or extent, will interfere with the use of the castings.

8. Dimensions, dimensional and geometrical tolerances

8.1 The dimensions are the responsibility of the manufacturer and the report on the dimensional inspection is to be handed over to the Surveyor, who may require checks to be made in his presence.

8.2 Static balancing is to be carried out on all propellers in accordance with the approved drawing. Dynamic balancing may be necessary for propellers running above 500 rpm.

9. Non-destructive testing

9.1 All finished castings are subject to non-destructive testing in accordance with the requirements given in 9.2 to 9.9.

9.2 In order to relate the degree of non-destructive testing to the criticality of imperfections, propeller blades are divided into three severity Zones designated A, B and C. Further, a distinction is made between low skew and high skew propellers. IACS UR W24 refers.

9.3 For all propellers, separately cast blades and hubs, the surfaces covered by severity Zones A, B and C are to be liquid penetrant tested. Testing of Zone A is to be undertaken in the presence of the Surveyor, whilst testing of Zone B and C may be witnessed by the Surveyor upon his request.

9.4 If repairs have been made either by grinding or by welding, the repaired areas are additionally to be subjected to the liquid penetrant testing independent of their location and/or severity Zone. Weld repairs are, independent of their location, always to be assessed according to Zone A.

9.5 The following definitions relevant to liquid penetrant indications apply:

Indication: the presence of detectable bleed-out of the penetrant liquid from the material discontinuities appearing at least 10 minutes after the developer has been applied;

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 2mm or less edge-to-edge;

Open indication: an indication that can be detected by the use of contrast dye penetrant;

Non-open indication: an indication that cannot be detected by the use of contrast dye penetrant,



W27 *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 1.5mm shall be considered relevant.

9.6 For the purpose of evaluating indications, the surface is to be divided into reference areas of 100cm², which may be square or rectangular with the major dimension not exceeding 250mm. The area shall be taken in the most unfavorable location relative to the indication being evaluated.

9.7 The indications detected may, with respect to their size and number, not exceed the values given in the Table 3.

9.8 Where serious doubt exists that the castings are not free from internal defects, further non-destructive inspections are to be carried out upon request of the Surveyor, e.g. radiographic and/or ultrasonic tests. The acceptance criteria are then to be agreed between the manufacturer and the Classification Society.

9.9 The foundry is to maintain records of inspections traceable to each casting. These records are to be reviewed by the Surveyor. The foundry is also to provide the Surveyor with a statement confirming that non-destructive tests have been carried out with satisfactory results.

10. Repair

10.1 Defective castings are to be repaired in accordance with the requirements given in 10.2 to 10.7 and, where applicable, the requirements of Section 11.

10.2 In general the repairs are to be carried out by mechanical means, e.g. by grinding or milling. The resulting grooves are to be blended into the surrounding surface so as to avoid any sharp contours. Complete elimination of the defective material is to be verified by liquid penetrant testing.

10.3 Weld repairs are to be undertaken only when they are considered to be necessary and have prior approval of the Surveyor. All weld repairs are to be documented by means of sketches or photographs showing the location and major dimensions of the grooves prepared for welding. The documentation is to be presented to the Surveyor prior to repair welding.

10.4 The excavations are to be suitably shaped to allow good access for welding. The resulting grooves are to be subsequently ground smooth and complete elimination of the defective material is to be verified by liquid penetrant testing. Welds having an area less than 5cm² are to be avoided.

10.5 Grinding in severity Zone A may be carried out to an extent that maintains the blade thickness. Repair welding is generally not permitted in severity Zone A and will only be allowed after special consideration by the Classification Society.

10.6 Defects in severity Zone B that are not deeper than t/40 mm ("t" is the minimum local thickness according to the Rules) or 2mm, whichever is greatest, are to be removed by grinding. Those defects that are deeper may be repaired by welding subject to prior approval from the Classification Society.

10.7 Repair welding is generally permitted in severity Zone C.

11. Weld repair procedure

11.1 The scope of the procedure tests involved in the qualification is given in Appendix A. 

W27 Before welding is started, a detailed welding procedure specification is to be submitted covering the weld preparation, welding positions, welding parameters, welding consumables, preheating, post weld heat treatment and inspection procedures.

11.2 All weld repairs are to be made by qualified welders using qualified procedures.

11.3 Welding is to be done under controlled conditions free from draughts and adverse weather.

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

11.5 Slag, undercuts and other imperfections are to be removed before depositing the next run.

11.6 The martensitic steels are to be furnace re-tempered after weld repair. Subject to prior approval, however, local stress relieving may be considered for minor repairs.

