RULES
FOR THE CLASSIFICATION
AND CONSTRUCTION
OF SHIPS
(Rev.2020)

INTERMARITIME CERTIFICATION SERVICES (*ICS Class*)

Chapter 13 Materials

Section

SECTION 1
General

1.1 Application

1.1.1 The present Chapter applies to materials and products that are subject, in conformity with the other Chapters of the Rules, to the manufacture supervision of *ICS Class*.

Requirements pertaining to the choice and application of materials and products are to be found in the relevant Chapters of the Rules.

1.1.2 In addition to the requirements of the present Chapter, materials and products are to meet the requirements of the relevant Chapters of the Rules.

1.1.3 The materials, being part of a structure or product, on which the requirements not included in the present Chapter are imposed due to conditions of their operation as well as materials not regulated by the present Chapter the chemical composition, mechanical and service properties of which were not considered by *ICS Class* for a particular application are to be specially considered by *ICS Class*.

1.1.4 The materials and products subject to supervision that are listed below should be manufactured by works for which recognition certificates were issued by *ICS Class*:

.1 Rolled products of hull structural steel, Z-steel and higher strength steel for welded structures.
.2 Rolled steel for Class I and Class II boilers and pressure vessel.
.3 Steel pipes for boilers, pressure vessels and Class I and Class II piping.
.4 Steel forgings and castings subject to supervision during its manufacturing.
.5 Iron castings subject to supervision during its manufacturing.
.6 Propeller castings of copper-based alloys.
.7 Semi-finished products of aluminum alloys for hull structures.
.8 Chain cables and ropes.

1.2 Definitions and explanations

1.2.1 Definitions and explanations relating to the general terminology of the Rules are given in the General Regulations for the Supervision.

1.2.2 For the purpose of the present Chapter the following definitions have been adopted:

- **A specimen:** Test piece of specified shape and size prepared from a sample and used for the determination of mechanical, technological and other properties of material by testing.
- **A semi - finished product:** Item manufactured by casting, forging, rolling, drawing or other similar methods and intended for machining or technological treatment in order to obtain the finished state.
- **A sample:** Portion of a semi-finished product or product or a specially fabricated blank of which test specimens are to be machined.
- **Lamellar tearing:** Breaking of welded structure components, made of rolled plates or pipes, due to considerable welding stresses and/or external loads applied in a perpendicular direction to the plate surface.
- **Z - steel:** Steel with guaranteed through - thickness properties which is intended for welded structures and can withstand considerable stresses perpendicular to the plate surface.

1.3 Scope of supervision

1.3.1 General provisions

1.3.1.1 The regulating provisions for the extent and procedure of supervision are to be found in *General Regulations for the Supervision*.

For the approval of the steel according to *3.13* shall be presented, besides, evidences about the supply conditions, recommendations for welding, cold- and hot-forming and for the heat treatment after the welding.

1.3.1.2 The supervision of materials and products, carried out by *ICS Class*, is to be composed of the following:

.1 Consideration of technical documentation containing technical requirements for manufacture.

.2 Survey and recognition of material and product manufacturers.

.3 Manufacture survey and testing of materials and products.

.4 Issue of relevant documents by *ICS Class* on the basis of supervision.

1.3.2 Approval of materials and methods of their manufacture

1.3.2.1 Materials that are used for the first time for the manufacture of structure subject to *ICS Class* supervision as well as procedures of material manufacture not regulated by the present Chapter should be approved by *ICS Class*.

To obtain a type approval certificate, the Manufacturer is to forward an application to *ICS Class*.

1.3.2.2 Together with the application, the following should be enclosed: information on the purpose and manufacturing procedure of the material, technical documentation for the manufacture with indication of the chemical composition, mechanical and technological properties, results of earlier testing and data on application (if any).

1.3.2.3 If, after consideration of the information submitted to *ICS Class* are obtained acceptable results, and also are complied the conditions specified in DR 4020-19, then the materials shall be considered as approved products.

1.3.3 Approval of products

1.3.3.1 Prior to the manufacture of the materials and products listed in *1.1.4* under *ICS Class*'s supervision, the Manufacturer is to forward an application to the latter for the commencement of the approval process of the product.

1.3.3.2 Attached to the application should be the information on the process of manufacture and the system of quality control of the items under supervision as well as a program of control testing. The test program is to be drawn up on the basis of the Rules and the conditions specified in DR 4020-19 "Procedure for the approval of products and services".

1.3.3.3 The products or materials approved shall not require the supervision of *ICS Class*, provided the Approval Certificates are in force.

1.3.4 Manufacture supervision of non-approved materials

1.3.4.1 Materials and products listed in *1.1.4* are to be subjected to the manufacture supervision of *ICS Class* including surveys and testing prescribed by the relevant requirements of this Chapter or by standards and technical documentation.

Control of the surface, dimensions and mass of materials and products should be carried out by the Manufacturer.

The availability of *ICS Class* certificate does not relieve the Manufacturer of the responsibility if a material or product is subsequently found defective or does not comply with agreed standards or technical requirements as regards its dimensions, mass and surface finish.

Survey and testing of materials and products including the issue of relevant Register certificates is generally affected at the Manufacturer's works, but in any case, after the final technological operation which substantially affects the properties of the material (for instance, heat treatment).

The tests required by materials and products shall be carried out in laboratories approved by *ICS Class*.

1.3.4.2 Prior to survey and testing, the Manufacturer is to submit the following information to *ICS Class*:

.1 Name, type or trade mark of material/product.
.2 Name and number of standard.
.3 Grades of or requirements for materials according to the condition of supply.
.4 Customer and order number.
.5 Quantity.
.6 Number of cast, identification number.
.7 Numbers of samples/specimens prepared for testing.

The Manufacturer is to confirm that the materials/products submitted are to the satisfaction of *ICS Class*.

1.3.5 Testing

1.3.5.1 Testing should be conducted under *ICS Class* supervision or in laboratories with approved testing services.

1.3.5.2 If testing results are unsatisfactory, the tests may be repeated subject to the following conditions:

.1 Where the test results are unsatisfactory due to local defects in the specimen material, faulty machining of specimens or faulty test equipment, the test should be repeated on the same number of specimens.
.2 Where the test results are unsatisfactory, the test should be repeated on a double number of specimens machined from the same piece.

In case the results of re-testing are satisfactory, the product in question as well as the other products of the batch may be accepted. If, in the case of retesting, at least one test yields unsatisfactory results the product is to be rejected and the rest of the batch may be accepted provided the test results obtained on specimens that are machined from two other products of the same batch prove satisfactory.

When the average impact energy value of three impact test specimens according to *Fig. 2.2.3.1-2* fails to meet the required value, or the value for two specimens is below the required average value, or when the value for a single specimen is below 70 % of specified average value, three additional specimens of the same material may be tested. Proceeding from the results of initial and additional testing the average impact value for six specimens is determined. If this average complies with the requirements and not more than two values are lower than the average or not more than one value is below 70 % of it the piece or batch may be accepted.

.3 If the properties of material are improved as a result of heat treatment then after it the tests should be repeated and the extent of testing is to be similar to that of initial testing.

.4 When, to ensure required mechanical properties, the heat treatment has to be repeated one should be guided by agreed standards or should act on agreement with a Surveyor to *ICS Class*; the heat treatment may not be repeated more than thrice.

.5 When a batch of material is rejected the products comprising the batch may, at the Manufacturer's discretion, be tested individually and the products for which the test results are satisfactory may be accepted.

1.3.5.3 If confusion of specimens or test results is detected or the test results do not make it possible to assess the material properties with the required degree of accuracy, *ICS Class* may require the tests to be repeated in the presence of its representative.

1.3.5.4 The material produced, the properties of which do not fully agree with the requirements of this Chapter, the deviations being not essential for the operation of the structure or product, may be used in accordance with the purpose only after to be subjected to the special consideration of *ICS Class* and being available a relevant application from the Manufacturer and the approval of the owner.

1.3.6 Documents

1.3.6.1 When the results of surveys and testing stated under *1.3.3*, *1.3.4* and *1.3.5* are satisfactory *ICS Class* shall issue forms relevant to the case.

1.3.6.2 The certification shall ensure that the material has been manufactured and has satisfactorily withstood all the tests required by the rules.

1.4 Marking

1.4.1 The marking of materials is to be carried out in accordance with standards taking the following requirements into consideration:

In the case of semi-finished products delivered in single pieces each one of them is to be marked. For shipments in bundles two weather-resistant labels containing the marking are to be provided and firmly fastened to the opposite ends of the bundle.

When a great number of semi-finished products is delivered and these are of small size, the marking procedure and the content of the marking are to be agreed with *ICS Class*.

Semi-finished products which shall undergo further machining are to be stamped, as far as possible, in spots that shall not be machined.
The stamp is to stand out clearly and be framed with a bright paint resistant to atmosphere.

1.4.2 As a rule, the stamp is to include the following information:

- grade or quality of material;
- figures or other designation to indicate the origin of the semi-finished product (number of semi-finished product, number of cast, etc.);
- Manufacturer's name or trade mark;
- stamp of the quality control service of the manufacturer's;
- Register's brand (if required).

1.4.3 If the semi-finished product does not withstand the tests required by the Rules or defects are revealed which make its use in accordance with the purpose impossible, *ICS Class* brand and the material grade designation are to be removed or cancelled.

1.5 Laboratories engaged in testing

1.5.1 The present rules apply to laboratories engaged in testing of materials subject to the supervision of *ICS Class*. Also, the tests are to be approved by *ICS Class* according to the provisions stated in DR 4020-19.

1.5.2 Laboratories of metallurgical works and of other works and bodies engaged in manufacture of materials and testing are entitled to effect testing for the purpose of determining material properties. Such testing may be carried out under the special consideration of *ICS Class*, through the Approval Certificate where are specified the recognized testing procedures.

Reports or statements of those laboratories which reveal the testing results, tests conducted are to be sufficient for entering data on chemical composition, mechanical properties, etc. in the Approval Certificate of the material or in the Technical Reports required to issue by *ICS Class*.

1.5.3 Laboratories engaged in non-destructive testing of materials (for instance, radiography, magnetic particle tests, etc.) are to be recognized by *ICS Class*. The documents issued by the above laboratories are to contain information about the testing method and other technical data necessary for assessing the test results. The assessment shall be carried out by the surveyors to *ICS Class*.

1.5.4 Laboratories engaged in the ultrasonic testing of materials and products are to be recognized by means a Certificate issued by *ICS Class*. In the Certificate, the scope and conditions of applying the ultrasonic testing are to be defined. To be recognized for applying the ultrasonic testing, an application is to be forwarded to *ICS Class* supplemented by the following documents confirming that the Manufacturer is ready to carry out the ultrasonic testing:

.1 Documents in confirmation of availability of qualified personnel together with the name of the body having carried out the certification of the personnel.
.2 Technical characteristics of ultrasonic equipment with instructions on the application.
.3 Instructions for testing performance.

Tests should be made to confirm reliability of the test results and the possibility of their reproduction. The test program is to be approved by *ICS Class*.

1.5.5 The results of material testing and investigations conducted are to be recorded in the prescribed way (entered in the test log, report, etc.). The test log (report, etc.) is to contain all the data necessary for the assessment of material quality and subsequent issue of certificate.

A report of the ultrasonic testing of products is to include at least the following information:

- Kind of product.
- Material and main dimensions of the product.
- Type of ultrasonoscope and finders.
- Testing frequency.
- Testing method and type of unified reference block.
- Size and position of defects.
- Name of operator.
- Testing date.

May be included other data if these are in accordance with ISO 25.

SECTION 2
Test procedures

2.1 General provisions

2.1.1 The requirements of the present Section cover the types and procedures of testing materials which are subject to the supervision of *ICS Class* during their manufacture. *ICS Class* may accept the use of other methods and specimens which differ from those set out in this Section, if it is allowable to define and assess properly the material characteristics.

2.1.2 The types of tests to which are to be carried out on the material, taking into account the particulars conditions of its specific use, are set out in the corresponding Sections and Subsections of this Chapter.

2.1.3 All tests are to be carried out by competent personnel on testing machines of adequate capacity. The machines are to ensure appropriate accuracy of measurements, be regularly checked and be calibrated by a designated authority.
The results of regular checks are to be submitted to *ICS Class*.

2.1.4 When tests are carried out, the requirements of the standards or other regulating documents approved by *ICS Class* are to be met.

