PART III CONSTRUCTION COMPONENTS

TITLE 62 MACHINERY

SECTION 5 ENGINES AND MECHANICS

CHAPTERS

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CHAPTER A
APPROACH

CHAPTER CONTENTS

A1. APLICATION

100. Component classification .

101. These requirements apply to components used in construction or repair of machinery, incluing equipment, pipes and gears, covered under these Rules for classification.

102. Other materials not listed herein may optionally be used, if they are approved by RBNA, who, if it's necessary, will establish the process for this approval. This also applies to materials for which there is official control or established practice in countries where the material is produced, in view of its application.

103. The general rules for the manufacturing process of the components, witnessing tests, defects and re-testing, as well as obtaining the specimens, are those set in the present Title 62, Section 2, Parte 5 of the present Rule.

200. Definitions

See Part III, Title 61, Section 2, Chapter B1.

CHAPTER B
STEEL CASTINGS
[IACS WR 8]

See Part III, Title 61, Section 2, Chapter C

CHAPTER C
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CHAPTER D
GREY IRON CASTINGS
[IACS W9]

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D1. CHARACTERISTICS

100. Requirements

101. The characteristics, the requirements for the test and the treatment are established in Norma ABNT-NBR-6589.

D2. SCOPE

100. General

101. All major grey iron castings, as defined in the relevant construction Rules, are as be manufactured and tested in accordance with the requirements of the following paragraphs.

102. Alternatively, castings which comply with national or proprietary specifications may be accepted provided such specifications give reasonable equivalence to these requirements or otherwise are specially approved or required by RBNA.

103. Where small castings are produced in large quantities, the manufacturer may adopt alternative procedures for testing and inspection subject to the approval of the Classification Society.

D3. MANUFACTURE

100. Manufacture.

101. All major castings are to be made at foundries where the manufacturer has demonstrated to the satisfaction of the Classification Society that the necessary manufacturing and testing facilities are available and are supervised by qualified personnel. A programme of approval tests may be required in accordance with the procedures of individual

102. Classification Societies. Suitable mechanical methods are to be employed for the removal of surplus material from castings. Thermal cutting processes are not acceptable, except as a preliminary operation to mechanical methods.

103. Where castings of the same type are regularly produced in quantity, the manufacturer is to make any tests necessary to prove the quality of the prototype castings and is also to make periodical examinations to verify the continued efficiency of the manufacturing technique. The Surveyor is to be given the opportunity to witness these tests.

D4. QUALITY OF CASTINGS, CHEMICAL COMPOSITION AND HEAT TREATMENT

100. Castings are to be free from surface or internal defects which would be prejudicial to their proper application in service. The surface finish is to be in accordance with good practice and any specific requirements of the approved plan.

101. The chemical composition of the iron used is left to the discretion of the manufacturer, who is to ensure that it is suitable to obtain the mechanical properties specified for the castings. When required by individual Classification Societies the chemical composition of ladle samples is to be reported.

102. Except as required by D2.103 castings may be supplied in either the as cast or heat treated condition.

103. For some applications, such as high temperature service or where dimensional stability is important, castings may require to be given a suitable tempering or stress relieving heat treatment.

D5. MECHANICAL TESTS AND MECHANICAL PROPERTIES

100. Mechanical tests

101. Test material sufficient for the required tests and for possible re-tests is to be provided for each casting or batch of castings.

102. Separately cast test samples are to be used unless otherwise agreed between the manufacturer and purchaser and generally are to be in the form of bars 30 mm in diameter and of a suitable length. They are to be cast from the same ladle as the castings in moulds of the same type of material as the moulds for the castings and are not to be stripped from the moulds until the metal temperature is below 500°C. When two or more test samples are cast simultaneously in a single mould, the bars are to be at least 50 mm apart as given in Figure.F.D5.102.1.

103. Integrally cast samples may be used when a casting is more than 20 mm thick and its mass exceeds 200 Kg, subject to agreement between the manufacturer and the purchaser. The type and location of the sample are to be selected to provide approximately the same cooling conditions as for the casting it represents and also subject to agreement.

104. With the exception of D5.107 at least one test sample is to be cast with each batch.

105. With the exception of D5.106, a batch consists of the castings poured from a single ladle of metal, provided that they are all of similar type and dimensions. A batch should not normally exceed two tonnes of fettled castings and a single casting will constitute a batch is its mass is 2 tonnes or more.

106. For continuous melting of the same grade of cast iron in large tonnages the mass of a batch may be increased to the output of 2 hours of pouring.

107. If one grade of cast iron is melted in large quantities and if production is carefully monitored by systematic checking of the melting process, such as chill testing, chemical analysis or thermal analysis, test samples may be taken at longer intervals.

108. All test samples are to be suitably marked to identify them with the castings which they represent.

109. Where castings are supplied in the heat treated condition, the test samples are to be heat treated together with the castings which they represent. For cast-on-test samples the sample shall not be cut off from the casting until after the heat treatment.

110. One tensile test specimen is to be prepared from each test sample and for 30mm diameter samples is to be machined to the dimensions given in Part III, Title 61, Section 2, Subchapter A4. Where test samples of other dimensions are specially required the tensile test specimens are to be machined to agreed dimensions.

111. All tensile tests are to be carried out using test procedures in accordance with Part III, Title 61, Section 2, Subchapter A. Unless otherwise agreed all tests are to be carried out in the presence of the Surveyor.

200. Mechanical properties

201. Only the tensile strength is to be determined and the results obtained from tests are to comply with the minimum value specified for the castings being supplied.

201. The value selected for the specified minimum tensile strength is to be not less than 200 N/mm2 but subject to any additional requirements of the relevant construction Rules. The fractured surfaces of all tensile test specimens are to be granular and grey in appearance.

202. Re-test requirements for tensile tests are to be in accordance with `Part III, Title 61, Section 2, Subchapter A .

D6. INSPECTION AND RECTIFICATION OF DEFECTIVE CASTINGS

100. Inspection.

101. All castings are to be cleaned and adequately prepared for examination. The surfaces are not to be hammered, peened or treated in any way which may obscure defects.

102. Before acceptance, all castings are to be visually examined including, where applicable, the examination of internal surfaces. Unless otherwise agreed, the verification of dimensions is the responsibility of the manufacturer.

103. Supplementary examination of castings by suitable nondestructive testing procedures is generally not required except in circumstances where there is reason to suspect the soundness of the casting.

104. When required by the relevant construction Rules, castings are to be pressure tested before final acceptance.

105. In the event of any casting proving defective during subsequent machining or testing it is to be rejected notwithstanding any previous certification.

200. Rectification of defective castings

201. At the discretion of the Surveyor, small surface blemishes may be removed by local grinding.

202. Subject to the prior approval of the Surveyor, castings containing local porosity may be rectified by impregnation with suitable plastic filler, provided that the extent of the porosity is such that it does not adversely affect the strength of the casting.

203. Repairs by welding are generally not permitted.

D7. IDENTIFICATION OF CASTINGS

100. Identification of castings

101. The manufacturer is to adopt a system of identification, which will enable all finished castings to be traced to the original ladle of metal. The Surveyor is to be given full facilities for so tracing the castings when required.

102. Before acceptance, all castings which have been tested and inspected with satisfactory results are to be clearly marked by the manufacturer. At the discretion of Classification Societies any of the following particulars may be required:

a. Quality of cast iron.

b. Identification number or other marking which will enable the full history of the casting to be traced.

c. Manufacturer's name or trade mark.

d. RBNA's name, initials or symbol.

e. Abbreviated name of RBNA's local office.

f. Personal stamp of Surveyor responsible for inspection.

g. Where applicable, test pressure.

h. Date of final inspection

103. Where small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with the Classification Society.

D8. CERTIFICATION

100. Certification.

101. The manufacturer is to provide the Surveyor with a test certificate or shipping statement giving the following particulars for each casting or batch of castings which has been accepted:

a. Purchaser's name and order number.

b. Description of castings and quality of cast iron.

c. Identification number.

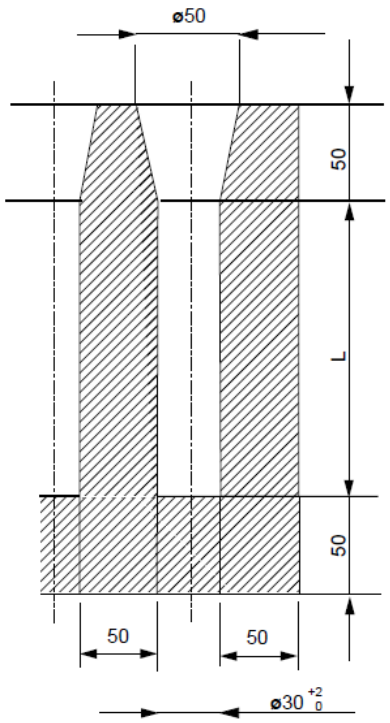
d. Results of mechanical tests.

e. Where applicable, general details of heat treatment.

f. When specially required, the chemical analysis of ladle samples.

g. Where applicable, test pressure.

FIGURE F.D5.102.1 TEST SAMPLE FOR GREY CAST IRON *(dimensions in millimeters)*



CHAPTER E
SPHEROIDAL OR NODULAR GRAPHITE IRON CASTINGS
[IACS UR W10]

CONTENTS

E1. SCOPE

100. General.

101. All important spheroidal or nodular graphite iron castings, as defined in the relevant construction Rules, are to be manufactured and tested in accordance with the requirements of the following paragraphs.

102. These requirements are applicable only to castings where the design and acceptance tests are related to mechanical properties at ambient temperature. For other applications additional requirements may be necessary, especially when the castings are intended for service at low or elevated temperatures.

103. Alternatively, castings which comply with national or proprietary specifications may be accepted provided such specifications give reasonable equivalence to these requirements or otherwise are specially approved or required by the Classification Society.

104. Where small castings are produced in large quantities the manufacturer may adopt alternative procedures for testing and inspection subject to the approval of the Classification Society.

105. The requirements of Norma ABNT-EB-585-Part 1/79 are to be complied with.

E2. MANUFACTURE

100. Manufacture.

101. All important castings are to be made at foundries where the manufacturer has demonstrated to the satisfaction of the Classification Society that the necessary manufacturing and testing facilities are available and are supervised by qualified personnel. A programme of approval tests may be required in accordance with the procedures of individual Classification Societies.

102. Suitable mechanical methods are to be employed for the removal of surplus material from castings. Thermal cutting processes are not acceptable, except as a preliminary operation to mechanical methods.

103. Where castings of the same type are regularly produced in quantity, the manufacturer is to make any tests necessary to prove the quality of the prototype castings and is also to make periodical examinations to verify the continued efficiency of the manufacturing technique. The Surveyor is to be given the opportunity to witness these tests.

E3. QUALITY OF CASTINGS, CHEMICAL COMPOSITION

100. Quality of castings.

101. Castings are to be free from surface or internal defects which would be prejudicial to their proper application in service. The surface finish is to be in accordance with good practice and any specific requirements of the approved plan.

200. Chemical composition

201. Unless otherwise specially required, the chemical composition of the iron used is left to the discretion of the manufacturer, who is to ensure that it is suitable to obtain the mechanical properties specified for the castings. When required by individual Classification Societies the chemical composition of ladle samples is to be reported.

E3. HEAT TREATMENT

100. Heat treatment.

101. Except as required by E3.102-E3.103 below castings may be supplied in either the as cast or heat treated condition.

102. For some applications, such as high temperature service or where dimensional stability is important, it may be required that castings be given a suitable tempering or stress relieving heat treatment.

103. This is to be carried out after any refining heat treatment and before machining the special qualities with 350 N/mm2 and 400 N/mm^2 nominal tensile strength and impact test shall undergo a ferritizing heat treatment.

104. Where it is proposed to locally harden the surfaces of a casting full details of the proposed procedure and specification are to be submitted for approval by the Classification Society.

E4. MECHANICAL TESTS, MECHANICAL PROPERTIES

100. Mechanical tests

102. Test material, sufficient for the required tests and for possible re-test purposes, is to be provided for each casting or batch of castings.

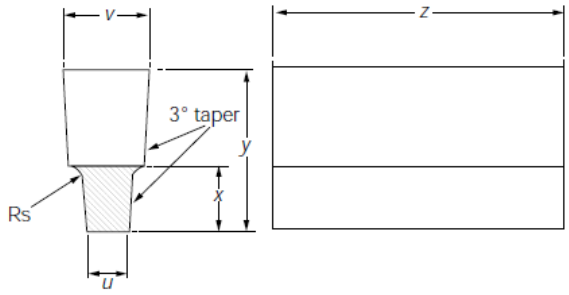
103. The test samples are generally to be one of the standard types detailed in Figs F.E4.103.1 - F.E4.103.3 with a thickness of 25 mm. Test samples of other dimensions, as detailed in Figs. F.E4.103.1 - F.E4.103.3 may, however, be specially required for some components.

104. At least one test sample is to be provided for each casting and unless otherwise required may be either gated to the casting or separately cast. Alternatively test material of other suitable dimensions may be provided integral with the casting.

105. For large castings where more than one ladle of treated metal is used, additional test samples are to be provided so as to be representative of each ladle used.

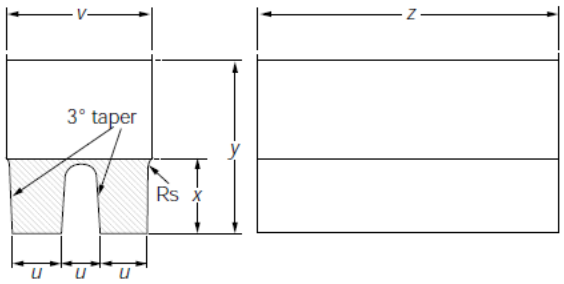
106. As an alternative to E4.104, a batch testing procedure may be adopted for castings with a fettled mass of 1 tonne or less. All castings in a batch are to be of similar type and dimensions, cast from the same ladle of treated metal. One separately cast test sample is to be provided for each multiple of 2,0 tonnes of fettled castings in the batch.

FIG. F.E4.103.1 TYPE A TEST SAMPLE (U-TYPE)



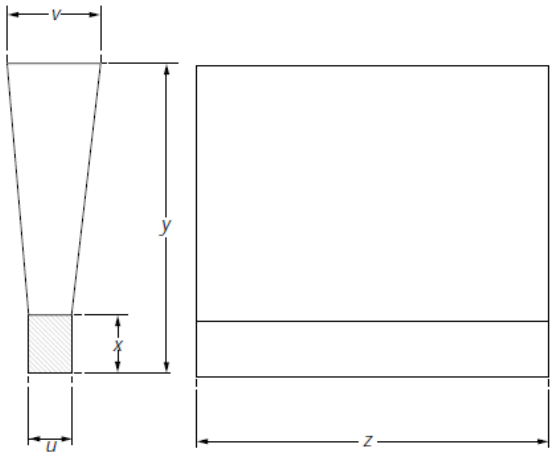
Dimensions	Standard sample	Alternative samples when specially required		
u (mm)	25	12	50	75
v (mm)	55	40	90	125
x (mm)	40	30	60	65
y (mm)	100	80	150	165
z	To suit testing machine			
Rs	Approximately 5 mm			

FIG. F.E4.103.2 TYPE B TEST SAMPLE (DOUBLE U-TYPE)



Dimensions	Standard sample
u (mm)	25
v (mm)	90
x (mm)	40
y (mm)	100
z	To suit testing machine
Rs	Approximately 5 mm

FIG. F.E4.103.3 TYPE C TEST SAMPLE (Y-TYPE)



Dimensions	Standard sample	Alternative samples when specially required		
u (mm)	25	12	50	75
v (mm)	55	40	100	125
x (mm)	40	25	50	65
y (mm)	140	135	150	175
z	To suit testing machine			
Thickness of mould surrounding test sample	40 mm min.	40 mm min.	80 mm min.	80 mm min.