11.7 On completion of heat treatment the weld repairs and adjacent material are to be ground smooth. All weld repairs are to be liquid penetrant tested.

11.8 The foundry is to maintain records of welding, subsequent heat treatment and inspections traceable to each casting repaired. These records are to be reviewed by the Surveyor.

12. Identification

12.1 Prior to final inspection by the surveyor, each casting is to be suitably identified by the manufacturer with the following:

- a) Heat number or other marking which will enable the full history of the casting to be traced;
- b) The Society's certificate number;
- c) Ice class symbol, where applicable;
- d) Skew angle for high skew propellers,
- e) Date of final inspection.

12.2 The Society's stamp is to be put on when the casting has been accepted.

13. Certification

13.1 The manufacturer is to provide the Surveyor with an inspection certificate giving the following particulars for each casting which has been accepted:

- a) Purchaser's name and order number;
- b) Vessel identification, where known;
- c) Description of the casting with drawing number;
- d) Diameter, number of blades, pitch, direction of turning;
- e) Skew angle for high skew propellers;



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- f) Final mass;
 - g) Alloy type, heat number and chemical composition;
 - h) Casting identification number;
 - i) Details of time and temperature of heat treatment,
 - j) Results of the mechanical tests.

13.2 The manufacturer is to provide a statement regarding non-destructive tests as required by 9.9 and, where applicable, records of weld repairs as required by 11.8.

Table 1 - Typical chemical composition for steel propeller castings

Alloy type	C Max. (%)	Mn Max. (%)	Cr (%)	Mo ¹⁾ Max. (%)	Ni (%)
Martensitic (12 Cr 1 Ni)	0,15	2,0	11,5-17,0	0,5	Max. 2,0
Martensitic (13 Cr 4 Ni)	0,06	2,0	11,5-17,0	1,0	3,5-5,0
Martensitic (16 Cr 5 Ni)	0,06	2,0	15,0-17,5	1,5	3,5-6,0
Austenitic (19 Cr 1 1 Ni)	0,12	1,6	16,0-21,0	4,0	8,0-13,0

Note: 1) Minimum values are to be in accordance with recognised national or international standards

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Table 2 - Mechanical Properties for steel propeller castings

Alloy type	Proof stress $R_{p0.2}$ min. (N/mm ²)	Tensile strength R_m min. (N/mm ²)	Elongation A_5 min. (%)	Red. of area Z min. (%)	Charpy V-notch ¹⁾ Energy min. (J)
12 Cr 1Ni	440	590	15	30	20
13 Cr 4Ni	550	750	15	35	30
16 Cr 5Ni	540	760	15	35	30
19 Cr 11Ni	180 ²⁾	440	30	40	-
<p>1) Not required for general service and the lowest Ice class notations. For other Ice class notations, tests are to be made -10°C.</p> <p>2) $R_{p1,0}$ value is 205 N/mm².</p>					



W27 Table 3 - Allowable number and size of indications depending on severity zones

Severity zone	Max. total number of indications	Indication type	Max. number for each type ¹⁾ ²⁾	Max. dimension of indication (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
<p>¹⁾ Single non-linear indications less than 2mm in Zone A and less than 3mm in other zones may be disregarded.</p> <p>²⁾ The total number of non-linear indications may be increased to the maximum total number, or part thereof, represented by the absence of linear or aligned indications.</p>				

W27**Appendix A
Welding Procedure Qualification Test****1. Preparation of test assembly**

A test assembly of minimum 30mm thickness is to be welded. The types of specimens to be prepared are shown in Fig. 1.

2. Non-destructive testing

Prior to sectioning, the test assembly is to be visually inspected and liquid penetrant tested. Imperfections shall be assessed in accordance with Section 9.

3. Macro-examination

Two macro-sections shall be prepared and etched on one side to clearly reveal the weld metal, the fusion line, and the heat affected zone. The sections are to be examined by eye (aided by low power hand lens if desired) for any imperfections present in the weld metal and HAZ. Cracks or crack-like imperfections, slag inclusions, and pores greater than 3mm are not permitted.

4. Tensile testing

Two flat transverse tensile test specimens shall be prepared. Testing procedures shall be in accordance with IACS UR W2.4.2.8 b). The tensile strength shall meet the specified minimum value of the base material. The location of fracture is to be reported, i.e. weld metal, HAZ or base material.

5. Bend testing

Two transverse side bend test specimens shall be prepared in accordance with IACS UR W2. The former diameter shall be 4 x thickness except for austenitic steels, in which case the former diameter shall be 3 x thickness. The test specimen, when visually inspected after bending, shall show no surface imperfections greater than 2mm in length.