2.1.5 Test samples from which test specimens are cut are to have undergone the same treatment as the material from which they have been taken (e.g. heat treatment). Test specimens are to be prepared in such a manner that properties of the material are not affected.

2.2 Test procedures for metals

2.2.1 Temperature

2.2.1.1 The temperature of the ambient air during the tests is to comply with the requirements of the standards unless expressly provided otherwise in the subsequent Sections and Subsections.

2.2.2 Tensile tests

2.2.2.1 When carrying out tensile tests, the following tensile properties of metals are to be determined:

.1 Yield stress R_e, is the value of stress measured at the commencement of plastic deformation at yield without any marked increase of the elastic stress rate.
.2 Upper yield stress R_{eH} is the value of stress measured at the first peak obtained during yielding.
.3 Lower yield stress R_{eL} is the smallest value of stress at yield with no regard to the initial transient effect, if any.
.4 Proof stress at 0,2 percent of elongation R_p is the value of stress at which plastic deformation reaches its pre-set value expressed as a percentage of the original gauge length ($R_{PO,2}$, $R_{po\ 0,5}$).
.5 Transitory strength R_m is the value of stress corresponding to the maximum load directly before the test specimen fractures.
.6 Percentage elongation after fracture A is the ratio of an increment of the gauge length of the test specimen after fracture to the original gauge length, expressed in per cent.
.7 Percentage reduction of area after fracture Z is the ratio of the difference between the original and the minimum cross-sectional areas of the test specimen after fracture to the original cross-sectional area, expressed in per cent.

.8 When tensile tests are carried out at an elevated temperature, the test temperature is to be indicated by an inferior figure (e.g. $R_{m/350}$, $ReL_{/350}$, $A5_{/350}$, and Z350 where 350 is the test temperature in degrees Celsius).

2.2.2.2 The elastic strain rate is to be determined using standards or technical documentation. For the determination of the yield stress R_e, the elastic stress rate is not to exceed 30 MPa per second. For non-ferrous materials the elastic stress rate is to be not in excess of 10 MPa per second.

2.2.2.3 Tensile tests are to be carried out on the test specimens of the following types (*Figs. 2.2.2.3-1 - 2.2.2.3-5*)

Where:

do = diameter of the gauge length, mm;
a_o = thickness of the gauge length, mm;
bo = width of the gauge length, mm;
Lc = gauge length of the test specimen, mm;
Lo = design length of the test specimen, mm;
R = transition radius, mm;
So = cross-section of the gauge length, mm^2;
D = external tube diameter, mm;
t = plate thickness, mm.

Test specimens of rectangular cross-section with a gauge length equal to $Lo = 5{,}65\sqrt{So}$ or of circular cross-section with a gauge length *Lo = 5do* are called proportional test specimens.

Tests are to be carried out on the specimens according to *Table 2.2.2.3*.

Table 2.2.2.3 Specimens dimensioning according to its origin

Semi-product	Type of test specimens	Dimensions of the specimens
Forgings, castings, bars	*fig 2.2.2.3-1*	*do = 14 ± 0,2* *Lo = 70* *Lc = 85* *R = 20* *R = 20* for materials having $A_5 \leq 10\%$ and nodular cast iron
	fig 2.2.2.3-1 *fig 2.2.2.3-3*	On agreement with *ICS Class*, test specimens with a gauge length $5{,}65\sqrt{So}$ having other dimensions, *Lc = Lo + d*
Plates, strips, sections	*fig 2.2.2.3-2*	*ao* = thickness of test specimen *bo = 25* $Lo = 5{,}65\sqrt{So}$ $Lc = Lo + 2\sqrt{So}$ *R = 25* or *ao* = thickness of test specimen *bo = 25* *Lo = 200* *Lc = 225* *R = 25* For material over 300 mm in thickness, test specimens shown in *Fig. 2.2.2.3-1* with *d = 14 mm* may be used. The axes of these specimens are to be located at approximately one-quarter of the thickness from one side of the rolled surface
Tubes	*fig 2.2.2.3-4* *or* *fig 2.2.2.3-5*	$Lo = 5{,}65\sqrt{So}$ *Lc = Lo + D* *ao = t* *bo = 12* $Lo = 5{,}65\sqrt{So}$ *Lc = Lo + 2b*

When a gauge length other than $5{,}65\sqrt{So}$ is used subject to agreement with *ICS Class*, the equivalent percentage elongation value is to be calculated using the following formula:

$$A = 2 \cdot A_5 \left(\frac{\sqrt{So}}{Lo} \right)^{0,40} \qquad (2.2.2.3)$$

2.2.2.4 For the determination of tensile strength R_m of nodular cast iron, test specimens of circular cross-section shown in *Fig. 2.2.2.4* are to be used.

Figure 2.2.2.3 Test specimens according to the semi-product

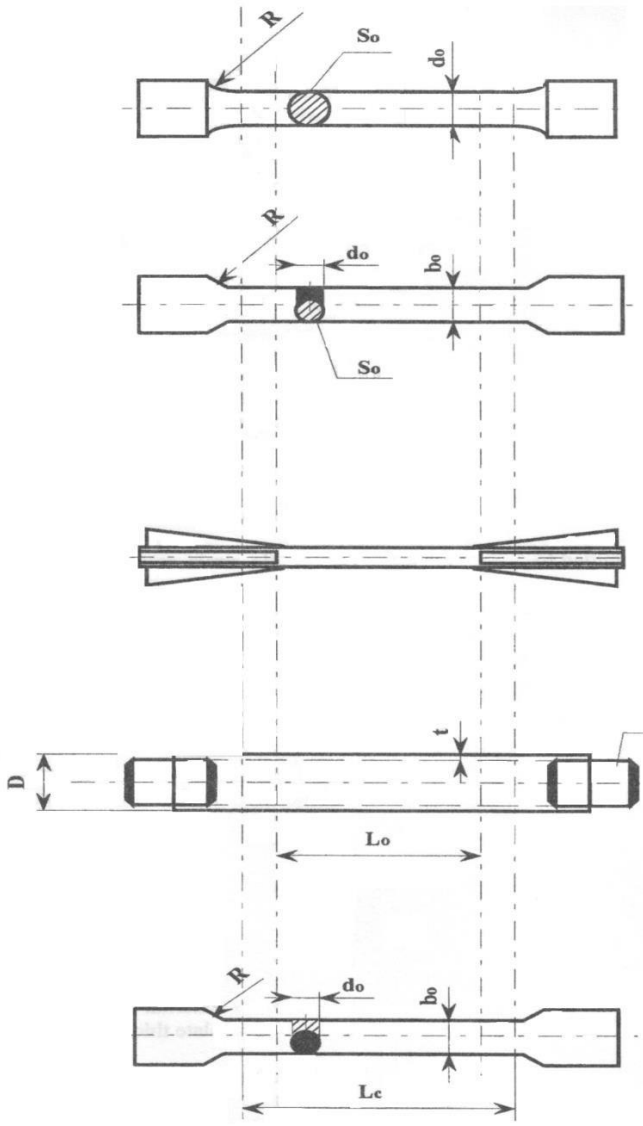


Figure 2.2.2.3-1 For cast, forged or rolled steel profiles

Figure 2.2.2.3-2 For rolled steel profiles

Figure 2.2.2.3-3 For cast, forged or rolled steel profiles

Figure 2.2.2.3-4 For tubes

Figure 2.2.2.3-5 For tubes

2.2.3 Impact tests

2.2.3.1 The impact toughness KCU is to be determined on Charpy U-notch type test specimens as in *Fig. 2.2.3.1-1* and *Table 2.2.3.1-1*, the impact energy KV and KU on Charpy V-notch type test specimens and Charpy U-notch type test specimens as in *Figs 2.2.3.1-2* and *2.2.3.1-3*, and *Tables 2.2.3.1-2* and *2.2.3.1-3*.

Impact tests are to be carried out on Charpy machines having a striking energy from 150 to 300 J.

The impact energy KV and KU is to be determined on three test specimens and impact toughness KCU on at least two specimens. The impact energy KV and KU is to be determined as an average value obtained at testing three specimens and the values obtained are not to be less than 70 per cent of the required minimum value. When the impact toughness KCU is determined on two specimens, each of the results obtained is not to be less than the required minimum value.

The impact toughness KCU on test specimens having a thickness equal to, or less than, 10 mm is to be determined only if required by *ICS Class*. The required minimum value is subject to agreement with *ICS Class*.

Table 2.2.3.1-4 Decrease of the impact energy

Dimensions of test specimen (mm)	Average value of impact energy ***E*** **(joule)**
10 x 10 x 55	*E*
10 x 7,5 x 55	5/6 *E*
10 x 5 x 55	2/3 *E*

2.2.3.2 The dimensions of the test specimens without any notch used for impact tests are to be as shown in *Fig. 2.2.3.2*.

2.2.3.3 The distance between the supports is to be (40 ± 0,5) mm. The pendulum is to break the test specimen in the plane of symmetry of the notch and from the side opposite to it, the distance between the plane of symmetry of the notch and that of the pendulum being not in excess of 0,5 mm.

Table 2.2.3.1-1 Dimensions of Charpy U - notch type test specimens

Dimensions	Nominal	Tolerance
Length "*L*"	55 mm	± 0,60 mm
Width " *b* "	10 mm	± 0,10 mm
Thickness "*a*"	10 mm	± 0,10 mm
Depth below notch "*h*"	8 mm	± 0,10 mm
Root radius "*r*"	1 mm	± 0,10 mm
Distance of notch from the end of the test specimen "*L/2*"	2,75 mm	± 0,40 mm
Angle between symmetry plane of notch and the longitudinal axis of test specimen θ	90°	± 2°

Table 2.2.3.1-2 Dimensions of Charpy V - notch type test specimens

Dimensions	Nominal	Tolerance
Length "*L*"	55 mm	± 0,60 mm
Width " *b* "	10 mm	± 0,10 mm
Thickness "*a*"	10; 7,5; 5,0 mm	± 0,10;± 0,10; ± 0,06 mm
Angle of V-notch γ	45°	± 2°
Depth of notch "*h*"	8 mm	± 0,06 mm
Root radius "r"	0,25 mm	± 0,025 mm
Distance of notch from the end of the test specimen "*L/2*"	27,5 mm	± 0,040 mm
Angle between symmetry plane of notch and the longitudinal axis of test specimen θ	90°	± 2°

Figure 2.2.2.4 Test specimens of circular cross-section for the determination of tensile strength R_m of nodular cast iron

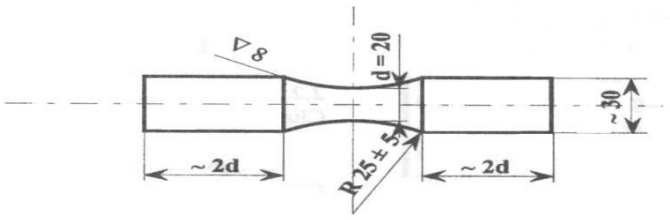


Figure 2.2.3.1-1 Charpy U - notch type test specimen

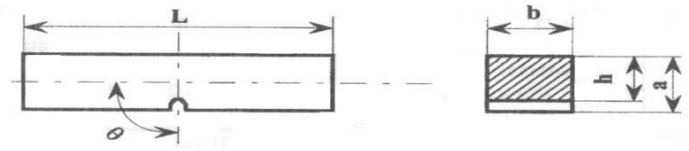


Figure 2.2.3.1-2 Charpy V - notch type test specimens

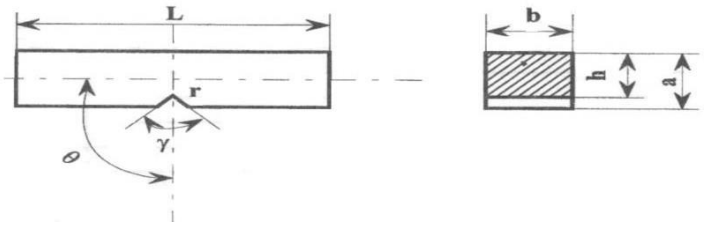


Figure 2.2.3.1-3 Test specimen with KU-notch for the performance of impact test

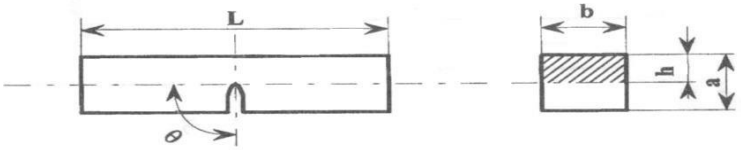


Table 2.2.3.1-3 Dimensions of test specimens with KU - notch for the performance of impact tests

Dimensions	Nominal	Tolerance
Length, "*L*"	55 mm	± 0,60 mm
Width, " *b* "	10 mm	± 0,11 mm
Thickness, "*a*"	10 mm	± 0,11 mm
Depth below notch "*h*"	5 mm	± 0,09 mm
Root radius "r"	1 mm	± 0,07 mm
Distance of the notch from the end of the test specimen " *L/2* "	2,75 mm	± 0,42 mm
Angle between the symmetry plane of the notch and the longitudinal axis of test specimen, θ	90°	± 2 °

In order to provide a specified test temperature during impact testing at low temperatures, the test specimens are to be subjected to supercooling. When the tests are carried at a temperature down to -60º C, the test specimens are to be supercooled to -4º C. Deviations from the required test temperature at the moment of breaking of the test specimen are not to exceed ± 2º C.