107. Where separately cast test samples are used, they are to be cast in moulds made from the same type of material as used for the castings and are to be taken towards the end of pouring of the castings. The samples are not to be stripped from the moulds until the temperature is below 500°C.

108. All test samples are to be suitably marked to identify them with the castings which they represent.

109. Where castings are supplied in the heat treated condition, the test samples are to be heat treated together with the castings which they represent.

110. One tensile test specimen is to be prepared from each test sample and is to be machined to the dimensions given in Part III, Title 61, Section 2, Chapter A.

111. All tensile tests are to be carried out using test procedures in accordance with Part III, Title 61, Section 2, Chapter A. Unless otherwise agreed all tests are to be carried out in the presence of the Surveyors.

200. Mechanical properties

201. Table T.E4.201.1 gives the minimum requirements for 0,2% proof stress and elongation corresponding to different strength levels. Typical Brinell hardness values are also given in Table 1 and are intended for information purposes only.

202. Castings may be supplied to any specified minimum tensile strength selected within the general limits detailed in Table T.E4.201.1 but subject to any additional requirements of the relevant construction Rules

203. Unless otherwise agreed only the tensile strength and elongation need be determined. The results of all tensile tests are to comply with the appropriate requirements of Table T.E4.201.1.

TABLE T.E4.201.1 MECHANICAL PROPERTIES

Specified minimum tensile strength (N/mm^2)		0,2% proof stress (N/mm^2) min.	Elongation on 5,65 $\sqrt{So}$ (%) min.	Typical hardness values (Brinell) (see E4.202)	Impact energy		Typical structure of matrix (see E5.203)
					Test temp. ^0C	KV(2) J min	
Ordinary qualities	370	230	17	120-180	-	-	Ferrite
	400	250	12	140-200	-	-	Ferrite
	500	320	7	170-240	-	-	Ferrite/Perlite
	600	370	3	190-270	-	-	Ferrite/Perlite
	700	420	2	230-300	-	-	Perlite
	800	480	2	250-350	-	-	Perlite or Tempered structure
Special qualities	350	220	22(3)	110-170	+20	17(14)	Ferrite
	400	250	18(3)	140-200	+20	14(11)	Ferrite

Note
1 For intermediate values of specified minimum tensile strength, the minimum values for 0,2% proof and elongation may be obtained by interpolation.
2 The average value measured on 3 Charpy V-notch specimens. One result may be below the average value but not less than the minimum shown in brackets.
3 In the case of integrally cast samples, the elongation may be 2 percentage points less.

E5. INSPECTION , METALLOGRAPHIC EXAMINATION

100. Inspection

101. All castings are to be cleaned and adequately prepared for examination. The surfaces are not to be hammered, peened or treated in any way which may obscure defects.

102. Before acceptance, all castings are to be visually examined including, where applicable, the examination of internal surfaces. Unless otherwise agreed the verification of dimensions is the responsibility of the manufacturer.

103. Supplementary examination of castings by suitable nondestructive testing procedures is generally not required except in circumstances where there is reason to suspect the soundness of the casting.

104. When required by the relevant construction Rules, castings are to be pressure tested before final acceptance.

105. In the event of any casting proving defective during subsequent machining or testing is to be rejected notwithstanding any previous certification.

106. Cast crankshaft are to be subjected to a magnetic particle inspection. Crack like indications are not allowed.

200. Metallographic examination

201. For crankshafts the metallographic examination will be mandatory.

202. When required, a representative sample from each ladle of treated metal is to be prepared for metallographic examination. These samples may conveniently be taken from the tensile test specimens but alternative arrangements for the provision of the samples may be adopted provided that they are taken from the ladle towards the end of the casting period.

203. Examination of the samples is to show that at least 90% of the graphite is in a dispersed spheroidal or nodular form. Details of typical matrix structures are given in Table T.E4.201.1 and are intended for information purposes only.

E6. RECTIFICATION OF DEFECTIVE CASTINGS, IDENTIFICATION OF CASTINGS

100. Rectification of defective castings.

101. At the discretion of the Surveyor, small surface blemishes mat be removed by local grinding.

102. Subject to the prior approval of the Surveyor, castings containing local porosity may be rectified by impregnation with a suitable plastic filler, provided that

the extent of the porosity is such that it does not adversely affect the strength of the casting.

103. Repairs by welding are generally not permitted.

200. Identification of castings

201. The manufacturer is to adopt a system of identification which will enable all finished castings to be traced to the original ladle of treated metal and the Surveyor is to be given full facilities for so tracing the castings when required.

202. Before acceptance, all castings which have been tested and inspected with satisfactory results are to be clearly marked by the manufacturer.

203. At the discretion of RBNA any of the following particulars may be required.

a. Quality of cast iron.

b. Identification number or other marking which will enable the full history of the casting to be traced.

c. Manufacturer's name or trade mark.

d. The Classification Society's name, initials or symbol.

e. Abbreviated name of the Classification Society's local office.

f. Personal stamp of Surveyor responsible for inspection.

g. Where applicable, test pressure.

h. Date of final inspection.

204. Where small castings are manufactured in large numbers, modified arrangements for identification may be specially agreed with the Classification Society.

E7. CERTIFICATION

100. Certification

101. The manufacturer is to provide the Surveyor with a test certificate or shipping statement giving the following particulars for each casting or batch of castings which has been accepted:

a. Purchaser's name and order number.

b. Description of castings and quality of cast iron.

c. Identification number.

d. Results of mechanical tests.

e. Where applicable, general details of heat treatment.

f. Where specifically required, the chemical analysis of ladle samples.

g. Where applicable, test pressure.

CHAPTER F
HOT-ROLLED STEEL BARS.

CONTENTS

F1. CHARACTERITICS

100. Prescription

101. The characteristics, requirements for the test and treatment are established in Part III, Title 61, Section 2, Chapter B, of the present Rules.

CHAPTER G
CAST COPPER ALLOY PROPELERS

CHAPTER CONTENTS

G1. SCOPE
[IACS UR W24 1]

100. Scope

101. These unified requirements are a aplicable to the moulding, casting, inspection and repair procedures of new cast copper alloy propellers, blades and bosses. Upon special consideration of the individual Classification Society these requirements may also be applied for the repair and inspection of propellers becoming damaged during service.

G2. FOUNDRY APPROVAL
[IACS UR W24 2]

100. Approval
[IACS UR W24 2.1]

101. All propellers and propeller components are to be cast by foundries approved by the classification society. For this purpose, the foundries have to demonstrate that

they have available the necessary facilities and skilled personnel to enable proper manufacture of propellers which will satisfy these rules.

102. Application for approval: The approval is to be applied for at the classification society. The applications are to be accompanied by specifications of the propeller materials, manufacturing procedures, repair, NDT inspection procedures and a description of the foundry facilities, including the maximum capacity of the ladles.

103. Scope of the approval test The scope of the approval test is to be agreed with the Classification Society. This should include the presentation of cast test coupons of the propeller materials in question for approval testing in order to verify that the chemical composition and the mechanical properties of these materials comply with these rules.

104. **Inspection facilities:** The foundry is to have an adequately equipped laboratory, manned by experienced personnel, for the testing of moulding materials chemical analyses, mechanical testing and microstructure testing of metallic materials. Provision is also to be made for NDT inspection. If these test facilities are not available at the foundry, details are to be provided of an approved local laboratory which will provide such services.

G3. MOULDING AND CASTING [IACS UR W24 3]

100. Moulding and casting

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

G4. GENERAL CHARACTERISTICS OF CASTINGS [IACS UR W24 4]

100. Freedom from defects

101. All castings must have a workman like finish and must be free from defects liable to impair their use. 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,cf. Subchapter G14.

102. Stress relieving: 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 society for approval. For stress relieving temperatures and holding times see tables T.G15.301.1 and T.G15.306

200. Removal of defects

201. 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 Subchapter G14 and repaired within the limits and restrictions for the severity zones. Full description and documentation must be available for the surveyor.

G5. DIMENSIONS, DIMENSIONAL AND GEOMETRICAL TOLERANCES [IACS UR W24 5]

100. Dimensional and geometrical tolerances

101. The dimensions and the dimensional and geometrical tolerances are governed by the data contained in the approval drawings or order documents. These shall be submitted to the Surveyor at the time of the test. The accuracy and verification of the dimensions are the responsibility of the manufacturer, unless otherwise agreed.

102. RBNA requires that the ISO Standards 484 part 1 and 484 part 2 or equivalents are to be followed.

103. Static balancing is to be carried out on all propellers in accordance with the approved drawing.

104. Dynamic balancing is necessary for propellers running above 500 rpm.

G6. CHEMICAL COMPOSITION AND STRUCTURE CHARACTERISTICS [IACS UR W24.6]

100. Chemical composition

101. Typical copper propeller alloys are grouped into the four types CU 1, CU 2, CU 3 and CU 4 depending on their chemical composition as given in table T.G6.101.1. Copper alloys whose chemical composition deviate from the typical values of T.G6.101.1 must be specially approved by the Society.

TABLE T.G6.101.1 TYPICAL CHEMICAL COMPOSITIONS OF CAST COPPER ALLOYS FOR PROPELLERS

Alloy type	CHEMICAL COMPOSITION (%)							
	Cu	**Al**	**Mn**	**Zn**	**Fe**	**Ni**	**Sn**	**Pb**
CU1	52-62	0,5-3,0	05,-4,0	35-40	0,5-2,5	max 1,0	0,1-1,5	max. 0,5
CU2	50-57	0,5-2,0	1,0-4,0	33-38	05,-2,5	3,0-8,0	max. 0,15	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

200. Metallurgical characteristics

201. The main constituents of the microstructure in the copper-based alloys categories CU 1 and CU 2 are alpha and beta phase.

202. Important properties such as ductility and resistance to corrosion fatigue are strongly influenced by the relative proportion of beta phase (too high a 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 is to be kept low.

203. The concept of the zinc equivalent should be used as control since it summarizes the effect of the tendency of various chemical elements to produce beta phase in the structure.

204. The structure of CU 1 and CU 2 type alloys must contain an alpha phase component of at least 25 % as measured on a test bar by the manufacturer. To ensure adequate ductility and corrosion fatigue resistance, the proportion of beta phase is to be kept low. For this purpose, the zinc equivalent defined by the following formula shall not exceed a value of 45 %:

$$\textit{Zinc}\ \text{equivalent}\ (\%) = 100 - \frac{100\,\%\,\text{Cu}}{100 + \text{A}}$$

in which A is the algebraic sum of the following values:

1	% Sn
5	% Al
-0,5	% Mn
-0,1	% Fe
-2,3	% Ni

205. Note: The negative sign in front of the elements Mn, Fe and Ni signifies that these elements tend to r7.

G7. MECHANICAL CHARACTERISTICS [IACS UR W24.7]

100. Standardized alloys

101. The mechanical characteristics must conform to the values shown in table T.G7.101.1. These values are applicable to test specimens taken from separately cast samples in accordance with Fig. F.G7.101.1, or with any other recognized national standard.

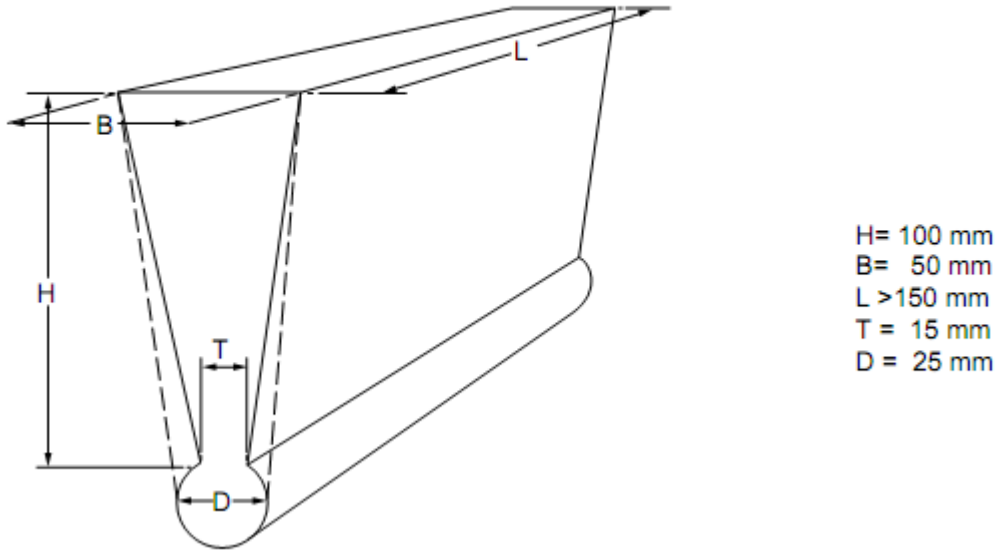
102. Note: These properties are a measure of the mechanical quality of the metal in each heat; and they are generally not representative of the mechanical properties of the propeller casting itself, which may be up to 30 % lower than that of a separately cast test coupon.

103. For integrally cast test specimens the requirements are specially to be agreed with the Society educe the proportion of beta phase.

TABLE T.G7.101.1 - MECHANICAL CHARACTERISTICS OF CAST COPPER ALLOYS FOR PROPELLERS (SEPARATELY CAST TEST COUPONS)

Alloy type	Proof stress Rp 0,2 [N/mm^2] min.	Tensile strength R_m [N/mm^2] min.	Elongation A_5 [%] min.
CU1	175	440	20
CU2	175	440	20
CU3	245	590	16
CU4	275	630	18

FIG. F.G7.101.1 - TEST SAMPLE CASTING



200. Other alloys

201. The mechanical characteristics of alloys not meeting the limiting values of Table T.G7.101.1 must be in accordance with a specification approved by the Society.

G8. INSPECTION AND TESTS [IACS UR W24.8]

100. Inspection and tests

101. The following tests and inspections are to be performed. For test specimen's dimensions and testing procedures reference is made to Part III, title 61, Section 2, Chapter A.

200. Chemical composition. The manufacturer shall furnish proof of the composition of each ladle.

300. Tensile test

301. The tensile strength, 0,2 % proof stress and elongation shall be determined by tensile test. For this purpose, at least one tensile test specimen shall be taken from each ladle.

302. Generally, the specimens shall be taken from separately cast sample pieces, see G7.100. The test samples shall be cast in moulds made of the same material

as the mould for the propeller and they must be cooled down under the same conditions as the propeller.

303. If propellers are subjected to a heat treatment the test samples are to be heat treated together with them.

304. Where test specimens are to be taken from integrally cast test samples, this shall be the subject of special agreement with the Society. Wherever possible, the test samples shall be located on the blades in an area lying between 0,5 to 0,6 R, where R is the radius of the propeller. The test sample material must be removed from the casting by non thermal procedures.

400. Micrographic examination

402. The micro structure of alloy types CU 1 and CU 2 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. The requirements of item G6.200 are to be fulfilled.

500. Surface quality and dimensions

501. Propeller castings should be visually inspected at all stages of manufacture and the whole surface is to be subjected to a comprehensive visual inspection in the finished condition by the Surveyor. This has to include the bore.

502. The dimensions are to be checked by 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.

503. The Surveyor may be require areas to be etched (e.g. by iron chloride) for the purpose of investigating weld repairs.

G9. NON-DESTRUCTIVE INSPECTIONS [IACS UR W24.9]

100. Dye penetrant inspection

101. The severity zones "A" (see subchapter G12) are to be subjected to a dye penetrant inspection in the presence of the Surveyor. For the inspection and acceptance standard see subchapter G.13. In zones "B" and "C" the dye penetrant inspection is to be performed by the manufacturer and may be witnessed by the Surveyor upon his request.