6. Charpy V-notch testing

Impact test is not required, except where the base material is impact tested. Charpy V-notch test specimens shall be in accordance with IACS UR W2. Two sets shall be taken, one set with the notch positioned in the center of the weld and one set with the notch positioned in the fusion line, respectively. The test temperature, and impact energy shall comply with the requirement specified for the base material.

7. Hardness testing

One of the macro-sections shall be used for HV5 hardness testing. Indentations shall traverse 2mm below the surface. At least three individual indentations are to be made in the weld metal, the HAZ (both sides) and in the base material (both sides). The values are to be reported for information.



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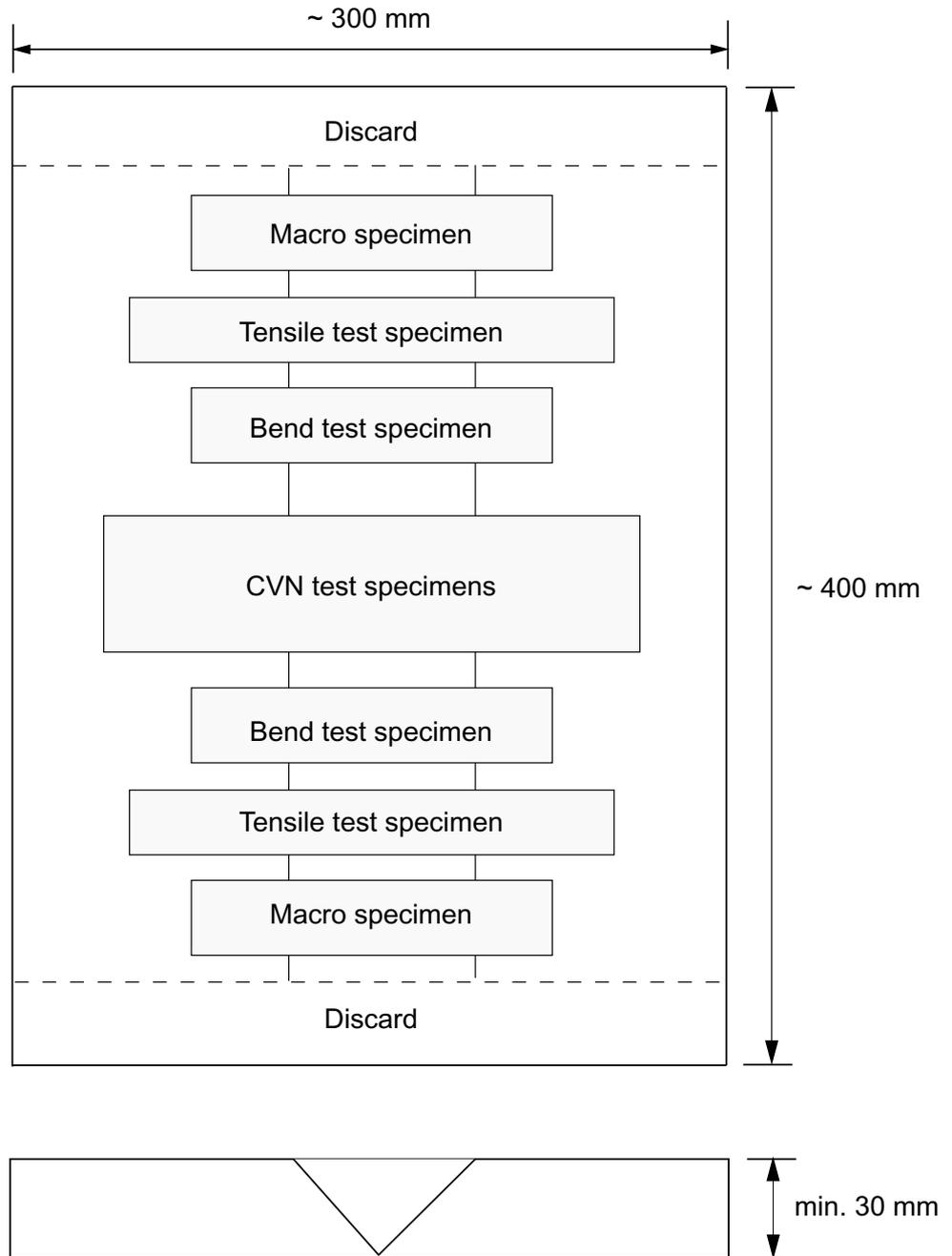


Fig. 1 Weld test assembly