2.2.3.4 The ageing resistance is to be proved by impact testing of specimens according to *2.2.3.1*. Samples from which test specimens are prepared are to be pre-elongated to reach a 10 per cent permanent set, then heat treated for at least 30 min at (250 ± 5) ºC. When machined, the specimens are not to get heated above the said temperature. Unless specified otherwise, the aged specimens are to show the impact test value equal to 50 per cent of the minimum specified impact energy value KV or impact toughness value KCU obtained on non-aged specimens at 20º C; in no case, however, will the impact energy be below 27 J and the impact toughness below 29 J/cm^2.

2.2.4 Hardness testing

Hardness is to be determined according to Brinell (HB), Vickers (HV), Rockwell (HRC) or using any other method approved by *ICS Class*.

2.2.5 Technological tests

2.2.5.1 The test specimens cut as shown in *Fig. 2.2.5.1* are to be used for bend test. Edges of the specimens on the tension side may be rounded to a radius of 1 to 2 mm. The mandrel diameter and the angle of specimen bending are indicated in the relevant parts of this Chapter. The bend test of plates and sections is to be carried out on the test specimens of the following dimensions: *ao = t , bo = 30 mm*, *t* is the product thickness. Where the thickness of the product exceeds 25 mm, the test specimen may be machined on one side to a thickness of 25 mm. During the test the machined surface is to be on the compression side of the bend test specimen. The bend tests of forgings, castings and similar semi-finished products are to be carried out on the specimens having the following dimensions: $a_o = 20$ *mm*, $b_o = 25$ *mm*.

2.2.5.2 The flattening test is carried out on the pipes with an external diameter $D \leq 400$ mm and wall thickness $t \leq 15$ per cent of the external diameter. The length of the specimen (pipe length) is to be equal to 1,5 times the external diameter, but is to be not less than 10 mm or greater than 100 mm. Unless otherwise provided in the Rules or standards, the distance *H*, in mm, between the platens is to be determined by the formula:

$$H = \frac{(1+c)t}{C + \frac{t}{D}}$$

Where:

C = constant dependent on the material and assumed on agreement with *ICS Class*;
t = specified thickness of the pipe, mm;
D = external diameter, mm.

The test specimens are to be flattened until the distance between the platens is equal to 2,25t.

For welded pipes or tubes, the weld is to be placed at 90º to the direction of flattening.

Figure 2.2.3.2 Test specimens without any notch for the performance of impact tests

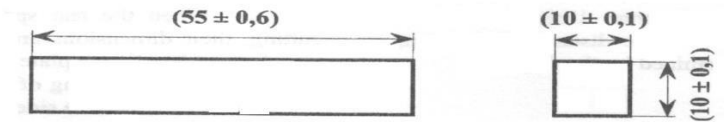
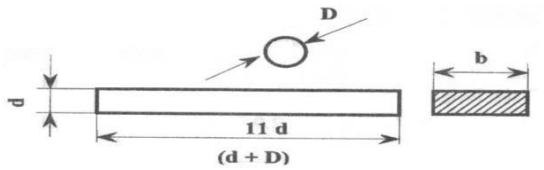


Figure 2.2.5.1



2.2.5.3 The drift expanding test is to be carried out on tubes having an external diameter less than, or equal to 150 mm and a wall thickness up to 9 mm. A conical mandrel is to be forced into the test specimen vertically to the longitudinal axis until the required degree of expansion is reached. The angle of drift α is to be 30º, 45º, 80º or 120º.

The length of the test specimen L is to be equal, for steel tubes:

$L = 2\,D$ when $\alpha = 30°$.

$L = 1{,}5\,D$ when $\alpha = 45°$, but not less than 50 mm;

for copper and aluminum alloys:

$L = (2 \div 3)\,D$

2.2.5.4 The ring expanding test is to be made on steel tubes with an external diameter of 110 to 508 mm and a wall thickness not more than 30 mm.

The width of the ring is to be between 10 and 15 mm.

The test specimen is to be expanded until it breaks, using two mandrels with a diameter equal to 3 times the tube wall thickness.

For welded tubes tests, the weld is to be placed at 90º to the direction of the expansion.

2.2.6 Drop weight tests

2.2.6.1 Where required by the Rules, the drop weight test and evaluation of results are made according to the standards.

The test specimens are to have the following dimensions:
25 x 90 x 360 mm
19 x 50 x 130 mm
16 x 50 x 130 mm

When the test specimens are made using flame cutting, their dimensions are to be increased by at least 25 mm, but not less than a plate thickness.

The machining of the plate to prescribed specimen thickness is to be on one side only.

If not otherwise specified, the specimens may have any orientation.

2.2.7 Macro- and micro-structural analysis

2.2.7.1 Where required by this or other Chapters of the Rules, macro- and micro-structural analysis of metals is to be made in compliance with relevant standards recognized by *ICS Class*, in approved laboratories.

2.2.8 Chemical analysis

2.2.8.1 The methods for the determination of chemical composition of metals and permissible deviations are to be determined by means of recognized standards in laboratories approved by *ICS Class*.

2.2.9 Non-destructive testing

2.2.9.1 When radiography testing is carried out, the results are to be recorded in the form of radiographs with a summary of test evaluations attached which are to be in accordance with the relevant standards.

2.2.9.2 Ultrasonic testing is to be carried out using the pulse-echo methods. For control purposes dual-search units are used.

To provide for more precise examination, single-dual and prismatic search units are used on agreement with *ICS Class*. Good condition and accuracy of the test equipment are to be regularly checked.

The method for determination of a defect size is selected in compliance with relevant standards; otherwise it is to be agreed with *ICS Class*. The size of permissible defects and criteria for their estimation are subject to agreement with *ICS Class* as a part of design documentation for the product. The surface of the product is to provide a safe and uniform acoustic contact with the search unit. The ultrasonic testing is to be carried out after heat treatment at the stage of manufacture when the product has the simplest shape.

2.2.9.3 For magnetic particle testing only technique proved satisfactory in practice may be used. For the portion or part of the surface material which is submitted to test shall be ensured an appropriate intensity of the magnetic field.

A need in demagnetization of the product after completion of the test is to be specified in the technical documentation.

2.2.9.4 On agreement with *ICS Class*, testing methods other than those referred to in *2.2.9.1* to *2.2.9.3* may be used. The evaluation criteria test results are to be agreed with *ICS Class*.

2.2.9.5 The evaluation of non-destructive testing results is to be made only by approved laboratories. Records of testing are to be appended to *ICS Class* certificate in case that non-destructive examination is required by the Rules.

2.3 Testing procedures for non-metallic materials

2.3.1 Testing conditions

2.3.1.1 Before testing, test specimens are to be conditioned at an ambient air temperature 23 ± 2 ºC and relative humidity 50 ± 5%. Unless expressly provided otherwise, the duration of conditioning is to be at least 16 h. Testing is to be carried out immediately after completion of conditioning of the test specimens

The conditioning may be omitted if it is proved to *ICS Class* that testing conditions do not significantly affect the test results and their stability.

2.3.1.2 The test specimens of reinforced material are cut in the warp or weft direction so that the axis of the test specimen is to be parallel to the fibers of warp or weft, respectively.

2.3.1.3 In well-grounded cases, on agreement with *ICS Class*, tests may be carried out on the test specimens whose shape and dimensions differ from those required by this Chapter.

2.3.1.4 Testing conditions other than those specified in this Chapter are to comply with the relevant standards.

2.3.2 Tensile tests

2.3.2.1 The tensile strength of glass-reinforced plastics is to be determined on the test specimens according to *Figs 2.3.2.1-1* and *2.3.2.1-2*, and *Table 2.3.2.1*.

Table 2.3.2.1 Dimensions of specimens for the performance of tensile strength tests of glass-reinforced plastics

Dimensions (mm)	**Fig 2.3.2.1-1**	**Fig 2.3.2.1-2**
L_1 min	150	250
L_2	115 ± 5	170 ± 5
L_3	60 ± 0,5	-
L_0	50 ± 0,5	50 ± 1
b_1	20 ± 0,5	25 ± 0,5
b_2	10 ± 0,5	-
t	1....10	1.....6
r	60	-

2.3.2.2 The tensile strength and elongation at rupture of laminated textiles are to be determined on test specimens having a width of 50 ± 1 mm. The original length between the grips of the testing machine shall be of 200 ± 5 mm.

The pre-load applied is 2N for cloths with a density of 200 g/m^3 or less, 5N for cloths with a density more than 200 and up to 500 g/m^3 and 10N for cloths with a density above 500 g/m^3 .

2.3.2.3 The tear propagation strength of laminated textiles is to be determined on rectangular tests specimens measuring (225 ± 5) x (75 ± 5) mm. An incision of 80 ± 1 mm long shall be made in the middle of one of the specimen ends parallel to the longitudinal edge. Both ends of the incised specimen are then fixed in the grips of the testing machine, so that the area where the tear begins shall be parallel to the direction in which the breaking load is applied. The moving rate of the testing machine grips shall be 100 ± 20 mm/min.

2.3.2.4 The strength of interlayer bonds in textiles is to be determined on rectangular test specimens measuring (50 ± 5) x (200 ± 5) mm. The specimen coat is to be carefully cut to the cloth and separated using a knife over a length of 50 mm on the side of the oblique notch as shown in *Fig. 2.3.2.4* (the separated area is lined). The ends of layers separated in this manner are to be clamped in the grips of the testing machine.
Delaminating is to be effected on a length of 100 mm, and the forces applied are plotted on a graph. The interlayer bond strength is to be determined as an arithmetic mean of 50 % of the lowest peak values measured on the central section of the specimen length making up 50 % of the total separated length.

2.3.2.5 The tear strength of bond joints of laminated textiles is to be determined on the test specimens prepared in such a manner that the middle of the bond joint coincides with the middle of the specimen length and cover this up to 25 mm. The shape and dimensions of the test specimens are to be determined as stated in *2.3.2.2*. The width and execution of the bond joints and the bond used are to be in line with the manufacturing conditions of the products.

2.3.3 Compression test

2.3.3.1 Compression strength of glass-reinforced plastics is to be determined on the test specimens according to *Fig. 2.3.2.1-1* and *Table 2.3.3.1*.

2.3.3.2 Compression strength of rigid foamed plastics is to be determined on rectangular test specimens with side dimensions (50,0 ± 0,5) x (50 ± 0,5) mm and a height from 25 ± 1 to 50 ± 1 mm. The load is to be increased uniformly. The loading rate is to be not in excess of 5 mm/min.

Figures 2.3.2.1-1 and 2.3.2.1-2 Specimens for the performance of tensile strength tests of glass - reinforced plastics

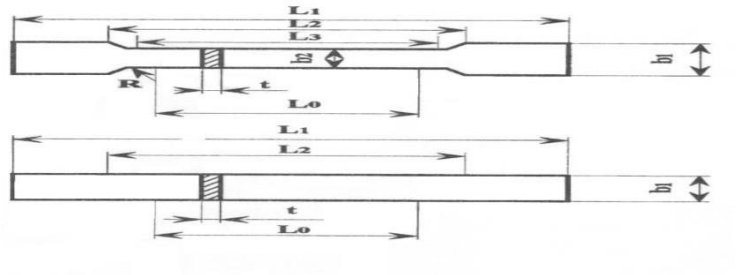


Table 2.3.3.1 Dimensions of the specimens for the compression tests

L_1, and L_2, mm	L_3; mm	b_1; mm	b_2; mm	R; mm	t; mm
not regulated	80	20	10 ± 0,5	160	10

2.3.4 Determination of modulus of elasticity for glass-reinforced plastics

2.3.4.1 The modulus of elasticity in tension is to be determined according to *2.3.2.1*, and in compression according to *2.3.3.1*. The strain increment is to be determined with initial load P_o and maximum load ρ_{max}, which are equal to 2 and 8-10 per cent of the breaking load, respectively.