102. If repairs have been made either by grinding or by welding the repaired areas are additionally to be subjected to the dye penetrant inspection independent of their location and/or severity zone.

200. Radiographic and ultrasonic inspection

201. Where serious doubts exist 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. For this purpose, the following is to be observed: T h e acceptance criteria are to be agreed between the manufacturer and the classification Society in accordance with a recognized standard.

202. Guidance

a. The absorption of the X-rays and gamma-rays is stronger in copper-based alloys than in steel. For propeller bronzes, 300 kV X-rays can normally be used up to 50 mm and Co60 gamma-rays up to 160 mm thickness. Due to the limited thicknesses that can be radiographed as well as for other practical reasons radiography is generally not a realistic method for checking of the thickest parts of large propellers.

b. *As a general rule, ultrasonic testing of CU 1 and CU 2 is not feasible due to the high damping capacity of these materials. For CU 3 and CU 4, ultrasonic inspection of subsurface* defects is possible.

300. Documentation of defects and inspections

301. All defects requiring welding repair on the castings are to be documented preferably on drawings or special sketches showing their dimensions and locations. Furthermore, the inspection procedure is to be reported. The documentation is to be presented to the Surveyor prior to any repair weldings will be carried out.

G10. IDENTIFICATION AND MARKING [IACS UR W24.10]

100. Identifications

101. The manufacturer must employ a monitoring system which enables all castings to be traced back to their heats.

102. On request, the Surveyor shall be given proof of this.

200. Marking

201. Prior to final inspection by the Surveyor each casting shall be marked by the manufacturer at least with the following symbols:

a. Grade of cast material or corresponding abbreviated designation

b. Manufacturer’s mark

c. Heat number, casting number or another mark enabling the manufacturing process to be traced back

d. Specimen number

e. Date of final inspection

f. Number of the Society's test certificate

g. Ice class symbol, where applicable

h. Skew angle for high skew propellers.

G11. MANUFACTURER'S CERTIFICATES [IACS UR W24.11]

100. Manufacturers' certificates

101. For each propeller the manufacturer must supply to the Surveyor a certificate containing the following details:

a. Purchaser and order number

b. Shipbuilding project number, if known

c. Description of the casting with drawing number

d. Diameter, number of blades, pitch, direction of turning

e. Grade of alloy and chemical composition of each heat

f. Heat or casting number

g. Final weight

h. Results of non-destructive tests and details of test procedure where applicable

i. Portion of alpha-structure for CU 1 and CU 2 alloys

j. Results of the mechanical tests

k. Casting identification No.

l. Skew angle for high skew propellers, see G12.100

G12. DEFINITION OF SKEW, SEVERITY ZONES [IACS UR W24.12]

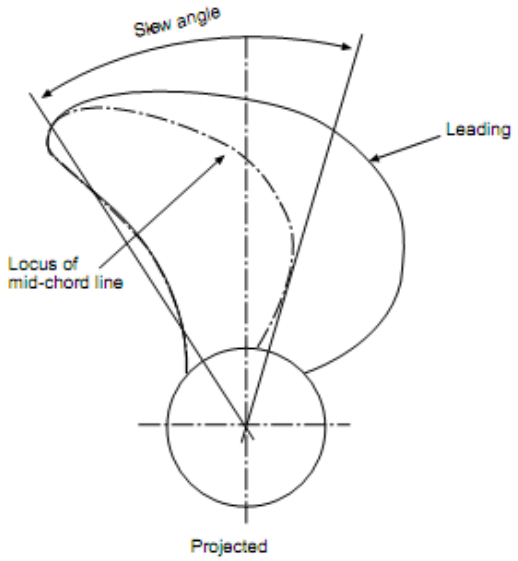
100. Definition of skew

101. The skew of a propeller is defined as follows:

a. The maximum skew angle of a propeller blade 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, see Fig F.G12.101.1.

b. High skew propellers have a skew angle greater than 25˚, low skew propellers a skew angle of up to 25˚

FIGURE F.G12.101.1 – DEFINITION OF SKEW ANGLE



200. Severity zones

201. 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 zones designated A, B and C.

202. **Zone A** is the region carrying the highest operating stresses and which, therefore, requires the highest degree of inspection. Generally, the blade thicknesses are greatest in this area giving the greatest degree of restraint in repair welds and this in turn leads to the highest residual stresses in and around any repair welds. High residual tensile stresses frequently lead to fatigue cracking during subsequent service so that relief of these stresses by heat treatment is essential for any welds made in this zone. Welding is generally not permitted in Zone A and will only be allowed after special consideration by the Classification Society. Every effort should be made to rectify a propeller which is either defective or damaged in this area without recourse to welding even to the extent of reducing the scantlings, if this is acceptable. If a repair using welding is agreed, post-weld stress relief heat treatment is mandatory.

203**.** **Zone B** is a region where the operation stresses may be high. Welding should preferably be avoided but generally is allowed subject to prior approval from the Classification Society. . Complete details of the defect / damage and the intended repair procedure are to be submitted for each instance in order to obtain such approval

204. **Zone C** is a region in which the operation stresses are low and where the blade thicknesses are relatively small so that repair welding is safer and, if made in accordance with an approved procedure is freely permitted.

205. Low-skew propellers

a. Zone 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 Cr from the leading edge and 0,2 times Cr from the trailing edge, respectively (see Figure F.G12.205.1). Where the hub radius (Rb) exceeds 0,27R, the other boundary of zone A is to be increased to 1,5Rb.

b. Zone A also includes the parts of the separate cast propeller hub which lie in the area of the windows as described in Figure F.G12.205.3 and the flange and fillet area of controllable pitch and built-up propeller blades as described in F.G12.205.4

c. Zone B is on the pressure side the remaining area up to 0,7R and on the suction side the area from the fillet to 0,7R (see F.G12.101.1).

d. Zone C is the area outside 0,7R on both sides of the blade. It also includes the surface of the hub of a monobloc propeller and all the surfaces of the hub of a controllable pitch propeller other than those designated Zone A above.

FIGURE F.G12.205.1 – SEVERITY ANGLES FOR INTEGRITY CAST LOW SKEW PROPELLERS

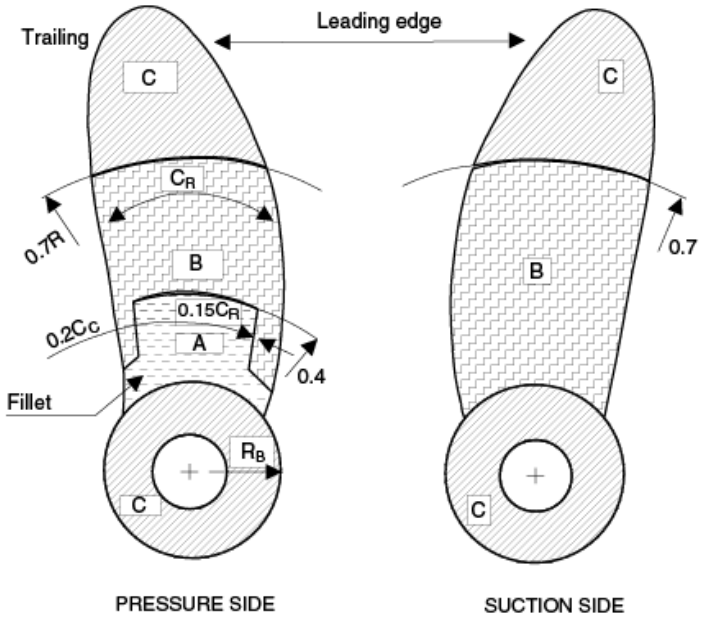


FIG. F.G12.205.3 - SEVERITY ZONES FOR CONTROLLABLE PITCH PROPELLER BOSS

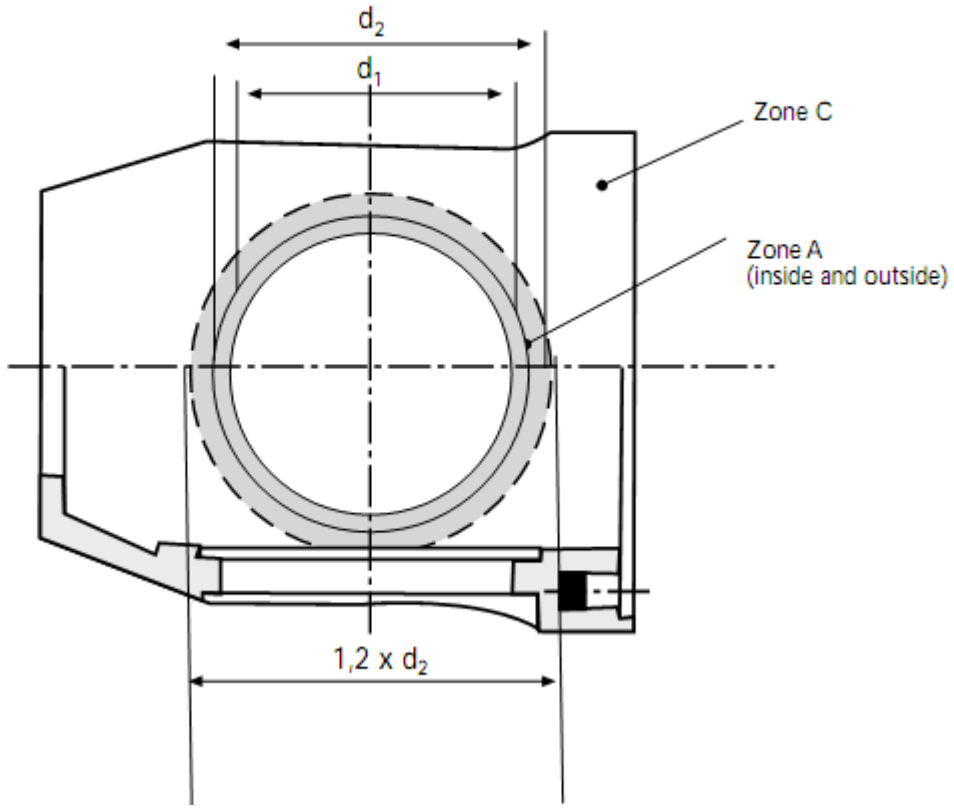


FIG. F. G12.303.1 - SEVERITY ZONES IN BLADES WITH SKEW ANGLES GRATER THAN 25°

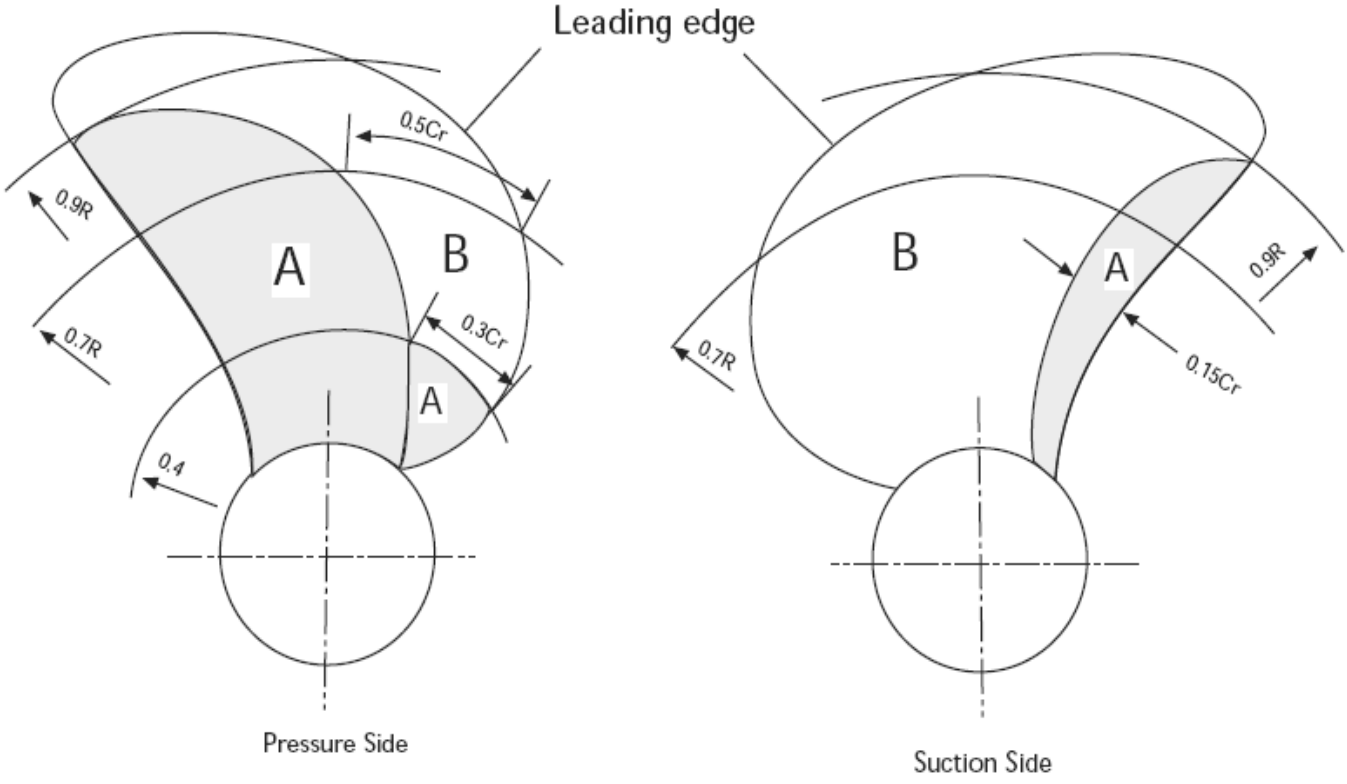
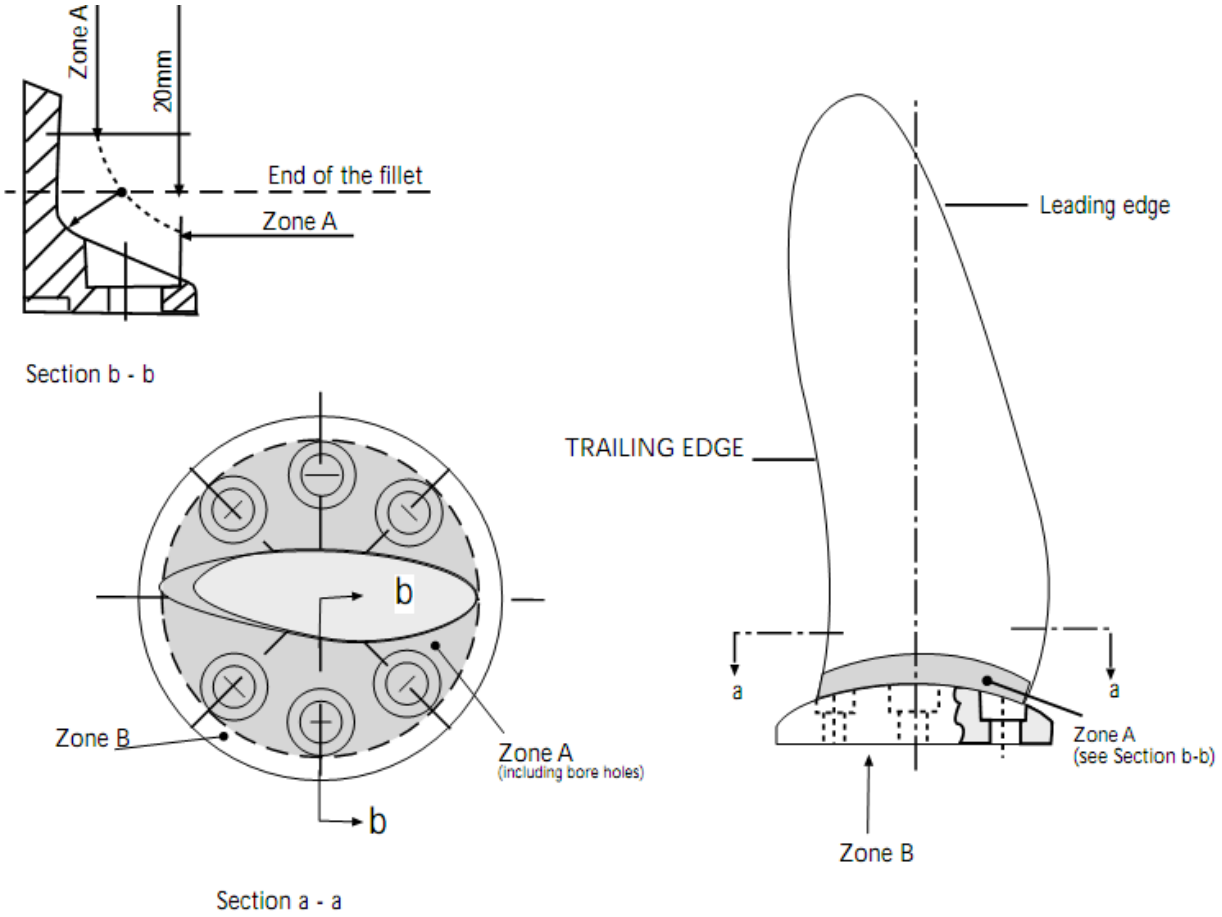


FIG. F.G12.205.4 SEVERITY ZONES FOR CONTROLLABLE PITCH AND BUILT-UP PROPELLER



300. High-skew propellers

301. **Zone A** is the area on the pressure face contained within the blade root-fillet and a line running from the junction of the leading edge with the root fillet to the trailing edge 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. It also includes an area along the trailing edge on the suction sde 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.

302. **Zone B** constitutes the whole of the remaining blade surfaces.

303. Zone A and B are illustrated in Figure F. G12.303.1

304. Note: The remaining surface of the propeller blades are to be divided into the severity zones as given for solid cast propellers cf. figures Figure F.G12.205.1 and F. G12.303.1.

G13. ACCEPTANCE CRITERIA FOR DYE PENETRANT INSPECTION

100. Inspection procedure

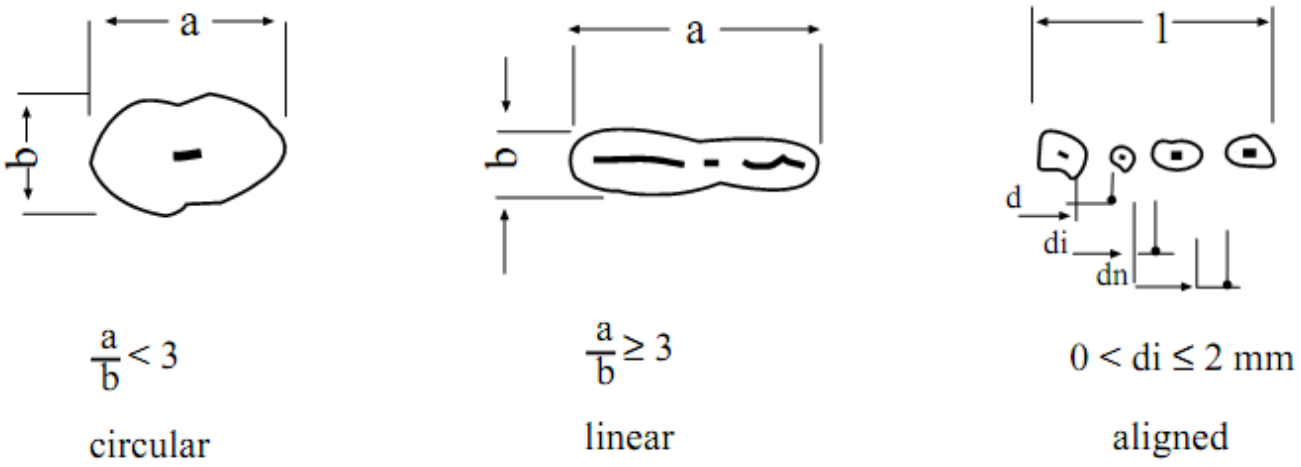
101. The dye penetrant inspection is to be carried out in accordance with a standard or specification approved by the Society.

200. Definitions

201. **Indication**: In the dye penetrant inspection an indication is 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.

202. **Shape of indications** A distinction is made between circular, linear and aligned indications, see Figure F.G13.202.1

FIGURE F.G13.202.1 SHAPE OF INDICATIONS



Reference area: The reference area is defined as an area of 100 cm^2 which may be square or rectangular with the major dimension not exceeding 250 mm.

300. Acceptance standard

301. For the judgment, the surface to be inspected is to be divided into reference areas of 100 cm^2 as given in the definitions, see G13.200 . The indications detected may, with respect to their size and number, not exceed the values given in the Table T.G13.301.1.The area shall be taken in the most unfavourable location relative to the indication being evaluated.

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

TABLE T.G13.301.1 - ALLOWABLE NUMBER AND SIZE OF INDICATIONS IN A REFERENCE AREA OF 100 CM^2, DEPENDING ON SEVERITY ZONES

Severity zone	Max. total Number of indication	Type of indication	Max. number of Each type [1) 2)]	Max. acceptable value for “a” or “l” of indications [mm]
A	7	Circular Linear Aligned	5 2 2	4 3 3
B	14	Circular Linear Aligned	10 4 4	6 6 6
C	20	Circular Linear Aligned	14 6 6	8 6 6

Notes:

1) Singular circular indications less than 2 mm for zone A and less than 3 mm for the other zones may be disregarded

2) The total number of circular indications may be increased to the max. total number or part, thereof, represents by the absence of linear/aligned indications

G14. REPAIR OF DEFECTS

100. Definition

101. Indications exceeding the acceptance standard of Table T.G3.301.1, cracks, shrinkage cavities, sand, slag and other non-metallic inclusions, blow holes and other discontinuities which may impair the safe service of the propeller are defined as defects and must be repaired.

200. Repair procedures

201. In general the repairs shall be carried out by mechanical means, e. g. by grinding, chipping or milling. Welding may be applied subject to the agreement of the Society's Surveyor if the requirements of the items G14.300, G14.400 and/or G14.500 will be complied with.

202. After milling or chipping grinding is to be applied for such defects which are not to be welded. Grinding is to 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 minimise cavitation corrosion.

203. Welding of areas less than 5 cm^2 is to be avoided.

300. Repair of defects in zone A

301. In zone A, repair welding will generally not be allowed unless specially approved by the Classification Society.
302. Grinding may be carried out to an extent which maintains the blade thickness of the approved drawing.

303. The possible repair of defects which are deeper than those referred to above is to be considered by the classification Society.

400. Repair of defects in zone B

401. Defects that are not deeper than dB = (t/40) mm (t = min. local thickness in mm according to the Rules) or 2 mm (whichever is greatest) below min. local thickness according to the Rules should be removed by grinding.

402. Those defects that are deeper than allowable for removal by grinding may be repaired by welding.

500. Repair of defects in zone C

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

G15. REPAIR WELDING

100. General requirements

101. Companies wishing to carry out welding work on propellers must have at their disposal the necessary workshops, lifting gear, welding equipment, preheating and, where necessary, annealing facilities, testing devices as well as certified welders and expert welding supervisors to enable them to perform the work properly. Proof shall be furnished to the Surveyor that these conditions are satisfied before welding work begins.

102. The company concerned shall prepare and submit to the classification Society a detailed welding specification covering the weld preparation, welding procedure, filler metals, preheating and post weld heat treatment and inspection procedures.

103. Before welding is started, Welding Procedure Qualification Test are to be carried out and witnessed by the Surveyors. Each welder / operator is to demonstrate his ability to carry out the proposed welding using the same process, consumable and position which are to be used in actual repair (the scope of tests is given in subchapter G17.).

200. Welding preparation

201. Defects to be repaired by welding are to be ground to sound material according to the requirements as given under item G14.200. To ensure complete removal of the defects the ground areas are to be examined by dye penetrant methods in the presence of the Surveyor. The welding grooves are to be prepared in such a manner which will allow a good fusion of the groove bottom.

300. Welding repair procedure

301. Metal arc welding is recommended for all types of repair on bronze propellers. For material thickness less than 30 mm, gas welding may give a satisfactory weldment for CU 1 and CU 2 materials. Arc welding with coated electrodes and gas-shielded metal arc process (GMAW) are generally to be applied. Argon-shielded tungsten welding (GTAW) should be used with care due to the higher specific heat input of this process. Recommended filler metals, pre-heating and stress relieving temperatures are listed in Table T.G15.301.1

302. Adequate pre-heating is to be carried out with care to avoid local overheating, c. f. Table T.G15.301.1

303. All propeller alloys are generally to be welded in down-hand (flat) position. Where this cannot be done, gas-shielded metal arc welding should be carried out. The section to be welded is to be clean and dry. Flux-coated electrodes are to be dried before welding according to the maker's instructions. To minimize distortion and the risk of cracking, interpass temperatures are to be kept low. This is especially the case with CU 3 alloys. Slag,

undercuts and other defects are to be removed before depositing the next run.

304. All welding work is to be carried out preferably in the shop free from draughts and influence of the weather.

305. With the exception of alloy CU 3 (Ni-Al-bronze) all weld repairs are to be stress relief heat treated, in order to avoid stress corrosion cracking. However, stress relief heat treatment of alloy Cu 3 propeller castings may be required after major repairs in zone B (and specially approved welding in Zone A) or if a welding consumable susceptible to stress corrosion cracking is used. In such cases the propeller is to be either stress relief heat treated in the temperature 450 to 500˚C or annealed in the temperature range 650-800˚C, depending on the extent of repair, c. f. Table T.G15.301.1

306. The soaking times for stress relief heat treatment of copper alloy propellers should be in accordance with Table T.G15.306.1. The heating and cooling is to be carried out slowly under controlled conditions. The cooling rate after any stress relieving heat treatment shall not exceed 50˚C/h until the temperature of 200˚C is reached.

TABLE T.G15.301.1 - RECOMMENDED FILLER METALS AND HEAT TREATMENTS

Alloy type	Filler metal	Preheat temperature ^{o}C [min]	Interphase temperature ^{o}C [min]	Stress relief temperature ^{o}C	Hot straightening temperature ^{o}C
CU1	Al-bronze[1)] Mn-bronze	150	300	350-500	500-800
CU2	Al-bronze Ni-Mn-bronze	150	300	350-550	500-800
CU3	Al-bronze Ni-Al-bronze[2)] Mn-Al-bronze	50	250	450-500	700-900
CU4	Mn-Al-bronze	100	300	450-600	700-850

Notes:
1) Ni-Al-bronze and Mn-Al-bronze are acceptable
2) Stress relieving not required, if filler-metal Ni-Al-bronze is used

TABLE T.G15.306.1- SOAKING TIMES FOR STRESS RELIEF HEAT TREATMENT OF COPPER ALLOY PROPELLERS

Stress relief temperature ^{o}C [min]	Alloy grade CU1 and CU2		Alloy grade 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	1/2	2	5	15
500	1/4	1	1	5
550	1/4	1/2	1/2 [1)]	2 [1)]
600	-	-	1/4 [1)]	1 [1)]

Note: [1)] 550 ^{o}C and 600 ^{o}C only applicable for CU4 alloys

G16. STRAIGHTENING

100. Application of load

101. For hot and cold straightening purposes, static loading only is to be used.

200. Hot straightening

201. Straightening of a bent propeller blade or a pitch modification should be carried out after heating the bent region and approximately 500 mm wide zones on either side of it to the suggested temperature range given in T.G15.301.1.

202. The heating should be slow and uniform and the concentrated flames such as oxy-acetylene and oxy-propane should not be used. Sufficient time should be allowed for the temperature to become fairly uniform through the full thickness of the blade section. The temperature must be maintained within the suggested range throughout the straightening operation. A thermocouple instrument or temperature indicating crayons should be used for measuring the temperature.

300. Cold straightening

301. Cold straightening should be used for minor repairs of tips and edges only. Cold straightening on Cu 1, Cu 2 and Cu 4 bronze should always be followed by a stress relieving heat treatment, see T.G15.301.1.

G17. WELDING PROCEDURE AND WELDER'S QUALIFICATION TEST [Apendix A]

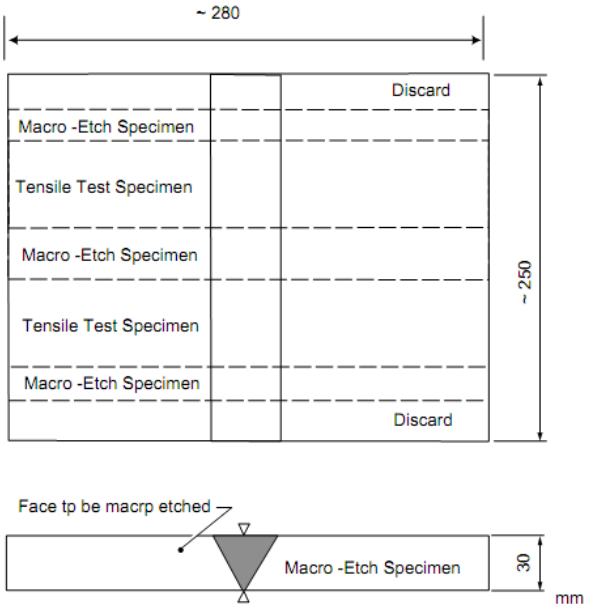
100. General

101. The qualification test is to be carried out with the same welding process filler metal, preheating and stress-relieving treatment as those intended applied by the actual repair work.

200. Test sample

201. A test sample of minimum 30 mm thickness is to be welded in down-hand (flat) position. The test specimens to be prepared and their dimensions are shown in Figure F.G17.201.1..

TABLE T.G17.201.1 – TEST SPECIMEN



300. Qualification testing

301. **Non-destructive testing**: After completion, the weldment is to be 100% tested by a dye-penetrant method. No cracks are permitted.

302. **Macro-etching**: Three macro-etch samples should be prepared (see Figure F.G17.201.1 A suitable etchant for this purpose is:

a. 5 g iron (III) chloride

b. 30 ml hydrochloric acid (cone)

c. 100 ml water.

a. Pores greater than 3 mm and cracks are not permitted.

303. **Mechanical testing**: Two tensile tests should be prepared as shown in Part III, Title 61, Section 2, Subchapter A5.The table requirements to the tensile strength, as given in Table T.G17.303.1,should be met. Alternatively tensile test specimens according to recognized standards may be used.

TABLE T.G17.303.1 – REQUIRED TENSILE STRENGTH VALUES

ALLOY TYPE	TENSILE STRENGH, N/mm^2, min
CU 1	370
CU 2	410
CU 3	500
CU 4	550

CHAPTER H

DIESEL ENGINES

CONTESTS

H1. APLICATION
[IACS UR M28/ M32]

100. General

101. Scope

102. These Guidelines apply to mass and non-mas produced internal combustion engines, which are manufactured in accordance with the Rules of RBNA and for which the manufacturer has received an approval as a supplier of mass produced and non-mass produced engines from RBNA.

104. For the purpose of these requirements, internal combustion engines are diesel engines.

105. The scope of these Guidelines is limited to engines with cylinder bores of ≤ 300 mm.

106. RBNA will decide which engine types / engine series meet the requirements for the application of these Guidelines.

107. Engines for which a mass production approval has already been issued and which are to be supplied with RBNA Class are subject to the requirements of the tests in H5 below.