2.3.5 Bend test

2.3.5.1 The bend test of rigid foamed plastics is to be carried out on the test specimens the length of which is 120 ± 1,2 mm, width 24 ± 0,25 mm and thickness 20 ± 0,2 mm. The distance between the supports is to be 100 mm and the rounding of the supports and the punch 5 ± 0,2 mm.
The rate of punch feed shall be 10 ± 2 mm/min.

2.3.5.2 The bend test of glass-reinforced plastics is to be carried out on test specimens, the length of which equals 20 times their thickness with a breadth of 25 mm. The distance between the supports should equal 16 times the specimen thickness. The load applied to the middling of the specimen should be smoothly increased until the latter breaks.

2.3.5.3 Bend test of laminated textiles

These tests shall be carried out on rectangular specimens measuring (300 ± 5) x (25 ± 5) mm, being fixed in the testing arrangement as shown in *Fig. 2.3.5.3*.

After to be fixed the test specimen, the distance between the grips is to be 30 mm.

When the test specimen has been fixed, the grips are to be brought together until they touch each other. At this time, the load upon the test specimen must be 10 N.

During the test, the movable grip shall perform 500 cycles of reciprocating movement with a frequency of 2 Hz and amplitude of 50 mm.

2.3.6 Determination of relative glass content in glass-reinforced plastic by mass

2.3.6.1 In the furnace at a temperature of 625 ± 25 ºC resin is removed from a specimen having dimensions (10 ± l,0) x (10 ± 1,0) mm x laminate thickness, the mass of which together with a crucible is to be determined with an accuracy up to 0,01 g. The glass content in the mass, in per cent, is obtained from the formula:

$$S = \frac{(G_2 - G_0)\cdot 100}{(G_1 - G_0)} \qquad (2.3.6.1)$$

Where:

G_1, G_2 = mass of the crucible together with the specimen before and after roasting, g;
G_0 = mass of the empty roasted crucible, g.

2.3.7 Determination of apparent density of foam plastics

2.3.7.1 The apparent density of foam plastics is to be determined on test specimens of regular shape, having a volume not less than 100 cm^3. Before conditioning in accordance with *2.3.1.1* the test specimens are to be dried at a temperature 40 ± 5 ºC to its constant mass. The apparent density is to be determined as the ratio of the mass of the specimen to its volume, in m^3.

2.3.8 Determination of shrinkage of plastics at limiting temperature.

2.3.8.1 A test specimen with dimensions (100 ± 1) x (100 ± 1) x (15 ± 0,5) mm is to be conditioned at the appropriate temperature during 48 h.

Shrinkage is determined as the ratio, in per cent, of linear deformation to the appropriate original size of the specimen after to be cooled and at the same temperature of the original measurement.

2.3.9 Water absorption test

2.3.9.1 Water absorption is to be determined on test specimens having the dimensions (50 ± 1) x (50 ± 1) mm and a thickness equal to the thickness of the product, but not more than 50 ± 1 mm.

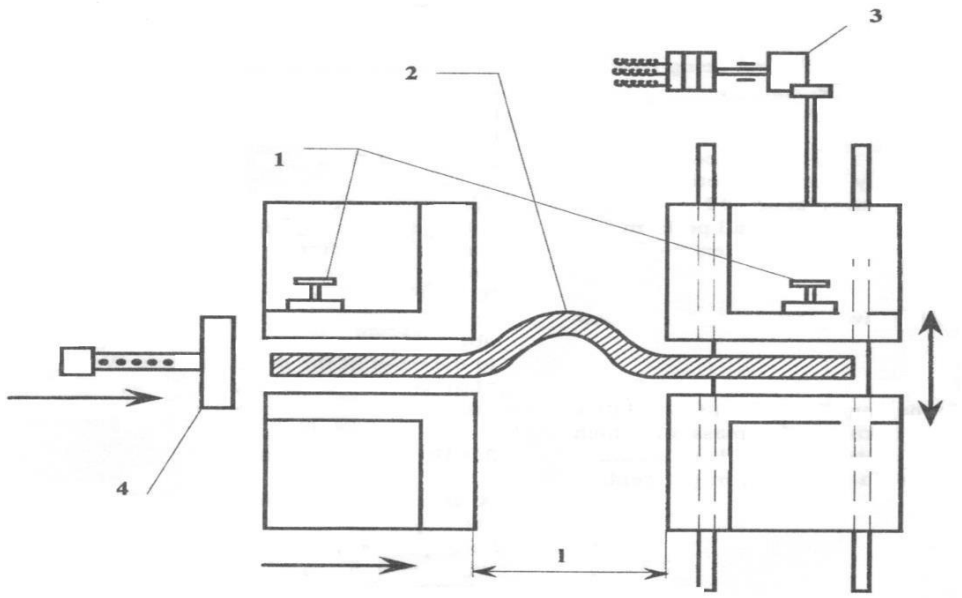
2.3.9.2 Before testing the specimens are to be dried to constant mass; drying conditions are specified in the relevant standards. After drying and weighing the specimens are immersed into distilled water and kept at a temperature 23 ± 2 ºC for 24 h. Then they are weighed again. Water is to be removed from the specimen surface. Water absorption is obtained as a fraction of total mass of absorbed water related to the mass of the dry specimen. Water absorption of foamed plastics shall be determined as the mass of absorbed water related to the surface area of the specimen.

2.3.10 Ageing test.

A sample, whose dimensions are determined depending on the required number and dimensions of test specimens shall be kept in semi-immersed condition in artificial sea water with a temperature 23 ± 2 ºC for 30 days. In the process of conditioning, the sample is to be subjected every day to two-hour ultra-violet irradiation with 500 W lamp placed at a distance of 50 cm from it.

After conditioning test specimens are prepared from the sample for carrying out the required tests.

Figure 2.3.5.3 Equipment for the bending tests of textiles

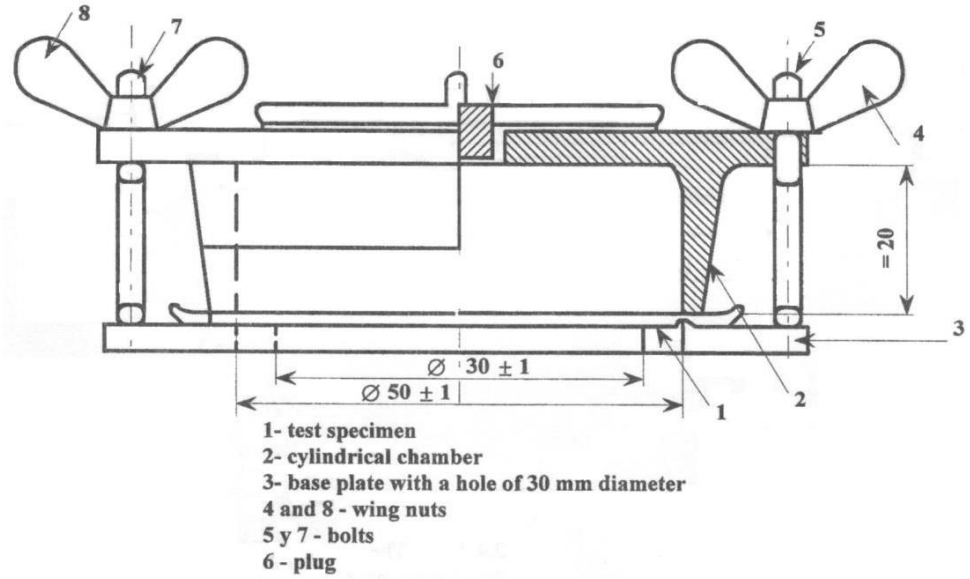


1 - piston
2- specimen
3- centering instrument
4- bolt for horizontal displacement

2.3.10.1 Two samples the size of which is determined proceeding from the number and size of specimens required are kept suspended during seven days at ambient temperature 70 ± 1º C, one of the samples being suspended in a closed volume above water. After that, the same number of test specimens is prepared out of each sample.

2.3.10.2 The test for creasing and stability of shape after ageing is effected on square specimens with a side measuring 100 ± 5 mm which are folded in two directions, parallel to the edges and at right angles to each other, unfolded and then folded once more along the same folds, but in the opposite direction. After each folding, the edges are to be smoothed down with the fingers.

Figure 2.3.11 Equipment for the petroleum-product resistance test



2.3.11 Petroleum-product resistance test

2.3.11.1 A disc-shaped specimen is inserted in the testing arrangement as shown in *Fig. 2.3.11*.

The arrangement is filled up to the level of 20 mm with a mixture of oils in the following proportion:

- 30% of 2, 2, 4 - trimethylethane,
- 50% of toluene,
- 15% of diisobutylene,
- 5% of ethanol.

On agreement with *ICS Class*, other oil products may be used such as diesel fuel, petrol, etc.

The test specimen is to be conditioned in oils during 22 h at a temperature 20 ± 2 °C. When the test specimen is extracted, it should be dried a little bit, the wet surface folded in two and the halves pressed to each other. The wet surfaces should not stick to each other, nor should the fingers be stained when the surfaces are touched.

2.3.12 Water resistance test

2.3.12.1 A sample, whose dimensions are determined depending on the required number and size of test specimen, is to be immersed in artificial sea water with a temperature of 23 ± 2 °C and conditioned during 5 months.

2.3.12.2 After conditioning, test specimens are prepared from the sample.

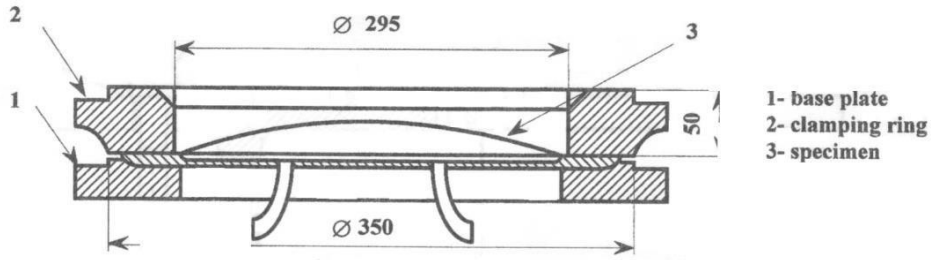
2.3.12.3 In the case of laminated textiles, a sample measuring 300 x 200 mm glued along the perimeter, should be conditioned in salt water with salt concentration 3,3 - 3,8 % during 4 hrs at a temperature of 40 ± 1 °C and at a depth of 500 mm.

2.3.13 Air permeability test

2.3.13.1 A disc-shaped specimen having a diameter of 350 mm is to be covered with wax in such a way that its center, 290 mm in diameter, is left open, and then shall be clamped between the flanges of the testing apparatus as shown in *Fig. 2.3.13.*

From below, a positive air pressure of 27.5 kPa acts upon the test specimen. In 10 - 15 min, the specimen is so immersed in water that its uppermost point is 13 mm below the surface 1 min later, no air bubbles should remain on the specimen surface. Within the following 5 min, no bubbles should rise to the surface.

Figure 2.3.13 Air permeability testing apparatus



2.3.14 Cold resistance test

2.3.14.1 The cold resistance test of laminated textiles is effected on rectangular specimens measuring (100 ± 5) x (50 ± 5) mm. After being conditioned at a temperature of –30 –5°C during 1 hr and at –60 –5 °C during 10 min, the specimens are bent through an angle of 90 °C.

A sketch of the testing apparatus is shown in *Fig.2.3.14.*

By the end of the test, the distance between the parallel parts of the test specimen should equal four times its thickness.

2.3.15 Ozone resistance test

2.3.15.1 A test specimen is bent through 180° round a mandrel equaling six times the specimen thickness in diameter, and subjected during 1 h to the influence of air with ozone concentration of 50 ppm at a temperature of 30 ± 2 °C and a relative humidity of 26%.