200. Ambient reference conditions [IACS UR M28]

201. The following ambient reference conditions apply for ships of unrestricted service:

a. Total barometric pressure 1000 mbar

b. Air temperature +45°C

c. Relative humidity 60%

d. Sea water temperature 32°C. (charge air coolant-inlet temperature of charge air coolers subject to seawater)

202. Note: The engine manufacturer shall not be expected to provide simulated ambient reference conditions at a test bed.

300. Definition of diesel engine type [IACS UR M32]

301. Engines are of the same type if they do not vary in any detail included in the definition in H1.302 below. When two engines are to be considered of the same type it is assumed that they do not substantially differ in design and their design details, crankshaft, etc., and the materials used meet Rule requirements and are approved by the RBNA.

302. The type of internal combustion engine expressed by the Engine Builder's designation is defined by:

a. the bore,

b. the stroke,

c. the method of injection (direct or indirect injection),

d. the kind of fuel (liquid, dual-fuel, gaseous),

e. the working cycle (4-stroke, 2-stroke);

f. the gas exchange (naturally aspirated or supercharged);

g. the maximum continuous power per cylinder at maximum continuous speed and/or maximum

h. continuous brake mean effective pressure;[1]

i. the method of pressure charging (pulsating system, constant pressure system);

j. the charging air cooling system (with or without intercooler, number of stages);

k. cylinder arrangement (in-line, vee).[2]

NOTE:[1.] After a large number of engines has been proved successfully by service experience, an increase in power up to maximum 10% may be permitted, without any further type test, provided approval for such power is given.

[2.] One type test suffices for the whole range of engines having different numbers of cylinders.

400. Definition of mass production [UR M14]

401. Mass production may be defined, in relation to construction of marine engines for main and auxiliary purposes, as that machinery which is produced:

a. in quantity under strict quality control of material and parts specified by the engine manufacturer and recognized by the RBNA;

b. by the use of jigs and automatic machines designed to machine parts to close tolerances for interchangeability, and which are to be verified on a regular inspection basis;

c. by assembly with parts taken from stock and requiring little or no fitting of the parts and which is subject to;

d. bench tests carried out on individual engines on a programme basis;

e. appraisal by final testing of engines selected at random after bench testing.

402. It should be noted that all castings, forgings and other parts for use in the foregoing machinery are also to be produced by similar methods with appropriate inspection.

403. The specification for machinery produced by the forgoing method must define the limits of manufacture of all component parts. The total production output is to be certified by the Manufacturer and verified as may be required, by the inspecting authority.

Guidance:

The following procedure applies to the inspection of mass produced internal combustion engines having a bore not exceeding 300 mm.

The components of mass produced engines must be manufactured on machining units which have been specially adjusted for that purpose and which are

subjected to the inspections necessary to quality assurance.

The engine components, the materials and spares must completely satisfy the engine manufacturer's quality requirements and recognized by RBNA, must be interchangeable and must be able to be fitted without reworking or adaptation.

End of guidance

H2. PROGRAMME FOR TYPE TESTING OF NON-MASS PRODUCED I.C. ENGINES [IACS UR M50]

100. General. Upon finalization of the engine design for production of every new engine type intended for the installation on board ships, one engine shall be presented for type testing as required by RBNA. For this purpose a type approval test in accordance with the scope in H2.104 below is to be performed.

101. A type test carried out for a particular type of engine at any place at any manufacturer will be accepted for all engines of the same type built by licensees and licensors.

102. Engines which are subjected to type testing are to be tested in accordance to the scope as specified below.

103. It is taken for granted that:

a. this engine is optimised as required for the condition of the type,

b. the investigations and measurements required for reliable engine operation have been carried out during internal tests by the engine manufacturer and

c. the design approval has been obtained for the engine type in question on the basis of documentation requested Part II, Title 11, Section 5, Subchapter E3 and RBNA has been informed about the nature and extent of investigations carried out during the pre-production stages.

104. The type test is subdivided into three stages, namely:

105. **Stage A - Internal tests.** Functional tests and collection of operating values including test hours during the internal tests, the relevant results of which are to be presented to the Classification Societies during the type test. Testing hours of components which are inspected according to H3.300 shall be stated.

106. **Stage B - Type approval test.** Test approval test in the presence of the Classification Societies' representatives.

107. **Stage C - Component inspection.** Component inspections by the Classification Societies after completion of the test programme.

108. The engine manufacturer will have to compile all results and measurements for the engine tested during the type test in a type test report, which will have to be handed over to the Classification Society in question.

200. Stage A - Internal tests. Function tests and collection of operating data during the internal tests.

201. During the internal tests the engine is to be operated at the load points important for the engine manufacturer and the pertaining operating values are to be recorded. The load points may be selected according to the range of application.

202. If an engine can be satisfactorily operated at all load points without using mechanically driven cylinder lubricators this is to be verified.

203. For engines which may operate of heavy fuel oil, the suitability for this will have to be proved in an appropriate form, at Manufacturer's (Licensor or Licensee) testbed in general, but, where not possible, latest on board for the first engine to be put into service.

204. **Normal case**. The normal case includes:

205. The load points 25%, 50%, 75%, 100% and 110% of the maximum rated power:

a. along the nominal (theoretical) propeller curve and at constant speed for propulsion engines

b. at constant speed for engines intended for generating sets.

206. The limit points of the permissible operating range. These limit points are to be defined by the engine manufacturer.

207. **Emergency operation situations**

208. For turbocharged engines the achievable continuous output is to be determined in the case of turbocharger damage.

a. engines with one turbocharger, when rotor is blocked or removed

b. engines with two or more turbochargers, when damaged turbochargers are shut off.

300. Stage B - TYPE APPROVAL TEST

301. During the type test the tests listed under are to be carried out in the presence of RBNA and the results achieved are to be recorded and signed by the attending

representatives. Deviations from this programme, if any, are to be agreed between the engine manufacturer and RBNA.

302. Load points: Load points at which the engine is to be operated according to the power/speed diagram (figure F.H2.302.1). The data to be measured and recorded when testing the engine at various load points are to include all necessary parameters for the engine operation.

303. The operating time per load point depends on the engine size (achievement of steady-state condition) and on the time for collection of the operating values. Normally, an operating time of 0.5 hour can be assumed per load point.

304. At the rated power as per H2.206 and operating time of two hours is required. Two sets of readings are to be taken at a minimum interval of one hour.

305. Rated power, i.e. 100% output at 100% torque and 100% speed corresponding to load point 1.

306. 100% power at maximum permissible speed corresponding to load point 2.

307. Maximum permissible torque (normally 110%) at 100% speed corresponding to load point 3. or maximum permissible power (normally 110%) and speed according to nominal propeller curve corresponding to load point 3a.

308. Minimum permissible speed at 100% torque corresponding to load point 4.

309. Minimum permissible speed at 90% torque corresponding to load point 5.

310. Part loads, e.g. 75%, 50%, 25% of rated power and speed according to nominal propeller curve corresponding to points 6, 7 and 8. and at rated speed with constant governor setting corresponding to points 9, 10 and 11.

311. Emergency operation. Maximum achievable power when operating along the nominal propeller curve and when operating with constant governor setting for rated speed as per H2.207.

312. Functional tests. Lowest engine speed according to nominal propeller curve. Starting tests, for non-reversible engines and/or starting and reversing tests, for reversible engines.

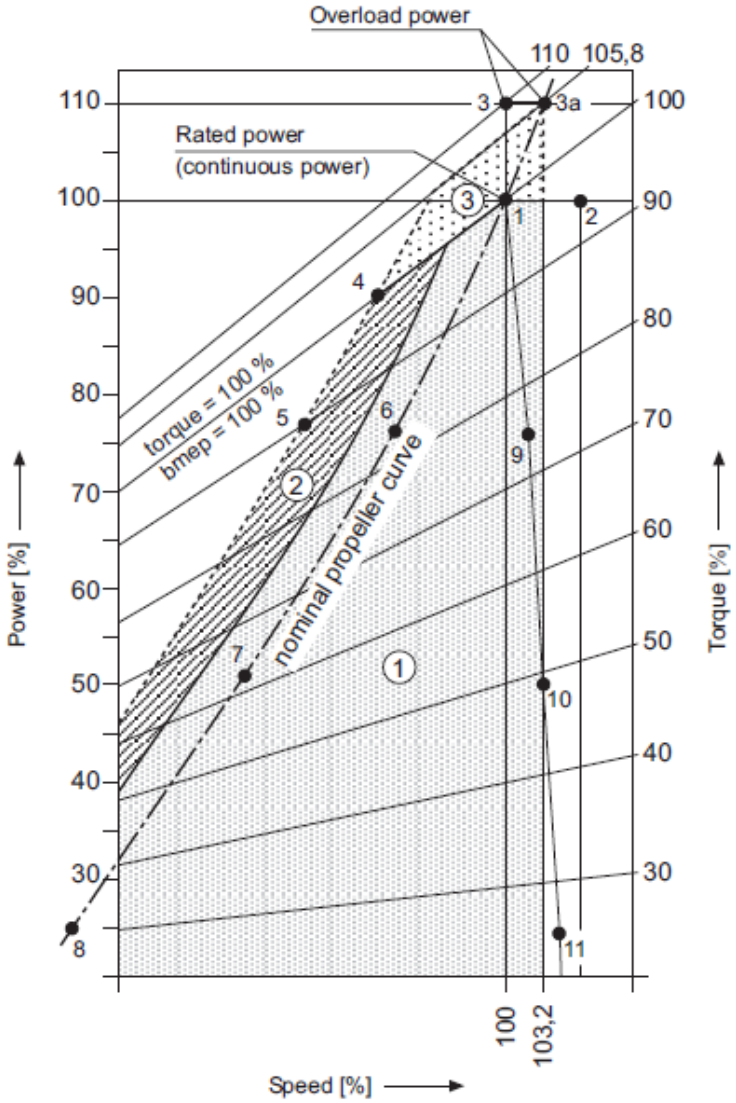
313. Governor test. Testing the safety system, particularly for overspeed and low lub. oil pressure.

314. Integration Test: For electronically controlled diesel engines integration tests shall verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes. The scope of these tests shall be agreed with the Society for selected cases based on the FMEA required in Part II, Title 11, Section 5, Subchapter E3

315. For engines, intended to be used for emergency services supplementary tests according to the regulations of administration may be required.

316. The performance points are required to conform to the power/speed diagram F.H2.302.1 and Table T.H2.316.

FIGURE. F.H2.302.1. POWER/SPEED DIAGRAM



① = Range of continuous operation

② = Range of intermitted operation

③ = Range of short-time overload operation in special applications

TABLE T.H2.316.1 – PROGRAME TYPE APPROVAL TEST

TEST PROGRAME			
Rated power (continuous power)	80 hours	Point 1	100% power
			100% torque
			100% speed (rated speed)
Power 100%	1 hour	Point 2	100% power
			Maximum permissible speed
Maximum permissible torque	8 hours	Point 3	110% torque
			100 % speed
		Point 3a	Maximum permissible power (normally 110 %)
			Speed according to nominal propeller curve
Minimum permissible speed for intermitted operation	0,5 hour	Point 4	100% torque
	0,5 hour	Point 5	90% torque
Partial load operation	8 hours	Point 6	75% of rated power
			Speeds according to nominal propeller curve
		Point 7	50% of rated power
			Speeds according to nominal propeller curve
		Point 8	25% of rated power
			Speeds according to nominal propeller curve
		Points 9, 10 e 11	Started from rated speed with constant governor setting
Intermitted load	-	-	100% power
			No load
Emergency operation			Maximum achievable power when operating along the nominal propeller curve and when operating with constant governor setting for rated speed as per H3.207 above.

Functional test	-	-	Test of minimum on-load speed for main propulsion engines and of idling speed for auxiliary engines
			Starting test and, where applicable, reversing manoeuvres
			Speed governor test
			Test of safety systems: - overspeed device - failure of lubricating oil system
			Test of engine with turbocharger out of action (where applicable)
			Integration Test: For electronically controlled diesel Engines integration tests shall verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes. The scope of these tests shall be agreed with the Society for selected cases based on the FMEA required in Part II, Title 11, Section 5, Subchapter E3.

NOTE: For engines, intended for various applications involving differing power and speed conditions, the type approval program and the testing periods are to be increased to cover the entire output and speed range of the engine type. For heavy-fuel engines, sutable proof is required of heavy-fuel operation capacity. The testing program is to be agreed with RBNA.

400. Stage C - Component inspection

401. Immediately after the test run the components of one cylinder for in-line engines and two cylinders for V-engines are presented for inspections.

402. The following components are concerned:

a. Piston removed and dismantled

b. Crosshead bearing, dismantled

c. Crank bearing and main bearing, dismantled

d. Cylinder liner in the installed condition

e. Cylinder head, valves disassembled

f. Control gear, camshaft and crankcase with opened covers.

403. NOTE: If deemed necessary by the representative of Classification Society further dismantling of the engine may be required.

500. Notes

501. If a type tested engine which has proven reliability in service is increased in output by not more than 10%, new type approval test is not necessary as laid down in H1.300. The agreement for granting an increased output will be subject to prior plan approval.

502. Each engine type has to be type tested as per definition of engine type given in H1.300.

503. If an electronically controlled diesel engine has been type tested as a conventional engine the Society may waive tests required by this requirement provided the results of the individual tests would be similar

H3. PROGRAMME FOR TYPE TESTING OF MASS PRODUCED I.C. ENGINES [UR M5]

100. Procedure for approval of mass production

101. Request for approval - documents to be submitted upon requesting approval for mass production of a type of internal combustion engine, the Manufacturer must submit all the necessary data concerning this type of engine:

a. Drawings

b. Technical specification of the main parts operation

c. maintenance manuals

d. list of subcontractors for the main parts.

200. Examination of the manufacturing processes and quality control procedures:

201. The Manufacturer will supply full information regarding the manufacturing processes and quality control procedures applied in the workshops. These processes and procedures will be thoroughly examined on the spot by the Surveyors. The examination will specially concern the following points:

a. organisation of quality control systems

b. recording of quality control operations

c. qualification and independence of personnel in charge of quality control.

202. Type test: A running test of at least 100 hours duration will be carried out on an engine chosen in the production line. The programme of this test is examined specially for each case.

203. At the end of the test, the main parts of the engine will be disassembled and examined.

204. Omission of the test for engines of well known type will be considered.

205. Validity of approval: The Classification Society reserves the right to limit the duration of validity of the approval.

300. Continuous review of production

301. Access of Surveyors to the Workshops:
The Classification Society Surveyors must have free access to the Workshops and to the Control Service premises and files.

302. Survey of production

a. Inspection and testing records are to be maintained to the satisfaction of the Surveyor.

b. The system for identification of parts is to be approved.

c. The Manufacturer must give full information about the quality control of the parts supplied by subcontractors, for which approval may be required.

303. The Classification Society reserves the right to apply direct and individual inspection procedures for parts supplied by subcontractors when deemed necessary.

304. Individual bench test:
The Classification Society may require that a bench test be made under supervision of the Surveyor.

400. Compliance and inspection certificate

401. For every engine liable to be installed on a ship classed by the Classification Society, the Manufacturer is to supply a statement certifying that the engine is identical to the one which underwent the tests specified in H8.400 and give the inspection and test result.

402. This statement is to be made on a form agreed with the Classification Society. Each statement bears a number which is to appear on the engine. A copy of this statement is to be sent to the Classification Society.

Guidance

Renewal of type test : if a type tested engine which has proven reliability in service is increased in output by not more than 10%, new type approval test is not necessary as laid down. Approval of the power increase includes examination of the relevant drawings.

If an electronically controlled diesel engine has been type tested as a conventional engine the RBNA may waive tests required by this Requirement provided the results of the individual tests would be similar.

End of guidance

500. Certification and markings [RBNA 2008]

501. After successful conclusion of the test and appraisal of the required documents RBNA issues a Certificate with an approval number attesting approval as a supplier of mass produced engines.

502. The approval is valid for 5 years from date of issue and is based on the manufacturing and quality assurance procedures existing at the time of the approval test.

503. Validity may be renewed on application by the engine manufacturer.

504. Every approval as supplier of mass produced engines is subject to the condition that RBNA has the right to check manufacture and quality assurance at any time and to have random rechecks carried out to ensure that the requirements stated in H2.300 are being observed. RBNA is to be allowed access to all necessary documents.

505. The engine manufacturer is obliged to notify RBNA of any significant design or functional changes as well as of all changes in operating characteristics. RBNA will decide whether any supplementary tests additional to the type test need to be performed for maintenance of the awarded approval.

H4. PROGRAMME FOR TRIALS OF MASS PRODUCED I.C. ENGINES TO ASSESS OPERATIONAL CAPABILITY [IACS UR M51]

100. Works trials (acceptance test)

101. The Programme for trials has been written on the assumption that RBNA may require that after the tests the fuel delivery system will be blocked so as to limit the engines to run at not more than 100% power.

102. Engines, which are to be subjected to trials on the test bed at the manufacturer's works and under the RBNA's supervision according to its Rules, are to be tested in accordance with the scope as specified below. Exceptions to this require the agreement of RBNA.

200. Scope of works trials

201. For all stages, the engine is going to be tested the pertaining operation values are to be measured and recorded by the engine manufacturer. All results are to be compiled in an acceptance protocol to be issued by the engine manufacturer.

202. In each case all measurements conducted at the various load points shall be carried out at steady operating conditions. The readings for 100% power (rated power at rated speed) are to be taken twice at an interval of at least 30 minutes.

203. **Main engines driving propellers**

a. 100% power (rated power) at rated engine speed n_o: at least 60 min – after having reached steady conditions.

b. 110% power at engine speed n – 1,032 n_o: 30-45 min – after having reached steady conditions. NOTE: After running on the test bed, the fuel delivery system of main engines is normally to be so adjusted that overload power cannot be given in service.

c. 90% (or normal continuous cruise power), 75%, 50% and 25% power in accordance with the nominal propeller curve.

d. Starting and reversing manoeuvres.

e. Testing of governor and independent overspeed protective device.

f. Shut down device.

204. **Main engines driving generators for propulsion.** The test is to be performed at rated speed with a constant governor setting under conditions of:

a. 100% power (rated power) at rated engine speed: at least 50 min – after having reached steady conditions.

b. 110% power: 30 min – after having reached steady conditions.

NOTE: After running on the test bed, the fuel delivery system of diesel engines driving generators must be adjusted such that overload (110%) power can be given in service after installation on board, so that the governing characteristics including the activation of generator protective devices can be fulfilled at all times.

c. 75%, 50% and 25% power and idle run.

d. Start-up tests.

e. Testing of governor and independent overspeed protective device.

f. Shut-down device.

205. **Engines driving auxiliaries.** Test to be performed in accordance with H4.204.

NOTE: After running on the test bed, the fuel delivery system of diesel engines driving generators must be adjusted such that overload (110%) power can be given in service after installation on board, so that the governing characteristics including the activation of generator protective devices can be fulfilled at all times.

206. **Inspection of components:** Random checks of components to be presented for inspection after the works trials are left to the discretion of the Society.

207. **Parameters to be measured:** The data to be measured and recorded, when testing the engine at various load points are to include all necessary parameters for the engine operation. The crankshaft deflection is to be checked when this check is required by the manufacturer during the operating life of the engine.

208. In addition the scope of the trials may be expanded depending on the engine application.

209. Integration tests: For electronically controlled diesel engines integration tests shall verify that the response of the complete mechanical, hydraulic and electronic system is as predicted for all intended operational modes. The scope of these tests shall be agreed with the Society for selected cases based on the FMEA required in Part II, Title 11, Section 5, Subchapter E3.

300. Shipboard trials.

301. Scope of trials. After the conclusion of the running-in programme, prescribed by the engine manufacturer, engines are to undergo the trials as specified below:

302. **Main propulsion engines driving fixed propellers**

a. At rated engine speed n_o: at least 4 hours and at engine speed corresponding to normal continuous cruise power: at least 2 hours;

b. At engine speed n = 1,032 n_o: 30 minutes (where the engine adjustment permits, see H4.203 b);

c. At minimum on-load speed;

d. Starting and reversing manoeuvres;

e. In reverse direction of propeller rotation during the dock or sea trials at a minimum engine speed of n = 0,7n_o: 10 minutes;

f. Monitoring, alarm and safety systems.

303. **Main propulsion engines driving controllable pitch propellers** or reversing gears H4.302 applies as appropriate. Controllable pitch propellers are to be tested with various propeller pitches.

304. **Single main engines driving generators for propulsion.** The tests to be performed at rated speed with a constant governor setting under conditions of:

a. 100% power (rated propulsion power): at least 4 hours and at normal continuous cruise propulsion power: at least 2 hours;

b. 110% power (rated propulsion power): 30 minutes;

c. In reverse direction of propeller rotation at a minimum speed of 70% of the nominal propeller speed: 10 minutes;

d. Starting manoeuvres;

e. Monitoring, alarm and safety systems.

Guidance RBNA 2008

Component tests*. All components subject to compulsory inspection under RBNA Rules are tested by the manufacturer and marked with evidence of the tests applied. Stamping of individual components by RBNA is not required.*

For tests on the materials of crankshaft and connecting rods, Acceptance Test Certificates (according to DIN 50 049 - 3.1.B) completed by the works are to be presented to the RBNA Surveyor which shall indicate the requirements and the actual values of the mechanical characteristics and chemical composition of the material. It must be possible to identify the components by reference to the Works Certificates.

The engine manufacturer is required to guarantee that the spares and reserve parts subject to compulsory inspection under RBNA Rules conform to the current Rules.

The manufacturer has to mark the parts so that they can be recognized as original spares.Stamping of individual components by RBNA is not required.

The results of the type approval test are to be compiled in a report which is to be submitted to RBNA.

The report has to contain the following details:

a) technical engine data;
b) test conditions in accordance with the list of test condition below;
c) operating parameters in accordance with list below;
d) results of follow-up inspection in accordance with the component inspection (c)below.

a) Test conditions:

a. ambient temperature;
b. barometric pressure;
c. relative humidity of air;
d. external cooling water temperature at inlet;
e. characteristics of fuel and lubricating oil.

b) Operating parameters. During the type test, at least the operating parameters listed below for the various loading points are to be measured and recorded at regular intervals:

a. torque or brake load;
b. engine speed;
c. engine power;
d. maximum combustion pressure (indicator diagrams if possible);
e. exhaust smoke (blackening index);
f. lubricating oil pressure and temperature;
g. cooling water pressure and temperature;
h. exhaust gas temperature in exhaust manifold and, if possible, at each cylinder outlet.

c) Component inspection.

After the type test all major parts of the engine are to be dismantled for inspection. The results of the component

inspections are to be placed on record. Important parts are to be photographed.

d) Additional information for turbocharged engines:
- *a. turbocharger speed;*
- *b. air temperature and pressure at turbocharger and charge air cooler inlet and outlet;*
- *c. exhaust gas temperature and pressure at exhaust gas turbine inlet and outlet;*
- *d. inlet temperature of charge air cooling water.*

End of guidance

400. Engine documents to be submitted [RBNA 2008]

401. The engine manufacturer has to present to the RBNA Surveyor the following documents: on occasion of the bench test

a. The engine manufacturer's confirmation that the engine presented for Classification meets the engine manufacturer's quality requirements on which the RBNA approval as supplier of mass produced engines is based.

b. Works Test Certificates for: testing of crankshaft material; testing of connecting rod material for engines with a cylinder bore of > 150 mm; important attachments where demanded by the Surveyor;

500. Engine stamping [RBNA 2008]

501. On completion of the tests, a RBNA Test Certificate indicating the mass produced engine approval number is issued for each mass produced engine. Each engine is stamped with the RBNA Test Certificate number, the test date (month and year), the responsible for the testing person (Surveyor's inicials), see the table below.

TABLE T.H 5.700.1 – EXAMPLE OF STAMP

RBNA 250 WCV 23.08.02

H5. PARTS OF INTERNAL COMBUSTION ENGINES FOR WHICH MATERIAL TESTS ARE REQUIRED [IACS UR M18]

100. Approved materials

101. The mechanical characteristics of materials used for the components of diesel engines shall conform to RBNA Rules Part III, Title 62, Section 5, Chapters A to F.

102. Parts for which material tests are required as given in item H5.103 are the following ones:

a. Crankshaft

b. Crankshaft coupling flange (non-integral) for main power transmissions

c. Coupling bolts for crankshaft

d. Steel piston crown

e. Piston rod

f. Connecting rod together with connecting rod bearing caps

g. Crosshead

h. Cylinder liner, steel parts

i. Steel cylinder cover

j. Bedplates of welded construction: plates and transverse bearing girders made of forged or cast steel

k. Frame and crankcase of welded construction

l. Entablatures of welded construction

m. Tie rods

n. Supercharger shaft and rotor, including blades. (Supercharger is understood as turbochargers and engine driven compressors (incl. "Root blowers"), but not auxiliary blowers.)

o. Bolts and studs for: cylinder covers, crossheads, main bearings, connecting rod bearings

p. Steel gear wheels for camshaft drives.

103. Material tests are required in accordance with the following:

Bore, b (mm)	Parts to be tested (numbered acc. to the list under H6.100)
b ≤ 300	1,6,10,11,12,13
300< b ≤ 400	1,6,8,9,10,11,12,13,14,15
b > 400	All parts

104. This list does not deal with the following items for which material tests may also be required: pipes and accessories of the air starting system and, possibly, other pressure systems, which are parts of engines.

105. All required material tests are to be witnessed in the presence of the RBNA's representative.

H6. PARTS OF INTERNAL COMBUSTION ENGINES FOR WHICH NONDESTRUCTIVE TESTS ARE REQUIRED [IACS UR M19]

100. The list given below covers only individually produced engines.

102. Parts for which non-destructive tests are required as given in H6.103 and H6.104 are the following:

a. Cast steel elements, including their welded connections, for bedplates (e.g. main bearing housings)
b. Solid forged crankshafts

c. Cast rolled or forged parts of fully built steel crankshafts

d. Cast or forged parts of semi-built steel crankshafts

e. Connecting rods

f. Piston rods

g. Steel piston crowns

h. Tie rods (NOTE: Magnetic particle test of tie rods be carried out at each threaded portion which is twice the length of the thread.)

i. Bolts which receive a direct fluctuating load: main bearing bolts, connecting rod bolts, crosshead bearing bolts, cylinder cover bolts

j. Steel cylinder covers

k. Steel gear wheels for camshaft drives.

103. Magnetic particle or liquid penetrant tests are required in accordance with the following and are to be at positions mutually agreed by the Surveyor and manufacturer, where experience shows defects are most likely to occur:

Bore, b (mm)	Parts to be tested (numbered acc. to the list under H6.100)
b ≤ 400	1,2,3,4,5
b > 400	All parts

104. Ultrasonic testing is required, with Maker's signed certificate, in accordance with the following:

Bore, b (mm)	Parts to be tested (numbered acc. to the list under H6.100)
b ≤ 400	1,2,3,4,7,10
b > 400	1,2,3,4,5,6,7,10

105. For important structural parts of engines, examination of welded seams by approved methods of inspection may be required.

106. In addition to tests mentioned above, where there is evidence to doubt the soundness of any engine component, non-destructive test by approved detecting methods may be required.

H7. TEST PRESSURES FOR PARTS OF INTERNAL COMBUSTION ENGINES [1] [IACS UR M6]

100. The individual components of internal combustion engines are subject to pressure tests at the pressures specified in table T.H7.100.1. RBNA Certificates are to be issued for the results of the pressure tests.

TABLE T.H7.100.1.TEST PRESSURES FOR PARTS OF INTERNAL COMBUSTION ENGINES [1)]

No.	Item		Test pressure [2)] [bar][3)]
1.	**Cylinder cover**, cooling space[4)]		7
2.	**Cylinder liner,** over whole cooling cylinder space		7
3.	**Cylinder jacket,** cooling space		4 but not less than 1.5 P
4.	**Exhaust valve**, cooling space		4 but not less than 1.5 P
5.	**Piston crown**, cooling space(where the cooling space is sealed by piston rod or by piston rod and skirt, test after assembly)[4)]		7
6.	**High pressure fuel injection system**	Fuel injection pump body, pressure side	1.5.P or P+300 whichever is the less
		Fuel injection valve	1.5.P or P+300 whichever is the less
		Fuel injection pipes	1.5.P or P+300 whichever is the less
7.	**Hydraulic system**	Piping, Pumps, actuators, etc. for hydraulic drive of valves	1.5.P
8.	**Scavenge pump cylinder**		4
9.	**Turboblower**, cooling space		4 but not less than 1.5 P
10.	**Exhaust pipe**, cooling space		4 but not less than 1.5 P
11.	**Engine driven air compressor** (cylinder, covers, intercoolers and aftercoolers)	Air side	1.5.P
		Water side	4 but not less than 1.5 P
12.	**Coolers,** each side[5)]		4 but not less than 1.5 P
13.	**Engine driven pumps** (oil, water, fuel, bilge)		4 but not less than 1.5 P

NOTES

1) In general, items are to be tested by hydraulic pressure as indicated in the Table T.H7.100.1. Where design or testing features may require modification of these test requirements, special consideration will be given.
2) P is the maximum working pressure in the part concerned.
3) 1 bar = 0,1 MPa = 0,1 N/mm^2.
4) For forged steel cylinder covers and forged steel piston crowns test methods other than pressure testing may be accepted. e.g. suitable non-destructive examination and dimensional control properly recorded.
5) Charge air coolers need only be tested on the water side

H8. MASS PRODUCTION OF ENGINES: MASS PRODUCED EXHAUST DRIVEN TURBOBLOWERS [IACS UR M23]

100. Field of application

101. The following procedure applies to the inspection of exhaust driven turboblowers which are manufactured on the basis of mass production methods and for which the maker has requested the approval.

200. Request for approval: documents to be submitted.

201. When the manufacturer of turboblowers built on the basis of mass production methods applies for a simplified method of inspection, the following documentation must be submitted in triplicate:

a. cross-sectional drawings with main dimensions,

b. drawings with necessary dimensions and material specifications as well as welding details of the rotating parts (shaft, wheels and blades),

c. technical specifications including maximum operating conditions (maximum permissible r.p.m. and maximum permissible temperature),

d. list of main current suppliers and subcontractors for rotating parts,

e. operation and maintenance manuals.

300. Material and quality control.

301. The manufacturer will supply full information regarding the control organization as well as the inspection methods, the way of recording and proposed frequency, and the method of material testing of important parts.
These processes and procedure will be thoroughly examined on the spot by the Surveyor.

400. Type test

401. The type test is to be carried out on a standard unit taken from the assembly line and is to be witnessed by the Surveyor.

402. Normally the type test is to consist of a hot running test of one hour's duration at maximum permissible speed and maximum permissible temperature. After the test the turboblower is to be opened up and examined.

403. Notes:

a. The performance data which may have to be verified are to be made available at the time of the type test.

b. For manufacturers who have facilities for testing the turboblower unit on an engine for which the turboblower is to be type approved, substitution of the hot running test by a test run of one hour's duration at overload (110% of the rated output) may be considered.

500. Validity of approval

501. RBNA reserves the right to limit the duration of validity of approval.

502. The approval will be invalid if there are any changes in the design, in the manufacturing or control processes or in the characteristics of the materials which haven not been approved in advance by RBNA.