2.4 Weldability test

2.4.1 This Subsection contains general requirements for the weldability testing procedure of materials being approved.

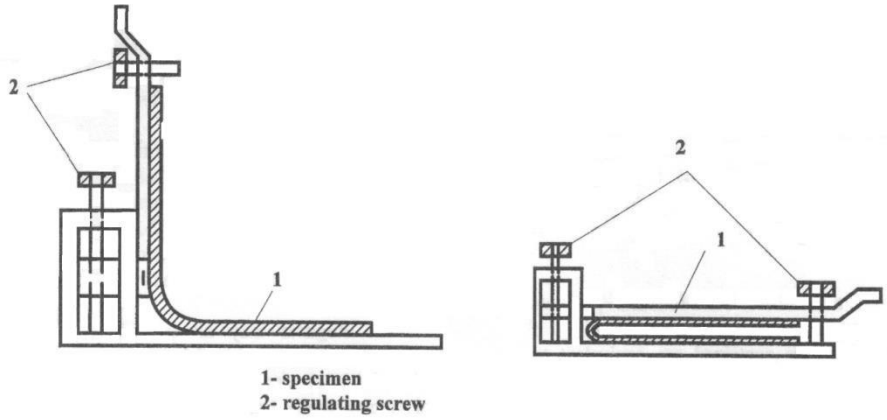
ICS Class reserves the right to increase or reduce the number of such tests.

Among the products tested for weldability there are rolled steel, steel castings, steel forgings and aluminum alloys applied in welded ship structures.

The test is to be carried out under the supervision of *ICS Class* or in a laboratory recognized by that body.

2.4.2 The weld ability of a material is to be examined in the course of approval test, by using the same welding methods that would be applied when producing structures subject to the supervision of *ICS Class*. The welding methods are to be indicated in the approval documentation for the material.

Figure 2.3.14 Sketch of testing machine



2.4.3 During the weld ability test the following is to be determined:

.1 Chemical composition and mechanical properties of the base metal.
.2 Cold cracking resistance.
.3 Susceptibility.
.4 Welded joint properties according to *Chapter 14*, *Section 4.*

2.4.4 The test mentioned under *2.4.3* is to be made on plates or other products of maximum thickness taken from at least three different casts.

2.4.5 For metallic materials other than the weld ability in each particular case is determined proceeding from the results of tests made in conformity with *ICS Class* approved program or according to standards approved by *ICS Class*.

SECTION 3
Steel and cast iron

3.1 General provisions

3.1.1 The present requirements are valid for bull structural steel, steel for boilers and pressure vessels, steel pipes and tubes, steel for rivets and cleats, steel for chains, steel forgings and castings, cast iron and steel wire ropes, high strength steel for welded constructions and Z-steel.

3.1.2 It is permitted to use semi-finished products manufactured according to standards or other specifications, if it is proved that requirements contained are equivalent to those stipulated by the Rules.

3.1.3 Steel is to be melted in open hearth or electric furnaces or in converters with top blowing of high purity gaseous oxygen. Cast iron is to be melted in cupolas or electric furnaces.
Use of other methods of steel and cast iron making is to be agreed with *ICS Class*
When steel is not produced at the works where it is rolled, forged or drawn, a certificate is to be supplied to the Surveyor at the mill engaged in further processing of the steel stating the steelworks, process of manufacture, number of cast and chemical composition of steel.
The Surveyor is to have the cast steel Certificate.

3.2 Hull structural steel

3.2.1 General provisions

3.2.1.1 The requirements of this Chapter apply to weldable heat-rolled steel plates, strips and sections up to 50 mm in thickness as well as to steel bars intended for hull structures and items subject to *ICS Class* supervision during their manufacture.

3.2.1.2 The present Chapter also includes additional requirements for hull structural steel plates and broad-strip steel of Grades E and E36, 50 through 100 mm thick.

3.2.1.3 Steel with different chemical composition, deoxidation method, heat treatment or mechanical properties, clad steel included, may be accepted subject to the special approval of *ICS Class*. Such steel is to have a special identification mark, namely, the letter *S* added to the grade symbol.

3.2.2 Chemical composition

The chemical composition of steel is to be determined by the Manufacturer from the results of analysis of the samples taken from each ladle of each cast. The Manufacturer's analysis will be accepted subject to periodical checks if required by *ICS Class*.

The chemical composition of normal strength steel is to comply with the requirements of *Table 3.2.2-1* and that of higher strength steel with the requirements of *Table 3.2.2-2*.

In *Tables 3.2.2-1 and 3.2.2-2* the content of acid soluble aluminum is included. If it is determined the general composition of the aluminum, this shall not be less than 0,020 per cent.

ICS may also require the content of elements to be determined which are not given in *Tables 3.2.2-1 and 3.2.2-2;* chromium, nickel and copper content in normal strength steel is not to exceed 0,30 per cent each.

For normal strength carbon steel the total carbon content plus 1/6 of the manganese contents is not to exceed 0,40 per cent.

The carbon equivalent, in per cent, for higher strength steels is calculated for guidance at approval tests from the ladle analysis using the formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + M_o + V}{5} + \frac{Ni + Cu}{15} (\%) \quad (3.2.2)$$

The arsenic contents in steels of all the grades is not to exceed 0,08 per cent.

The steels, in accordance with *Tables 3.2.2-1* and *3.2.2-2*, shall contain niobium, vanadium, aluminum or other elements not combined or with any kind of combination.

The composition of steels manufactured with only one element, shall be in accordance with the provisions stated in the *Tables 3.2.2-1* and *3.2.2-2*.

Where the elements are used in combinations, the content of at least one of them in the steel should agree with the value to be found in the tables.

Where the contents of aluminum or another grain refining element proves to be lower than required, *ICS Class* may require the austenite grain size to be determined which is not to be greater than grain size.

3.2.3 Mechanical properties

3.2.3.1 The mechanical properties of normal strength steel are to comply with the requirements given in *Table 3.2.2-1* while the mechanical properties of higher strength steel are to comply with the *Table 3.2.2-2*.

Table 3.2.2-1 Chemical composition and mechanical properties of normal strength steel

1	**Grade**		**A**	**B**	**D**	**E**		
2	Deoxidation		Killed or semi-killed	Killed or semi-killed	Killed	Killed, fine-grained, aluminum treated		
3	Condition of supply according to *Table 3.2.4-1*							
4	Chemical composition (ladle analysis), %	*C* max	0,21	0,21	0,21	0,18		
		Mn min	2,5 x C	0,80	0,60	0,70		
		Si max	0,50	0,35	0,35	0,35		
		P max	0,040	0,040	0,040	0,040		
		S max	0,040	0,040	0,040	0,040		
		Al min	-	-	0,015	0,015		
5	Tensile properties	Tensile strength, R_m (MPa)	400 - 490	400 - 900	400 - 900	400 - 900		
		Upper yield stress R_{eH} (MPa), min	235	235	235	235		
		Elongation A_5 (%), min	22	22	22	22		
6	Impact testing	Test temperature, (°C)	-	0	- 20	- 40		
		Plate thickness *t*, (mm)	-	≤ 50	≤ 50	≤ 50	50 <t ≤70	70 < t ≤ 100
		Impact energy (*J*), min, longitudinal specimens (KV_L)	-	27	27	27	34	41
		Impact energy (*J*), min, longitudinal specimens (KV_T)	-	20	20	20	24	27

NOTES:
.1 Grade A sections up to thickness of 12,5 mm may be accepted in rimmed steel.
.2 For section steel of Grade A, a carbon contents up to 0,23% is permitted.
.3 For section steel of Grade A, irrespective of thickness, the upper tensile strength may be increased on agreement with *ICS Class*.
.4 At 20 °C, Grade A steel is expected to withstand the impact energy (KV) of 27 J.
.5 On agreement with *ICS Class*, the manganese contents in Grade B steel being impact tested may be reduced to 0,60%.
.6 Grade D steel exceeding 25 mm in thickness should be killed, fine-grained and should contain A1 ≥ 0,015%.
.7 For tensile test in standard specimens, the minimum elongation shall be in accordance with the following values:

Thickness t, (mm)	**≤ 5**	**> 5 ≤ 10**	**> 10 ≤ 15**	**> 15 ≤ 20**	**> 20 ≤ 25**	**> 25 ≤ 30**	**> 30 ≤ 40**	**> 40 ≤ 50**
Elongation, %	14	16	17	18	19	20	21	22

Table 3.2.2-2 Chemical composition and mechanical properties of higher strength steel

1	**Grade**		**A32**	**D32**	**E32**	**A36**	**D36**	**E36**	**A40**	**D40**	**E40**
2	Deoxidation		Killed								
3	Supply condition		According to *Table 3.2.4-2*								
4	Chemical composition (ladle analysis), %	*C* max	0,18								
		Mn	0,90 up to 1,60								
		Si max	0,50								
		P max	0,040								
		S max	0,040								
		Cu max	0,35								
		Cr max	0,20								
		Ni max	0,40								
		Mo max	0,08								
		Al max	0,015								
		Nb	0,02.....0,05								
		V	0,05.....0,10								
		Ti max	0,02								
5	Tensile properties	Tensile strength, R_m, (MPa)	440.....590		490 620					510 650	
		Upper yield stress R_{eH}, min, (MPa)	315		355					390	
		Elongation A_5, min, (%)	22		21					20	
6	Impact testing	Test temperature, °C	0	- 20	- 40	0	- 20	- 40		0	- 20	- 40
		Plate thickness, *t* (mm)	≤ 50		≤50	≤50	≤50	55 < *t* ≤ 70	70 < *t* ≤ 100	≤ 50		
		Impact energy, *J* min, longitudinal specimens (KV_L)	31		34			41	50	41		
		Impact energy, *J*, min, transverse specimens (KV_T)	22		24			27	34	27		

NOTES:

.1 Up to a thickness of 12,5 mm the minimum manganese contents may be reduced to 0,70%.

.2 When steel is supplied in the thermo-mechanical controlled processed condition variations in the specified chemical composition may be allowed or required by *ICS Class*.

.3 When carrying out tensile tests on standard specimens the minimum elongation is to comply with the following requirements (in per cent):

Thickness *t*, mm ⇒ Grade of steel ⇓	**≤ 5**	**> 5 ≤ 10**	**> 10 ≤15**	**> 15 ≤ 20**	**> 20 ≤ 25**	**> 25 ≤ 30**	**> 30 ≤ 40**	**> 40 ≤ 50**
A 32 D 32 E 32	14	16	17	18	19	20	21	22
A 36 D 36 E 36	13	15	16	17	18	19	20	21
A 40 D 40 E 40	12	14	15	16	17	18	19	20

On agreement with *ICS Class*, the impact energy at impact testing may be determined either on longitudinal (KV_L) or transverse (KV_T) specimens.

3.2.4 Condition of supply

3.2.4.1 As far as the condition of supply is concerned, the steel is to be in agreement with *Tables 3.2.4-1* and *3.2.4-2*, and the condition of supply should be indicated in the certificate or the manufacturer's document.

Table 3.2.4-1 Condition of supply for normal strength steels

Grades	Thickness, mm	Condition of supply
A	All	Not regulated (any)
B	All	Not regulated (any)
D	≤ 35	Not regulated (any)
D	> 35	Normalised (*N*), controlled rolled (*CR*) or thermomechanical controlled processed (*TMCP*)
E	All	*N* or *TM*

NOTE:
.1 Subject to the special approval of *ICS Class*, sections in Grade D steel may be supplied in the hot-rolled condition provided satisfactory results are consistently obtained from impact tests. Similarly sections in Grade E steel may be supplied in the hot-rolled condition or after CR.

Table 3.2.4-2 Condition of supply for higher strength steels

Grades	Grain refining elements used	Thickness, mm	Condition of supply
A32, A36, A40	Nb, V	≤ 12,5 > 12,5	Not regulated (any) N, Cr or TM.
A32, A36, A40	Al or Al + Ti	> 20 ≤ 35 > 35	Not regulated (any) Hot-rolled subject to special approval of *ICS Class* (*I*) N, Cr or TM
D32, D36, D40	Nb, V	≤ 12,5 > 12,5	Not regulated (any) N, Cr or TM.
D32, D36, D40	Al or Al + Ti	> 20 ≤ 35 > 25	Not regulated (any) Hot-rolled subject to special approval of *ICS Class* (1) N, Cr or TM
D32, D36, D40	Any	All	N, TM, quenched and tempered at manufacture's discretion (*QT*)

NOTES:
.1 The requirements for impact tests are to be found in *3.2.6.2*.
.2 Subject to the special approval of *ICS Class*, sections in Grade A32, A36, A40, D32, D36 and D40 steels may be supplied in the hot-rolled condition provided satisfactory results are consistently obtained from impact tests. Similarly sections in Grade E32, E36 and E40 steels may be supplied in the hot-rolled condition or after CR. The frequency of impact tests is to be in accordance with *3.2.6.3*.

3.2.4.2 When controlled rolling or thermo-mechanical controlled processing is permitted as an alternative to normalizing (N), these procedures may be used subject to the special approval of *ICS Class*. These rolling procedures are defined as follows:

.1 Controlled rolling (CR) is a procedure in which generally the final rolling temperature is controlled within the range used for normalizing heat treatments so that the austenite completely recrystallises.

Thermo-mechanical controlled processing (TMCP) is a procedure which involves the strict control of both the steel temperature and the rolling reduction. Generally a high proportion of the rolling reduction is carried out close to or below the Ac_3 transition temperature and may involve rolling towards the lower end of the temperature range of the inter-critical duplex phase region thus permitting little if any recrys- tallisation of the austenite.

Before subjecting these steels to further heating for forming or stress relieving, or using high energy input welding, consideration must be given to the possibility of a consequent reduction in mechanical properties.

The use of accelerated cooling on completion of rolling may also be accepted subject to the special approval of *ICS Class*.

3.2.5 Sampling

3.2.5.1 Unless otherwise specified, the test samples are to be taken as follows:

.1 The test samples of plates and flats wider than 600 mm are to be taken from one end so that the sample axis is located midway between the longitudinal axis and the edge of the plate or flat (*Fig. 3.2.5-1*).
.2 From rolled bars 50 to 100 m thick, samples are to be taken 1/4 of the thickness dimension from the surface.
.3 The samples of flats 600 mm wide and less and of sections are taken from one end so that the sample axis his 1/3 from the flat edge or from the outer edge of the section flange or, in the case of small sections, as near as possible to this position (*Figs. 3.2.5-2, 3.2.5-3* and *3.2.5-4*).
.4 In the case of channels, T beams or semibulks the test samples may be alternatively taken from the position 1/4 from the web center line (*Fig. 3.2.5-3*).
.5 The test samples of bars and similar semi-finished products are taken from one end so that the sample axis is parallel to the direction of rolling.

Pieces of smaller cross-section may be tensile tested without prior machining.

3.2.5.2 In other cases, the test samples are to be taken so that their axes lie:

.1 For non-cylindrical semi-finished products, 1/3 of the half-diagonal from the outside (*Fig. 3.2.5-5*).
.2 For cylindrical semi-finished products, 1/3 of the radius from the outside (*Fig. 3.2.5- 6*).

3.2.5.3 Pieces selected for the preparation of tensile and impact test specimens are to be the thickest (greatest in diameter) in each batch with their longitudinal axes transverse to the final direction of rolling, except in the case of sections, bars and flats of 600 mm or less in width.

3.2.5.4 Specimens on which impact energy KV is to be determined should be prepared with their longitudinal axes either parallel or transverse to the final direction of rolling of the material unless required in special cases that the test samples are taken with their longitudinal axes transverse to the final direction of rolling.

The notch is to be cut perpendicular to the rolled surface and not closer than 25 mm to the flame cut or sheared edge.

Figure 3.2.5 Samples for tests in steels and cast irons

Figures 3.2.5-1 For plates wider than 600 mm, Figure 3.2.5-2 For flats 600 mm wide and less, Figure 3.2.5-3 For flats 600 mm wide and less, Figure 3.2.5-4 For flats 600 mm wide and less, Figure 3.2.5-5 For non-cylindrical semi- finished products, Figure 3.2.5-6 For cylindrical semi-finished products.

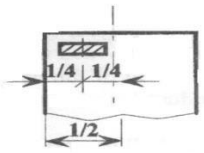


Figure 3.2.5-1 For plates wider than 600 mm

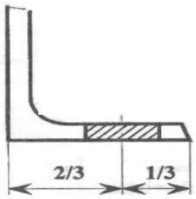


Figure 3.2.5-2 For flats 600 mm wide and less

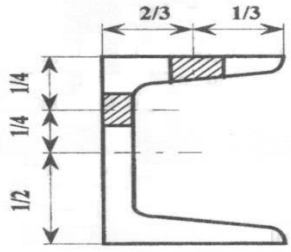


Figure 3.2.5-3 For flats 600 mm wide and less

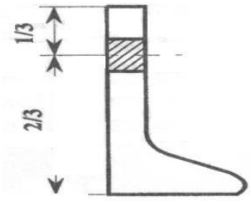


Figure 3.2.5-4 For flats 600 mm wide and less

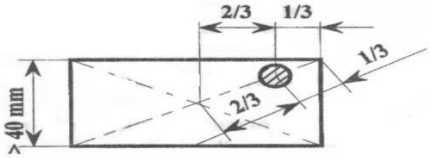


Figure 3.2.5-5 For non-cylindrical semi-finished products

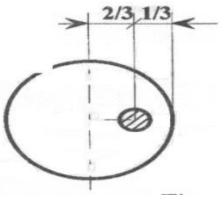


Figure 3.2.5-6 For cylindrical semi-finished products

3.2.6 Number of tests

3.2.6.1 Rolled material is to be presented for tests in batches. A batch is to comprise rolled products of the same type, from the same cast and in the same condition of supply. Unless otherwise specified, one tensile test piece and one set of impact test pieces is to be tested from each batch presented with the mass not exceeding 50 t (except Grade E, E32, E36 and E40 steel). Where the batch mass is in excess of 50 t, one extra tensile and impact test is to be made for each 50 t or fraction thereof. An additional test is to be made for every variation of more than 10 mm in the thickness of plates, or for every variation of more than 10 mm in the thickness or diameter of sections and bars comprising the batch.

3.2.6.2 When, subject to the special approval of *ICS Class*, material is supplied in the as-rolled condition, one set of impact test specimens is to be tested from each batch of 25 t or fraction thereof.

3.2.6.3 The number of impact tests for Grade E, E32, E36 and E40 steel should be as follows:

- for plates and wide flats each piece is to be tested;
- for sections and bars one set is to be tested from each batch of 25 t or fraction thereof.

When, subject to the special approval of *ICS Class*, sections are supplied in the as-rolled or controlled rolled condition, one set of specimens is to be tested from each batch of 15 t or fraction thereof.

3.2.7 Inspection

3.2.7.1 Allowable under-thickness tolerances of shell plates are to be in accordance with *Table 3.2.7.1*.

Table 3.2.7.1 Allowable under-thickness tolerances of sheel plates

Thickness *t*, mm	**Maximum permissible tolerances, mm**
$5 \le t < 8$	- 0,4
$8 \le t < 15$	- 0,5
$15 \le t < 25$	- 0,6
$25 \le t < 40$	- 0,8
$t \ge 40$	- 1,0

NOTES:
.1 The maximum permissible minus tolerances for the case of the thickness being less than 5 mm, are to be in accordance with standards.
.2 The thickness measurements are to be taken at a distance not less than 25 mm from the plate edge.

3.2.7.2 Segregations and non-metallic inclusions are not to be greater than those specified in the relevant standards recognized by *ICS Class*. The semi-finished products are to be free from cracks, slag inclusions and other defects prejudicial to the use of the material for its intended application. The semi-finished products are also to have workmanlike surface and are not to have been hammer dressed.

The manufacturer must guarantee complete elimination of piping which is to be verified by check tests. The methods of testing are to be agreed with *ICS Class*.

3.2.7.3 Surface defects may be removed by local grinding provided the nominal thickness is in no place reduced by more than 7 per cent, but in no case by more than 3 mm. The total area rectified by grinding is not to exceed 2 per cent of the product surface.

3.2.7.4 Surface defects which cannot be removed by local grinding may be repaired by chipping or grinding followed by welding, subject to the Surveyor's consent and under his supervision provided that:

- after removal of the defects before welding the thickness of the product is to be in no place reduced by more than 20 per cent;
- welding shall be carried out in accordance with an approved procedure by qualified welders with approved electrodes;
- the welded area is to be ground smooth to the correct nominal thickness;
- the area of a single welding is not to exceed 25 cm^2;
- the total welded area is not to be greater than 1 per cent of the product surface;
- after welding surface defects the advisability and type of heat treatment, if required, are to be agreed with a surveyor to *ICS Class*.

3.2.8 Marking

3.2.8.1 The steel maker is to adopt a system for identification of ingots, slabs and semi-finished products which would enable the material to be traced to its original cast.

3.2.8.2 Every semi-finished piece is to be clearly marked in a specified place and in a specified manner with *ICS Class* stamp or brand and at least the following particulars:

.1 Name or initials to identify the steelwork.
.2 Number or initials to identify the piece.
.3 Number of cast and unified identification mark for grade of steel and strength level (e.g. A, D36).

When required by *ICS Class*, material supplied in the thermo-mechanical condition is to have the letters TM added after the identification mark (e.g. E36TM).

3.3 Steel for boilers, heat exchangers and pressure vessels manufactured under the supervision of *ICS Class*

3.3.1 General provisions

3.3.1.1 The present requirements are applicable to rolled steel for marine boilers, heat exchangers and pressure vessels manufactured under the supervision of *ICS Class*.

3.3.1.2 The steel is to be manufactured in accordance with standards or specifications agreed with *ICS Class*.

3.3.1.3 Rolled steel which is manufactured and tested in accordance with these requirements is intended for operation at room or elevated temperatures.

3.3.2 Chemical composition

3.3.2.1 The chemical composition of steel is to be in accordance with standards proceeding from the required mechanical properties at room or elevated design temperatures and the content of base elements in per cent is not to exceed:

.1 For carbon and carbon-manganese steels (ladle analysis)

- Carbon	0,20
- Silicon	0,50
- Manganese	1,60
- Sulphur	0,040
- Phosphorus	0,040
- Chromium, nickel, copper	0,30 each

The use of steel with carbon content more than 0,20 per cent for welded structures is to be agreed with *ICS Class* on condition sufficient weldability is ensure.

.2 For low-alloy steel (ladle analysis)

- Carbon	0,18
- Silicon	0,50
- Manganese	0,80
- Sulphur	0,040
- Phosphorus	0,040
- Chromium	2,50
- Molybdenum	1,10
- Vanadium	0,35

3.3.2.2 The steel is to be killed. Using of rimming steel is not permitted, and semi-killed steel is permitted on agreement with *ICS Class*. Also, on agreement with *ICS Class*, the steel may be treated with grain-refining elements.

Carbon and carbon-manganese steel intended to operate at temperatures over 400º C is not to contain aluminum.

3.3.3 Mechanical properties

3.3.3.1 The mechanical properties of steel at room and elevated temperatures are to be in accordance with standards.

3.3.3.2 The properties of steel are to be confirmed by the following tests:

- tensile test (tensile strength, yield stress and percentage elongation are determined);
- bend test;
- Impact test (KCU or KV).
- The tensile test at elevated temperature and the ageing test are to be carried out if required by the relevant parts of the Rules or by standards.

At the request of *ICS Class* the test results obtained at determining the average stress to produce rupture at elevated temperature are to be submitted.

3.3.4 Supply conditions

3.3.4.1 The steel is to be manufactured as normalized, normalized and tempered or quenched and tempered. The method of heat treatment is to be as stipulated by standards.

3.3.4.2 On agreement with *ICS Class*, the steel may be manufactured without heat treatment provided the required properties are guaranteed, and controlled rolling may be accepted as a substitute for normalizing.

3.3.5 Sampling

3.3.5.1 Unless stated otherwise, sampling is to be carried out in accordance with *3.2.5*.

Tensile test specimens and those for determining the impact toughness KCU are to be cut out transverse to, and those for determining the impact energy KV - parallel to the direction of the last rolling.

3.3.6 Number of tests

3.3.6.1 Each rolled steel plate is to be submitted for testing. In the case of rolled plates of carbon steel up to 12 mm thick, as well as rolled sections, it is permitted to take 10 per cent of the total number of the plates (rolled pieces) or sections for testing purposes, but not less than two of the same thickness (diameter or shape), and one of the same cast and identical heat treatment.

3.3.6.2 Unless stated otherwise, not less than one specimen for tensile and bend testing and not less than one set of specimens for impact testing should be taken from the rolled piece intended for testing purposes.

3.3.6.3 The number of specimens for tensile testing and for the determining of long-term strength at elevated temperature, is to be established on agreement with *ICS Class*.