600. Continuous inspection of individual units

601. Inspection by the Surveyor. The Surveyors must have the right to inspect at random the quality control measures and to witness the under mentioned tests as deemed necessary, as well as to have free access to all control records and subcontractors certificates.

602. **Testing of individual units**. Each individual unit is to be tested in accordance with H8.604 – H8.607 by the maker who is to issue a final certificate.

603. **Identification of parts.** Rotating parts of the turboblower are to be marked for easy identification with the appropriate certificate.

604. **Material tests**. Material tests of the rotating parts are to be carried out by the maker or his subcontractor in accordance with the Classification Society's approval. The relevant certificate is to be produced and filed to the satisfaction of the Surveyor.

605. **Pressure tests**. The cooling space of each gas inlet and outlet casings is to be hydraulically tested at pressure of either 0,4 N/mm^2 (4bar) or 1,5 times the maximum working pressure, whichever is the greater.

606. **Balancing and overspeed test**.

a. Each shaft and bladed wheel as well as the complete rotating assembly has to be individually dynamically balanced in accordance with the approved procedure for quality control.

b. All wheels (impellers and inducers) have to undergo an overspeed test for 3 minutes at 20% over the maximum speed at room temperature or 10% over the maximum speed at working temperature.

c. If each forged wheel is individually controlled by an approved non-destructive examination method no overspeed test may be required except for wheels of type test unit.

607. **Bench test**

a. A mechanical running test of each unit for 20 minutes at maximum speed has to be carried out. NOTE. Subject to the agreement of each individual Society, the duration of the running test may be reduced to 10 minutes provided that the manufacturer is able to verify the distribution of defects established during the running tests on the basis of a sufficient number of tested turbo-charges.

b. For manufacturers who have facilities in their Works for testing the turboblowers on an engine for which the turboblowers are intended, the bench test may be replaced by a test run of 20 minutes at overload (110% of the rated output) on this engine.

700. Compliance and certificate

701. For every turboblower unit liable to be installed on an engine intended for a ship classed by a Classification Society, the Manufacturer is to supply a statement certifying that the turboblower is identical with one that underwent the tests specified in H8.400 and that prescribed tests were carried out. Results of these tests are to be also stated.

702. This statement is to be made on a form agreed with the Classification Society and copy is to be sent to the Classification Society.

703. Each satement bears a number which is to appear on the turboblower.

704. NOTE. In general, the pressure tests are to be carried out as indicated. Special consideration will be given where design or testing features may require modification of the test requirements.

H9. CHARGE AIR COOLERS [IACS UR M58]

100. Approval of charge air coolers

101. Plan approval. For charge air coolers, plans are not required for approval.

102. Welding and materials. Materials are to be supplied with work certificates. Welding procedures and welders qualified by a recognised body are to be employed.

103. Testing. Hydrostatic test on charge air cooler water side at 0.4 Nmm^2 (but not less than 1.5 times the maximum working pressure) is required.

CHAPTER I STEERING GEAR

CHAPTER CONTENTS

I1. STEERING GEAR: TESTS AT THE MANUFACTURER

100. Steering gear testing [IACS UR M42]

101. The requirements of the Classification Society relating to the testing of Class 1 pressure vessels, piping and relating fittings including hydraulic testing apply (see ASME IX).

102. A power unit pump is to be subjected to a type test.

103. The type test shall be for duration of not less than 100 hours, the test arrangements are to be such that the pump may run in idling conditions, and at maximum delivery capacity at maximum working pressure.

104. During the test, idling periods are to be alternated with periods at maximum delivery capacity at maximum working pressure. The passage from one condition to another should occur at least as quickly as on board.

105. During the whole test no abnormal heating, excessive vibration or other irregularities are permitted. After the test, the pump should be disassembled and inspected. Type tests may be waived for a power unit which has been proven to be reliable in marine service.

106. All components transmitting mechanical forces to the rudder stock should be tested according to the requirements of the Classification Society.

107. After installation on board the vessel the steering gear is to be subjected to the required hydrostatic and running tests.

CHAPTER J
TYPE TESTING PROCEDURE FOR CRANKCASE EXPLOSION RELIEF VALVES

CHAPTER CONTENTS

J1. TYPE TESTING PROCEDURE FOR CRANKCASE EXPLOSION RELIEF VALVES [IACS UR M66]

100. Scope

101. To specify type tests and identify standard test conditions using methane gas and air mixture to demonstrate that classification society requirements are satisfied for crankcase explosion relief valves intended to be fitted to engines and gear cases.

102. This test procedure is only applicable to explosion relief valves fitted with flame arresters.

103. Note: Where internal oil wetting of a flame arrester is a design feature of an explosion relief valve, alternative testing arrangements that demonstrate compliance with this Chapter may be proposed by the manufacturer. The alternative testing arrangements are to be agreed by the classification society.

200. Recognised Standards

201. EN 12874:2001: Flame arresters – Performance requirements, test methods and limits for use.

202. ISO/IEC EN 17025:2005: General requirements for the competence of testing and calibration laboratories.

203. EN 1070:1998: Safety of Machinery – Terminology.

204. VDI 3673: Part 1: Pressure Venting of Dust Explosions.

205. IMO MSC/Circular 677 – Revised Standards for the Design, Testing and Locating of Devices to Prevent the Passage of Flame into Cargo Tanks in Tankers.

206. Note:

a. Engines are to be fitted with components and arrangements complying with this Chapter when:

a.1. the engine is installed on existing ships (i.e. ships for which the date of contract for construction is before 1 July 2008) and the date of application for certification of the engine (i.e. the date of whatever document the Classification Society requires/accepts as an application or request for certification of an individual engine) is on or after 1 July 2008; or

a.2. the engine is installed on new ships (i.e. ships for which the date of contract for construction is on or after 1 July 2008).

b. The “contracted for construction” date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder.

300. Purpose

301. The purpose of type testing crankcase explosion relief valves is fourfold:

a. To verify the effectiveness of the flame arrester.

b. To verify that the valve closes after an explosion.

c. To verify that the valve is gas/air tight after an explosion.

d. To establish the level of over pressure protection provided by the valve.

400. Test facilities

401. Test houses carrying out type testing of crankcase explosion relief valves are to meet the following requirements 402-413:

402. The test houses where testing is carried out are to be accredited to a National or International Standard, e.g. ISO/IEC 17025, and are to be acceptable to the classification societies.

403. The test facilities are to be equipped so that they can perform and record explosion testing in accordance with this procedure.

404. The test facilities are to have equipment for controlling and measuring a methane gas in air concentration within a test vessel to an accuracy of ± 0.1%.

405. The test facilities are to be capable of effective point-located ignition of a methane gas in air mixture.

406. The pressure measuring equipment is to be capable of measuring the pressure in the test vessel in at least two positions, one at the valve and the other at the test vessel centre. The measuring arrangements are to be capable of measuring and recording the pressure changes throughout an explosion test at a frequency recognising the speed of

events during an explosion. The result of each test is to be documented by video recording and by recording with a heat sensitive camera.

406. The test vessel for explosion testing is to have documented dimensions. The dimensions are to be such that the vessel is not "pipe like" with the distance between dished ends being not more than 2.5 times its diameter. The internal volume of the test vessel is to include any standpipe arrangements.

407. The test vessel is to be provided with a flange, located centrally at one end perpendicular to the vessel longitudinal axis, for mounting the explosion relief valve. The test vessel is to be arranged in an orientation consistent with how the valve will be installed in service, i.e., in the vertical plane or the horizontal plane.

408. A circular plate is to be provided for fitting between the pressure vessel flange and valve to be tested with the following dimensions:

a. Outside diameter of 2 times the outer diameter of the valve top cover.

b. Internal bore having the same internal diameter as the valve to be tested.

409. The test vessel is to have connections for measuring the methane in air mixture at the top and bottom.

410. The test vessel is to be provided with a means of fitting an ignition source at a position specified in item 503.

411. The test vessel volume is to be as far as practicable, related to the size and capability of the relief valve to be tested. In general, the volume is to correspond to the requirement in Chapter D for the free area of explosion relief valve to be not less than $115cm^2/m^3$ of crankcase gross volume.

412. Notes:

a. This means that the testing of a valve having $1150cm^2$ of free area would require a test vessel with a volume of $10m^3$.

b. Where the free area of relief valves is greater than 115 cm^2/m^3 of the crankcase gross volume**,** the volume of the test vessel is to be consistent with the design ratio.

c. In no case is the volume of the test vessel to vary by more than +15% to -15% from the design cm^2/m^3 volume ratio.

500. Explosion test process

501. All explosion tests to verify the functionality of crankcase explosion relief valves are to be carried out using an air and methane mixture with a volumetric methane concentration of 9.5% ±0.5%. The pressure in the test vessel is to be not less than atmospheric and is not to exceed the opening pressure of the relief valve.

502. The concentration of methane in the test vessel is to be measured at the top and bottom of the vessel and these concentrations are not to differ by more than 0.5%.

503. The ignition of the methane and air mixture is to be made at the centreline of the test vessel at a position approximately one third of the height or length of the test vessel opposite to where the valve is mounted.

504. The ignition is to be made using a maximum 100 joule explosive charge.

600. Valves to be tested

601. The valves used for type testing (including testing specified in item 603) are to be selected from the manufacturer's normal production line for such valves by the classification society witnessing the tests.

602. For approval of a specific valve size, three valves are to be tested in accordance with J1.603 and J1.700. For a series of valves item J2.200 refers.

603. The valves selected for type testing are to have been previously tested at the manufacturer's works to demonstrate that the opening pressure is in accordance with the specification within a tolerance of ± 20% and that the valve is air tight at a pressure below the openin g pressure for at least 30 seconds.

604. Note: This test is to verify that the valve is air tight following assembly at the manufacturer's works and that the valve begins to open at the required pressure demonstrating that the correct spring has been fitted.

700. Method

701. The following requirements are to be satisfied at explosion testing:

a. The explosion testing is to be witnessed by a classification society surveyor.

b. Where valves are to be installed on an engine or gear case with shielding arrangements to deflect the emission of explosion combustion products, the valves are to be tested with the shielding arrangements fitted.

c. Successive explosion testing to establish a valve's functionality is to be carried out as quickly as possible during stable weather conditions.

d. The pressure rise and decay during all explosion testing is to be recorded.

e. The external condition of the valves is to be monitored during each test for indication of any flame release by video and heat sensitive camera.

f. The explosion testing is to be in three stages for each valve that is required to be approved as being type tested.

702. Stage 1:

a. Two explosion tests are to be carried out in the test vessel with the circular plate described in J1.409 fitted and the opening in the plate covered by a 0.05mm thick polythene film. These tests establish a reference pressure level for determination of the capability of a relief valve in terms of pressure rise in the test vessel, see J2.101(f).

703. Stage 2:

a. Two explosion tests are to be carried out on three different valves of the same size. Each valve is to be mounted in the orientation for which approval is sought i.e., in the vertical or horizontal position with the circular plate described in J1.409 located between the valve and pressure vessel mounting flange.

b. The first of the two tests on each valve is to be carried out with a 0.05mm thick polythene bag, having a minimum diameter of three times the diameter of the circular plate and volume not less than 30% of the test vessel, enclosing the valve and circular plate. Before carrying out the explosion test the polythene bag is to be empty of air. The polythene bag is required to provide a readily visible means of assessing whether there is flame transmission through the relief valve following an explosion consistent with the requirements of the standards identified in item J1.200. During the test, the explosion pressure will open the valve and some unburned methane/air mixture will be collected in the polythene bag. When the flame reaches the flame arrester and if there is flame transmission through the flame arrester, the methane/air mixture in the bag will be ignited and this will be visible.

c. Provided that the first explosion test successfully demonstrated that there was no indication of combustion outside the flame arrester and there are no visible signs of damage to the flame arrester or valve, a second explosion test without the polythene bag arrangement is to be carried out as quickly as possible after the first test. During the second explosion test, the valve is to be visually monitored for any indication of combustion outside the flame arrester and video records are to be kept for subsequent analysis. The second test is required to demonstrate that the valve can still function in the event of a secondary crankcase explosion.

d. After each explosion, the test vessel is to be maintained in the closed condition for at least 10 seconds to enable the tightness of the valve to be ascertained. The tightness of the valve can be verified during the test from the pressure/time records or by a separate test after completing the second explosion test.

704. Stage 3:

a. Carry out two further explosion tests as described in Stage 1. These further tests are required to provide an average baseline value for assessment of pressure rise, recognising that the test vessel ambient conditions may have changed during the testing of the explosion relief valves in Stage 2.

J2. REPORTING AND APPROVAL

100. Assessment and records

101. For the purposes of verifying compliance with the requirements of this Chapter, the assessment and records of the valves used for explosion testing is to address the following:

a. The valves to be tested are to have evidence of design appraisal/approval by the classification society witnessing tests.

b. The designation dimensions and characteristics of the valves to be tested are to be recorded. This is to include the free area of the valve and of the flame arrester and the amount of valve lift at 0.2bar.

c. The test vessel volume is to be determined and recorded.

d. For acceptance of the functioning of the flame arrester there is not to be any indication of flame or combustion outside the valve during an explosion test. This should be confirmed by the test laboratory taking into account measurements from the heat sensitive camera.

e. The pressure rise and decay during an explosion is to be recorded, with indication of the pressure variation showing the maximum overpressure and steady underpressure in the test vessel during testing. The pressure variation is to be recorded at two points in the pressure vessel.

f. The effect of an explosion relief valve in terms of pressure rise following an explosion is ascertained from maximum pressures recorded at the centre of the test vessel during the three stages. The pressure rise within the test vessel due to the installation of a relief valve is the difference between average pressure of the four explosions from Stages 1 and 3

and the average of the first tests on the three valves in Stage 2. The pressure rise is not to exceed the limit specified by the manufacturer.

g. The valve tightness is to be ascertained by verifying from the records at the time of testing that an underpressure of at least 0.3bar is held by the test vessel for at least 10 seconds following an explosion. This test is to verify that the valve has effectively closed and is reasonably gas-tight following dynamic operation during an explosion.

h. After each explosion test in Stage 2, the external condition of the flame arrester is to be examined for signs of serious damage and/or deformation that may affect the operation of the valve.

i. After completing the explosion tests, the valves are to be dismantled and the condition of all components ascertained and documented. In particular, any indication of valve sticking or uneven opening that may affect operation of the valve is to be noted. Photographic records of the valve condition are to be taken and included in the report.

200. Design series qualification

201. The qualification of quenching devices to prevent the passage of flame can be evaluated for other similar devices of identical type where one device has been tested and found satisfactory.

202. The quenching ability of a flame arrester depends on the total mass of quenching lamellas/mesh. Provided the materials, thickness of materials, depth of lamellas/thickness of mesh layer and the quenching gaps are the same, then the same quenching ability can be qualified for different sizes of flame arresters subject to (a) and (b) being satisfied.

$$\text{(a)}\ \frac{n_1}{n_2} = \sqrt{\frac{S_1}{S_2}}$$

$$\text{(b)}\ \frac{A_1}{A_2} = \frac{S_1}{S_2}$$

where:

n_1 = total depth of flame arrester corresponding to the number of lamellas of size 1 quenching device for a valve with a relief area equal to S_1

n_2 = total depth of flame arrester corresponding to the number of lamellas of size 2 quenching device for a valve with a relief area equal to S_2

A_1 = free area of quenching device for a valve with a relief area equal to S_1

A_2 = free area of quenching device for a valve with a relief area equal to S_2

203. The qualification of explosion relief valves of larger sizes than that which has been previously satisfactorily tested in accordance with J1.700 and J2.100 can be evaluated where valves are of identical type and have identical features of construction subject to the following:

a. The free area of a larger valve does not exceed three times + 5% that of the valve that has been satisfactorily tested.

b. One valve of the largest size, subject to J2.203(a)~~,~~ requiring qualification is subject to satisfactory testing required by J1.603 and J1.703 except that a single valve will be accepted in J1.703.(a) and the volume of the test vessel is not to be less than one third of the volume required by J1.412.

c. The assessment and records are to be in accordance with J2.100 noting that J2.101(f) will only be applicable to Stage 2 for a single valve.