3.3.6.4 From plates (rolled pieces) with a mass of more than 6 t or a length of more than 15 m the samples for test specimens are to be cut out on both ends.

3.3.7 Inspection

3.3.7.1 The rolled steel is to be free from defects prejudicial to the use of the material for the intended application. Freedom from non-allowable defects is to be guaranteed by the manufacturer and may be confirmed by the results of non-destructive testing.

Surface defects involved by the manufacturing process are permitted in case their depth is not greater than the allowable under-thickness tolerances, considering from the nominal thickness.

Repair of surface defects by welding followed by post-weld heat treatment is permitted on agreement with *ICS Class* only.

3.3.8 Marking

3.3.8.1 The marking is to be effected in accordance with *1.4*.

3.4 Steel tubes and pipes

3.4.1 General provisions

3.4.1.1 The present requirements apply to hot- and cold-formed steel pipes and tubes and also welded pipes intended for boilers, heat exchangers, pressure vessels, ship systems and piping which are submitted to supervision of *ICS Class* during manufacture.

3.4.1.2 The steel pipes and tubes are to be manufactured in accordance with standards or technical requirements agreed with *ICS Class*.

3.4.1.3 Pipes and tubes that are manufactured and tested in accordance with the present requirements are intended for operation at room or elevated temperatures.

3.4.1.4 The welded pipes and tubes may be manufactured by means of electric induction welding, pressure contact welding or fusion welding.

3.4.2 Chemical composition

3.4.2.1 The chemical composition of the steel for pipes and tubes is to be chosen on the basis of standards proceeding from the required mechanical properties at room of elevated design temperature; the content of base elements in per cent is not to exceed the values stated below.

.1 For carbon and carbon-manganese steel (ladle analysis)

-Carbon	0,23
-Silicon	0,50
-Manganese	1,50
-Sulphur	0,040
-Phosphorus	0,040
-Chromium, nickel, copper	0,30 each

.2 For low-alloy steel (ladle analysis)

- Carbon	0,20
- Silicon	0,50
- Manganese	1,00
- Sulphur	0,035
- Phosphorus	0,035
- Chromium	2,50
- Molybdenum	1,20
- Vanadium	0,35

3.4.2.2 The steel is to be killed. Rimming steel is not permitted for manufacturing pipes and tubes and semi-killed steel is permitted on agreement with *ICS Class*.

The treatment of steel with grain-refining elements is also permitted on agreement with *ICS Class*. Carbon and carbon-manganese steel intended for working temperatures above 400º C is not to contain aluminum.

3.4.2.3 The use of steel in which the base elements content exceeds the above limits, as well as steel containing other base alloying elements than those stated above, may be permitted on agreement with *ICS Class*.

3.4.2.4 The chemical composition is to be determined from the heat analysis (ladle analysis), and shall be required the determination of the chemical composition in the construction of the tubular couplings.

3.4.3 Mechanical and technological properties

3.4.3.1 At room and elevated design temperature the mechanical and technological properties of steel intended for pipes and tubes are to be in accordance with the approved standards.

3.4.3.2 In the process of manufacture the pipes and tubes are to undergo the following tests:

- tensile test (tensile strength, yield stress and elongation being determined) according to *2.2.2.1*;
- tensile test at elevated temperature (proof stress being determined);
- flattening test according to *2.2.5.2*, or tensile test of rings according to *2.2.5.4*;
- expanding test according to *2.2.5.3*.

Tensile test at elevated temperature, flattening test, tensile test of rings and expanding test are to be carried out when required by standards for pipes or by technical documentation approved by *ICS Class* on the basis of which the test results are estimated.

When required by *ICS Class* or provided for by the relevant parts of the Rules or by standards, the results of testing the steel intended for pipes and tubes for determining the average stress to produce rupture at elevated temperature are to be submitted.

3.4.4 Supply conditions

3.4.4.1 The pipes and tubes are to be heat treated, when stipulated by the relevant parts of the Rules, by standards or technical design documentation approved by *ICS Class*. The cold-formed and electrically welded pipes and tubes are in any case to be heat treated, normalized, normalized and tempered or quenched and tempered. The method and conditions of heat treatment are to be chosen by the manufacturer, reported to *ICS Class* and stated in the certificate.

3.4.5 Sampling

3.4.5.1 Unless stated otherwise, sampling for specimens is to be made from one end of not less than two pipes or tubes of the batch.

3.4.6 Scope of testing

3.4.6.1 The pipes and tubes are to be tested by batches. A batch is to consist of pipes and tubes of the same size manufactured from steel of the same heat and heat treated under similar conditions.

The number of pipes or tubes in a batch is not to exceed:

- 400 in the case of pipes or tubes with an outer diameter of 76 mm or less.
- 200 in the case of pipes or tubes with an outer diameter over 76 mm.

The rest of pipes or tubes which are less than half the number stated before is to be included in a relevant batch and those which are half and over, are to be considered in a separated batch.

3.4.6.2 For testing purposes, of each sample shall be chosen:

- 1 specimen for the tensile test.
- 1 specimen for the flattening test or the tensile test of rings. (2 specimens for the tests of welded tubes; for this, during the testing of one of the specimens, the welded joint is to be in the bending area).
- 1 specimen for the expanding test.

All the pipes and tubes are to be tested by hydraulic pressure. The test pressure is to be in accordance with standards for pipes and tubes or with documentation agreed with *ICS Class*, but in any case it is not to be less than that stated in *Chapter 8, rule 15.2*, and in *Chapter 10, rule 1.7*.

3.4.6.3 On agreement with *ICS Class*, hydraulic tests may be omitted if all the pipes and tubes undergo ultrasonic or other equivalent testing.
All the welds in welded pipes and tubes are to undergo the ultrasonic testing.

3.4.7 Inspection

3.4.7.1 All the pipes and tubes are to undergo visual examination.

3.4.7.2 The surface of the pipes and tubes is to be free from cracks, skins, fissures and laps.

A certain number of minor nicks and dents, marks, thin layers of scale, traces of defects grinding and small skins are permitted if due to them the wall thickness would not exceed the allowable under-thickness tolerances.

3.4.8 Marking

3.4.8.1 The marking is to be in accordance with *Subsection 1.4*.

3.5 Steel for structures intended for low temperature service

3.5.1 General provisions

3.5.1.1 Steel plates and sections up to 50 mm thick, steel forgings and castings intended for hull structures, ship equipment and machinery cooling up to minus 50° C at low ambient temperatures are to be manufactured in conformity with the requirements below and tested in the presence of a Surveyor to *ICS Class*.

3.5.1.2 Steel with a chemical composition, heat treatment and mechanical properties different from those required below, may be approved by *ICS Class* provided it shows no tendency to brittle fracture, as determined by drop-weight test in accordance with *2.2.6*, at design (service) temperature and provided adequate weldability is ensured where necessary. For rolled steel more than 50 mm thick, a special agreement of *ICS Class* is necessary.

3.5.1.3 Where provision for welding is made during the manufacture of forged or cast items or where such items are meant for welding inside the ship hull, the chemical composition of steel and the welding procedure are to ensure the welded joint resistance to cracking.

For weld metal, the mechanical properties and impact energy obtained at impact test at prescribed temperature are not to be lower than those required for the base metal.

3.5.1.4 The impact testing of steel is to be made on specimens complying with *Fig. 2.2.3.1-2* for steel plates and sections at the temperature in accordance with *Table 3.5.2.3*, for steel forgings and castings, in accordance with standards and technical requirements, but in any case at a temperature at least 5° C lower than the design temperature.

After impact testing of the specimens, the percentage of fiber in the fracture is to be determined on the basis of standards or by procedures agreed with *ICS Class*.

3.5.2 Hull structural steel

3.5.2.1 Manufacture

The steel is to be manufactured in basic oxygen furnaces or converters. Other manufacturing processes may be used subject to an agreement with *ICS Class*.

3.5.2.2 Chemical composition

The chemical composition of a particular steel grade is to be set forth by standards and technical requirements and is not to exceed the ultimate values of *Table 3.5.2.2*. The steel is to be fully killed and treated with grain-refining elements.

3.5.2.3 Mechanical properties

The mechanical properties of steel when tensile-tested, as well as impact test results, are to comply with *Table 3.5.2.3*.

The mechanical properties of steel more than 50 mm, thick should be agreed with *ICS Class*. In any case, the impact energy of such steel must comply with *Table 3.5.2.3* for the respective grade.

Table 3.5.2.3 Mechanical properties of hull structural steel

Steel grade	Yield stress (min.) R_{eH}, MPa	Tensile strength R_m, MPa	Min. elongation A_5	Impact test		
				Test temperature °C	Impact energy, J, min	
					Transv.	Longit.
F 32	315	440 ÷ 590	22	- 60	31	22
F 36	355	490 ÷ 620	21	- 60	34	24
F 40	390	510 ÷ 650	20	- 60	41	27

3.5.2.4 Supply conditions

Steel plates may either be normalized (N) or quenched and tempered (QT), or supplied in the thermo- mechanically controlled processed condition (TMCP). The condition of supply is to be agreed with *ICS Class* and shall be stated in the certificate.

3.5.2.5 Scope of testing

Impact tests of steel plates are to be made on longitudinal and transverse specimens on the following scale: in the case of steel as normalized and thermo-mechanically treated, one set of specimens from each batch shall be tested, and in the case of steel as quenched and tempered, one set of specimens from each furnace charge shall be tested.

The impact test of transverse specimens may not be taken into account by *ICS Class*. This test is to be, however, mandatory in case of steel acceptance or manufacturer approval (see also *1.3.2* and *1.3.3* respectively), by means of a certification procedure.

3.5.3 Steel forgings

3.5.3.1 Chemical composition.

The chemical composition of steel for forgings is to be chosen on the basis of standards agreed with *ICS Class* proceeding from the required properties at room temperature and low temperature and is to be in conformity with *rule 3.7.2*.

The content of sulphur and phosphorus in carbon and carbon-manganese steel is not to exceed 0,025% and 0,030%, accordingly, and in alloy steel not greater than 0,025% of each element.

3.5.3.2 Mechanical properties

The mechanical properties of forged steel and the results of impact testing at room temperature are to be in accordance with *3.5.1.4.*

The required impact energy values are to be chosen on the basis of standards or technical requirements, but in any case it is not to be less than 27 J. *ICS Class* may require the percentage of fiber in the fracture of the specimen to be determined after impact test, which is not to be less than 50%.

For the approval of steel to be used for important forgings which are to operate at minus 30 C and below, *ICS Class* may require resistance to brittle fracture to be confirmed either by impact testing of specimens with larger cross-sections, drop-weight testing in accordance with *2.2.6*, or by other procedures of cracking resistance testing agreed with *ICS Class*.

3.5.4 Steel castings

3.5.4.1 Chemical composition.

The chemical composition of steel for castings is to be chosen on the basis of standards agreed with *ICS Class* proceeding from the required properties at room and low temperatures and is to be in accordance with *3.8.2*. The content of sulphur and phosphorus is not to exceed 0,025% and 0,030%, accordingly.

3.5.4.2 Mechanical properties.

The mechanical properties of steel castings and the results of impact testing at room temperature are to be in accordance with *3.8.3*.

Besides, the steel is to be impact tested at the temperature determined proceeding from *3.5.1.4*. The required impact energy value is to be chosen on the basis of standards or technical requirements, but in any case it is not to be less than 27 J, and *ICS Class* may require the percentage of fiber in the fracture of the specimen to be determined after impact test, which is not to be less than 50%.

For the approval of steel to be used for important castings which are to operate at minus 30º C and below, *ICS Class* may require resistance to brittle fracture to be confirmed either by impact testing of specimens with larger cross-sections, drop-weight testing in accordance with *2.2.6*, or by other procedures of cracking resistance testing agreed with *ICS Class*.

3.6 Steel for chains

3.6.1 General provisions

3.6.1.1 The present requirements apply to rolled steel used to manufacture anchor chain cables subject to *ICS Class* supervision.

3.6.1.2 The rolled steel is to be manufactured by works approved by *ICS Class*, and *ICS Class* may require approval test of the material produced by the works in a heat treatment condition equivalent to that stipulated for a finished chain cable by *7.1.3.4*.

3.6.1.3 The Manufacturer is to submit specifications of the material to *ICS Class* for the approval.

Stated in the specification should be the melting and deoxidation procedure, specified chemical composition, supply condition and mechanical properties.