204. The qualification of explosion relief valves of smaller sizes than that which has been previously satisfactorily tested in accordance with J1.700 and J2.100 can be evaluated where valves are of identical type and have identical features of construction subject to the following:

a. The free area of a smaller valve is not less than one third of the valve that has been satisfactorily tested.

b. One valve of the smallest size, subject to J2.204(a), requiring qualification is subject to satisfactory testing required by J1.603 and J1.703 except that a single valve will be accepted in J1.703(a) and the volume of the test vessel is not to be more than the volume required by J1.412..

c. The assessment and records are to be in accordance with J2.100 noting that J2.100(f) will only be applicable to Stage 2 for a single valve.

300. The report

301. the test facility is to deliver a full report that includes the following information and documents:

a. Test specification.

b. Details of test pressure vessel and valves tested.

c. The orientation in which the valve was tested, (vertical or horizontal position).

d. Methane in air concentration for each test.

e. Ignition source.

400. Approval

401. The approval of an explosion relief valve is at the discretion of individual classification societies based on the appraisal of plans and particulars and the test facility's report of the results of type testing.

CHAPTER K
TYPE TESTING OF CARNKCASE OIL MIST DETECTION AND ALARM EQUIPMENT

CHAPTER CONTENTS

K1. TYPE TESTING OF CRANKCASE OIL MIST DETECTION AND ALARM EQUIPMENT [IACS UR M67]

100. Scope

101. To specify the tests required to demonstrate that crankcase oil mist detection and alarm equipment intended to be fitted to diesel engines satisfy classification society requirements.

102. Note: This test procedure is also applicable to oil mist detection and alarm equipment intended for gear cases.

200. Recognised Standards

201. IACS Unified Requirement E10 Type Test Specification.

300. Purpose

301. The purpose of type testing crankcase oil mist detection and alarm equipment is seven fold:

a. To verify the functionality of the system.

b. To verify the effectiveness of the oil mist detectors.

c. To verify the accuracy of oil mist detectors.

d. To verify the alarm set points.

e. To verify time delays between oil mist leaving the source and alarm activation.

f. To verify functional failure detection.

g. To verify the influence of optical obscuration on detection.

400. Test facilities

401. Test houses carrying out type testing of crankcase oil mist detection and alarm equipment are to satisfy the following criteria:

a. A full range of facilities for carrying out the environmental and functionality tests required by this procedure shall be available and be acceptable to the classification societies.

b. The test house that verifies the functionality of the equipment is to be equipped so that it can control, measure and record oil mist concentration levels in terms of mg/l to an accuracy of ± 10% in accordance with this procedure.

500. Equipment testing

501. The range of tests is to include the following:

502. For the alarm/monitoring panel:

a. Functional tests described in K1.600.

b. Electrical power supply failure test.

c. Power supply variation test.

d. Dry heat test.

e. Damp heat test.

f. Vibration test.

g. EMC test.

h. Insulation resistance test.

i. High voltage test.

j. Static and dynamic inclinations, if moving parts are contained.

503. For the detectors:

a. Functional tests described in K1.600.

b. Electrical power supply failure test.

c. Power supply variation test.

d. Dry heat test.

e. Damp heat test.

600. Functional tests

601. All tests to verify the functionality of crankcase oil mist detection and alarm equipment are to be carried out in accordance with 6.2 to 6.6 with an oil mist concentration in air, known in terms of mg/l to an accuracy of ±10%.

603. The concentration of oil mist in the test chamber is to be measured in the top and bottom of the chamber and these concentrations are not to differ by more than 10%. See also 803

603. The oil mist monitoring arrangements are to be capable of detecting oil mist in air concentrations of between 0 and 10% of the lower explosive limit (LEL) or between 0 and a percentage corresponding to a level not less than twice the maximum oil mist concentration alarm set point. The LEL corresponds to an oil mist concentration of approximately 50mg/l (~4.1% weight of oil in air mixture).

604. The alarm set point for oil mist concentration in air is to provide an alarm at a maximum level corresponding to not more than 5% of the LEL or approximately 2.5mg/l.

605. Where alarm set points can be altered, the means of adjustment and indication of set points are to be verified against the equipment manufacturer's instructions.

606. Where oil mist is drawn into a detector via piping arrangements, the time delay between the sample leaving the crankcase and operation of the alarm is to be determined for the longest and shortest lengths of pipes recommended by the manufacturer. The pipe arrangements are to be in accordance with the manufacturer's instructions/recommendations.

607. Detector equipment that is in contact with the crankcase atmosphere and may be exposed to oil splash and spray from engine lubricating oil is to be demonstrated as being such, that openings do not occlude or become blocked under continuous oil splash and spray conditions. Testing is to be in accordance with arrangements proposed by the manufacturer and agreed by the classification society.

608. Detector equipment may be exposed to water vapour from the crankcase atmosphere which may affect the sensitivity of the equipment and it is to be demonstrated that exposure to such conditions will not affect the functional operation of the detector equipment. Where exposure to water vapour and/or water condensation has been identified as a possible source of equipment malfunctioning, testing is to demonstrate that any mitigating arrangements such as heating are effective. Testing is to be in accordance with arrangements proposed by the manufacturer and agreed by the classification society.

a. This testing is in addition to that required by K1.503(e) and is concerned with the effects of condensation caused by the detection equipment being at a lower temperature than the crankcase atmosphere.

700. Detectors and alarm equipment to be tested

701. The detectors and alarm equipment selected for the type testing are to be selected from the manufacturer's normal production line by the classification society witnessing the tests.

702. Two detectors are to be tested. One is to be tested in clean condition and the other in a condition representing the maximum level of lens obscuration specified by the manufacturer.

800. Method

801. The following requirements are to be satisfied at type testing:

802. Oil mist generation is to satisfy K1.803 to K1.810.

803. Oil mist is to be generated with suitable equipment using an SAE 80 monograde mineral oil or equivalent and supplied to a test chamber having a volume of not less than $1m^3$. The oil mist produced is to have a maximum droplet size of 5 μm. The oil droplet size is to be checked using the sedimentation method.

804. The oil mist concentrations used are to be ascertained by the gravimetric deterministic method or equivalent. For this test, the gravimetric deterministic method is a process where the difference in weight of a 0.8 μm pore size membrane filter is ascertained from weighing the filter before and after drawing 1 litre of oil mist through the filter from the oil mist test chamber. The oil mist chamber is to be fitted with a recirculating fan.

805. Samples of oil mist are to be taken at regular intervals and the results plotted against the oil mist detector output. The oil mist detector is to be located adjacent to where the oil mist samples are drawn off.

806. The results of a gravimetric analysis are considered invalid and are to be rejected if the resultant calibration curve has an increasing gradient with respect to the oil mist detection reading. This situation occurs when insufficient time has been allowed for the oil mist to become homogeneous. Single results that are more than 10% below the calibration curve are to be rejected. This situation occurs when the integrity of the filter unit has been compromised and not all of the oil is collected on the filter paper.

807. The filters require to be weighed to a precision of 0.1mg and the volume of air/oil mist sampled to 10ml.

808. The testing is to be witnessed by authorised personnel from classification societies where type testing approval is required by a classification society.

809. Oil mist detection equipment is to be tested in the orientation (vertical, horizontal or inclined) in which it is intended to be installed on an engine or gear case as specified by the equipment manufacturer.

810. Type testing is to be carried out for each type of oil mist detection and alarm equipment for which a manufacturer seeks classification approval. Where sensitivity levels can be adjusted, testing is to be carried out at the extreme and mid-point level settings.

K2. ASSESSMENT, DESIGN SERIES QUALIFICATION, REPORTING AND APPROVAL

100. Assessment

101. Assessment of oil mist detection equipment after testing is to address the following:

a. The equipment to be tested is to have evidence of design appraisal/approval by the classification society witnessing tests.

b. Details of the detection equipment to be tested are to be recorded such as name of manufacturer, type designation, oil mist concentration assessment capability and alarm settings.

c. After completing the tests, the detection equipment is to be examined and the condition of all components ascertained and documented. Photographic records of the monitoring equipment condition are to be taken and included in the report.

200. Design series qualification

201. The approval of one type of detection equipment may be used to qualify other devices having identical construction details. Proposals are to be submitted for consideration.

300. The report

301. The test house is to provide a full report which includes the following information and documents:

a. Test specification.

b. Details of equipment tested.

c. Results of tests.

400. Acceptance

401. Acceptance of crankcase oil mist detection equipment is at the discretion of individual classification societies based on the appraisal plans and particulars and the test house report of the results of type testing.

402. The following information is to be submitted to classification societies for acceptance of oil mist detection equipment and alarm arrangements:

403. Description of oil mist detection equipment and system including alarms.

404. Copy of the test house report identified in K2.300.

405. Schematic layout of engine oil mist detection arrangements showing location of detectors/sensors and piping arrangements and dimensions.

405. Maintenance and test manual which is to include the following information:

a. Intended use of equipment and its operation.

b. Functionality tests to demonstrate that the equipment is operational and that any faults can be identified and corrective actions notified.

c. Maintenance routines and spare parts recommendations.

d. Limit setting and instructions for safe limit levels.

e. Where necessary, details of configurations in which the equipment is and is not to be used.

CHAPTER L
CAST STEEL PROPELLERS
[IACS W27]

CHAPTER CONTENTS

L1. GENERAL CHARACTERISTICS OF CAST STEEL PROPELLERS.

100. Scope

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

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

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

200. Foundry approval

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

300. General characteristics of castings

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

400. Chemical composition

401. Typical cast steel propeller alloys are grouped into four types depending on their chemical composition as given in Table T.L1.401.1.

500. Heat treatment

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

600. Mechanical properties

601. The mechanical properties are to meet the requirements in Table T.L1.601.1. These values refer to the test specimens machined from integrally cast test bars attached to the hub or on the blade.

602. 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.

603. 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.

604. 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.

605. At least one set of mechanical tests is to be made on material representing each casting in accordance with Part III, Title 61, Section2, Chapter A.

606. As an alternative to L1.605, 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.

607. At least one set of mechanical tests is to be provided for each multiple of five castings in the batch.

700. Visual inspection

701. 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.

702. 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.

800. Dimensions, dimensional and geometrical tolerances

801. 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.

802. 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.

L2. NON-DESTRUCTIVE TESTING, REPAIR AND WELD REPAIR PROCEDURE.

100. Non-destructive testing

101. All finished castings are subject to non-destructive testing in accordance with the requirements given in L2.102. to L2.109.

102. 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. Part III, Title 62, Section 5, Chapter G refers.

103. 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.

104. 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.

105. The following definitions relevant to liquid penetrant indications apply:

a. 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;

b. 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;

c. Aligned indication: three or more indications in a line, separated by 2mm or less edge-to-edge;

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

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

f. 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.

106. 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 unfavourable location relative to the indication being evaluated.

107. The indications detected may, with respect to their size and number, not exceed the values given in the Table T.L2.107.1.

108. 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 RBNA.

109. 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.

200. Repair

201. Defective castings are to be repaired in accordance with the requirements given in L2.202 to L2.207 and, where applicable, the requirements of L2.300.

201. 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.

203. 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.

204. 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 $5cm^2$ are to be avoided.

205. 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 RBNA

206. 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 RBNA.

207. Repair welding is generally permitted in severity Zone C.

300. Weld repair procedure

301. The scope of the procedure tests involved in the qualification is given in L4 below.

302. 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.

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

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

305. 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.

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

307. 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.

308. 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.

309. 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.

L3. IDENTIFICATION AND CERTIFICATION

100. Identification

101. 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. RBNA’s certificate number;

c. Ice class symbol, where applicable;

d. Skew angle for high skew propellers,

e. Date of final inspection.

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

200. Certification

201. 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;

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.

TABLE T.L1.401.1.- 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					

TABLE T.L1.601.1 - MECHANICAL PROPERTIES FOR STEEL PROPELLER CASTINGS

Alloy type	Proof stress $R_{p0.2}$ min. (N/mm^2)	Tensile stress R_m min. (N/mm^2)	Elongation A_5 min. (%)	Red. of area Z min (%)	Charply 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	-

[1] Not required for general service and the lowest Ice class notations. For other Ice class notations, tests are to be made -10^0C.

[2] $R_{p1,0}$ value is 205 N/mm^2.

TABLE T.L2.107.1 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

[1] Single non-linear indications less than 2mm in Zone A and less than 3mm in other zones may be disregarded.

[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.

L4. WELDING PROCEDURE QUALIFICATION TEST [Appendix A]

100. Preparation of test assembly

101. A test assembly of minimum 30mm thickness is to be welded. The types of specimens to be prepared are shown in FIG. F.L4.101.1.

200. Non-destructive testing

201. Prior to sectioning, the test assembly is to be visually inspected and liquid penetrant tested. Imperfections shall be assessed in accordance with L2.100.

300. Macro-examination

301. 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.

302. 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.

303. Cracks or crack-like imperfections, slag inclusions, and pores greater than 3mm are not permitted.

400. Tensile testing

401. Two flat transverse tensile test specimens shall be prepared. Testing procedures shall be in accordance with Part III, Title 61, Section2, Subchapter A5, Item 103.

402. 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.

500. Bend testing

501. Two transverse side bend test specimens shall be prepared in accordance with Part III, Title 61, Section2, Chapter A. ..The former diameter shall be 4 x thickness except for austenitic steels, in which case the former diameter shall be 3 x thickness.

502. The test specimen, when visually inspected after bending, shall show no surface imperfections greater than 2mm in length.

600. Charpy V-notch testing

601. Impact test is not required, except where the base material is impact tested. Charpy V-notch test specimens shall be in accordance with Part III, Title 61, Section2, Chapter A.

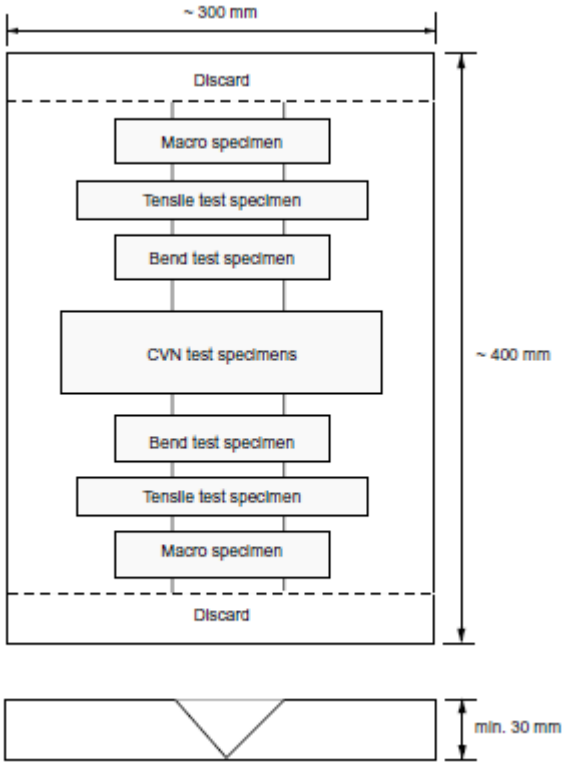
602. Two sets shall be taken, one set with the notch positioned in the centre of the weld and one set with the notch positioned in the fusion line, respectively.

603. The test temperature, and impact energy shall comply with the requirement specified for the base material.

700. Hardness testing

701. 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.

FIG. F.L4.101.1 WELD TEST ASSEMBLY



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