Melting and deoxidation procedure, chemical composition and condition of supply which do not fully comply with the requirements of *3.6.3 - 3.6.5* should be agreed with *ICS Class* in the process of specification approval.

3.6.2 Chemical composition

3.6.2.1 The chemical composition of rolled steel bars based on ladle analysis is to comply with *Table 3.6.2*.

Table 3.6.2 Chemical composition of rolled steel bars

Grade	Content of elements, %					
	C	Si	Mn	P	S	Al total[1]
	(max)			Maximum		
1	0,20	0,15 ÷ 0,35	Min 0,40	0,040	0,040	-
2 [2]	0,24	0,15 ÷ 0,55	Max 1,60	0,035	0,035	0,020
3	In conformity with approved specification					

[1] Aluminum may be replaced partly by other fine graining elements.
[2] If *ICS Class* agrees, additional alloying elements may be added.

The bars are to be of killed steel, and the steel used for the manufacture of grades 2 and 3 chain cables is to be fine grain treated.

3.6.3 Mechanical properties

3.6.3.1 The mechanical properties of rolled steel bars should ensure the properties of finished chain cable as prescribed in *Table 3.6.3*.

Table 3.6.3 Mechanical properties of finished chain cable material

Grade	R_{eH} MPa, min	R_m, MPa	A_5 %	Z %	Impact test [1] [2] *KV*	
			min		Test temperature, °C	Impact energy, J, min
1	-	max 490	25	-	-	-
2	295	490 ÷ 690	22	-	0	27
3	410	min 690	17	40	0 (- 20)	60 (35)

.1 The impact test of grade 2 materials may not be carried out, if the chain cable is supplied in a heat treated condition.
.2 On agreement with *ICS Class*, the impact test of grade 3 materials may alternatively be carried out at 20° C.

3.6.4 Supply condition

The steels are to be supplied in as rolled condition.

3.6.5 Scope of testing

3.6.5.1 The steel bars are to be submitted for testing in batches. A batch not more than 50 t in mass is to comprise bars of the same cast and supply condition with a tolerance of diameter within 4 mm.

3.6.5.2 From each batch of steel bars, a sample is to be taken out of which a tensile test specimen and, where necessary, impact test (KV) specimens are machined.

3.6.6 Sampling

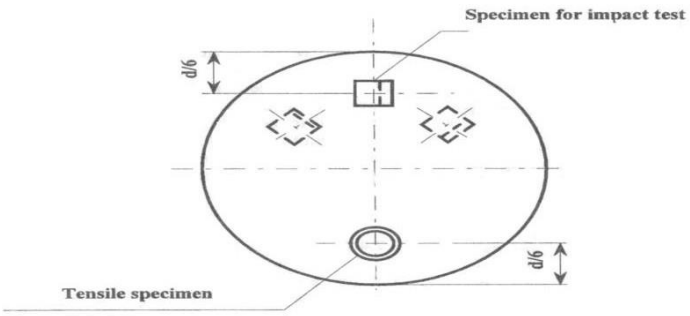
Test specimens should be taken from the test sample in the longitudinal direction at a distance of 1/6 diameter from the surface or as close as possible to this position in accordance with *Fig. 3.6.6*.

3.6.7 Inspection

3.6.7.1 The admissible tolerance of the steel bar diameter shall be determined by standards and stated in the specifications.

3.6.7.2 The steel bars must be free from internal and surface defects that might impair proper workability and use. Surface defects may be repaired by grinding provided the admissible tolerance is not exceeded.

Figure 3.6.6 Specimens for the tests of steel for chains



3.6.8 Marking is inserted upon each bar in conformity with *1.4*.

3.7 Steel forgings

3.7.1 General provisions

3.7.1.1 Steel forgings subject to supervision of *ICS Class*, when produced in conformity with the relevant parts of the Rules, are to be manufactured and tested in accordance with the requirements stated below.

3.7.1.2 The present requirements apply to forgings used in ship machinery construction.

3.7.1.3 The requirements apply also to rolled billets used as substitutes for forgings and for rolled steel the diameter of which does not exceed 250 mm used for manufacturing (by means of machining only) of shafts, bolts and similar items simple in shape.

3.7.1.4 The requirements for forgings to be used at low or high temperature, as well as for forgings of alloy steel with special properties (corrosion resistance, heat resistance, high temperature oxidation resistance, etc.) will be specially considered by *ICS Class* in each case. The documents submitted to *ICS Class* for agreement are to contain detailed information on the chemical composition, mechanical and special properties, as well as the methods and the scope of testing the forgings.

3.7.1.5 In the case of established manufacturing process where uniform forgings are produced, alternative testing methods and scope can be adopted on agreement with *ICS Class* provided the stable character of the technological processes and the quality of forgings are confirmed.

When two or more forgings are joined by welding to form a composite component, details of the chemical composition of steel and welding procedure are to be agreed with *ICS Class*. Welding procedure tests may be required.

3.7.1.6 When two or more forgings are joined by welding to form a composite component, details of the chemical composition of steel and welding procedure are to be agreed with *ICS Class*. Welding procedure tests may be required.

3.7.1.7 The forging ratio is to be such as to ensure freedom from defects, uniformity of structure and the required mechanical properties after the heat treatment, and as a rule it is to be in conformity with *Table 3.7.1.7*.

The wall thickness of the forging is to be not more than one half of the wall thickness of the hollow billet. Where this is not practicable, adequate working is to be given to the billet prior to expanding or drawing, and the reduction is to be not less than 2:1.

Table 3.7.1.7 Forging ratio

Method of manufacture	Total forging ratio
From ingot or forged billet	3 : 1 for L > D 1,5 : 1 for L ≤ D
From rolled billet	4 : 1 for L > D 2 : 1 for L ≤ D

NOTES:
.1 *L* and *D* are the length and diameter of a forging or its part respectively.
.2 The forging ratio is to be calculated with reference to the average cross-sectional area of the ingot. The initial upsetting of the ingot may be also taken into consideration.
.3 For rolled bars used as a substitute for forgings the reduction ratio is to be not less than 6: 1.

3.7.1.8 For certain components, where grain flow is required in the most favorable direction having regard to the mode of stressing in service, the proposed method of manufacture is to be agreed with *ICS Class*. During the manufacture of the forgings, tests may be required by *ICS Class* to demonstrate that a satisfactory structure and grain flow are obtained.

3.7.1.9 Unless otherwise agreed, flame cutting, scaring, and arc gouging are to be carried out before the final heat treatment. Pre-heating is to be employed when needed by the chemical composition of the steel and/or thickness.

3.7.2 Chemical composition

3.7.2.1 The chemical composition of steel for forgings is to be chosen for the particular type of steel and the required mechanical and special properties of the forgings being manufactured.

The forgings are to be made from killed steel.

3.7.2.2 For carbon and carbon-manganese steel forgings the chemical composition of ladle samples is to be within the following overall limits in per cent:

- Carbon 0,60 max
- Silicon 0,45 max
- Manganese 0,30 ÷ 1,50
- Sulphur 0,040 max
- Phosphorus 0,040 max
- Copper 0,30 max
- Chromium 0,30 max
- Molybdenum 0,15 max
- Nickel 0,40 max

3.7.2.3 For alloy steel forgings the chemical composition of ladle samples is to be in accordance with standards or with other technical requirements agreed with *ICS Class* and is to comply with the following overall limits in per cent:

- Carbon 0,45
- Silicon 0,45
- Sulphur 0,035
- Phosphorus 0,035

3.7.2.4 If not otherwise stated, grain refining elements may be added at the option of the manufacturer.

3.7.3 Mechanical properties

3.7.3.1 Proceeding from the tensile strength required, yield stress, elongation, reduction of area and the results of impact testing for forgings of alloy steel after quenching and tempering are conform to *Table 3.7.3.1-1*, and for forgings of alloy carburizing steel to *Table 3.7.3.1-2*.

Table 3.7.3.1-1 Mechanical properties of alloy steel forgings

Tensile strength R_m, MPa	**Yield stress R_{eH} or $R_{p0,2}$,** MPa	**Elongation A_5,** %	**Reduction of area *Z*,** %	**Impact testing results**			**Brinell hardness**
				Impact energy *KV*, J	**Impact energy *KU*,** J	**Impact toughness KCU,** J/cm²	
minimum							
600	420	18/14	50/35	41/24	35/24	70/48	175...215
650	450	17/13	50/35	32/22	30/23	60/46	190...235
700	480	16/12	45/30	32/22	30/23	60/46	205...245
750	530	15/11	45/30	32/22	30/22	60/44	215...260
800	590	14/10	40/27	32/22	30/22	60/44	235...275
850	640	13/9	40/27	27/18	26/20	52/40	245...290
900	690	13/9	40/27	27/18	26/20	52/40	260...320
950	750	12/8	35/24	25/16	25/18	50/36	275...340
1000	810	12/8	35/24	25/16	25/18	50/36	290...365
1050	870	11/7	35/24	21/13	23/15	46/30	310...375
1100	930	11/7	35/24	21/13	23/15	46/30	320...385

Table 3.7.3.1-2 Mechanical properties of alloy carburizing steel

Diameter or thickness of sample, mm	**Tensile strength R_m,** MPa	**Yield stress R_{eH},** MPa	**Elongation A_5,** %		**Reduction of area *Z*,**%		**Impact test results**					
							Impact energy *KV*, J		**Impact energy *KV5*,** J		**Impact toughness *KCU2*,** J/cm²	
		specimen										
30	80 - 1100	600	10	6	35	25	22	16	24	18	48	36
	1000 - 1300	680	8	6	35	25	18	14	20	15	40	30
	1050 - 1350	780	8	6	35	25	18	14	20	15	40	30
60	650 - 950	450	11	9	40	27	22	16	24	18	48	36
	800 - 1100	550	10	8	35	27	22	16	24	18	48	36
	950 - 1250	680	8	6	35	27	18	14	20	15	40	30

3.7.4 Supply conditions

3.7.4.1 All the forgings are to be suitably heat treated to obtain the required structure of metal, mechanical properties and also a decrease of the grain size. The procedure of heat treatment is to be chosen by the manufacturer proceeding from chemical composition of steel, the purpose and dimensions of the forgings. The following conditions are to be observed:

.1 The tempering temperature is to be not less than 550º C.
.2 If for any reason a forging is heated for further hot working, it is to be reheat treated.
.3 Where a forging is intended for surface hardening, full details of the proposed procedure and specification are to be agreed with *ICS Class*. For this purpose, the manufacturer may be required to demonstrate by test that the proposed procedure gives a uniform surface layer of the required hardness and depth and that it does not impair the soundness and properties of the steel.
.4 Where induction hardening, carburizing or nitriding is to be carried out after machining, forgings are to be heat treated (generally either by full annealing or by normalizing and tempering) to a condition suitable for this subsequent surface hardening.
.5 If any straightening operation is performed after the final heat treatment, a subsequent stress relieving heat treatment should be carried out.
.6 The method of heat treatment is to be reported to *ICS Class* and indicated in the certificate.

3.7.5 Sampling

3.7.5.1 Test material sufficient for the required tests and for possible re-test purposes, is to be provided with a cross-sectional area of not less than that part of the forging which it represents. The specimens are to be taken with their axes at a distance up to 10% of the diameter or thickness from the surface.

3.7.5.2 Except for components which are to be carburized or as otherwise specially agreed, test material is not to be cut from a forging until all heat treatment has been completed.

3.7.5.3 Generally, a tensile test specimen and a set of impact test specimens are to be machined from a sample.

3.7.6 Scope of testing

3.7.6.1 Forgings are to be submitted for testing individually or in batches. Except where specially provided otherwise, the number and direction of tests are to be as follows:

.1 Forgings for rudder stocks, pintles, shafting, connecting rods, etc.

One sample is to be taken from the end of each forging in a longitudinal direction according to *Figs 3.7.6.1.1-1, 3.7.6.1.1-2* and *3.7.6.1.1-3* (position A).
On agreement with the Surveyor a sample may be taken in the transverse direction according to the positions B, C and D. Where a forging exceeds both 4 t in mass and 3000 mm in length, one sample is to be taken from each end.
The mass and length of a forging to be quenched and tempered are to be those of the forging prior to heat treatment.

.2 Pinion forgings

Where the finished machined diameter of the toothed portion of the forging exceeds 200 mm, one sample is to be taken from each forging in the transverse direction according to *Fig. 3.7.6.1.2* (position B). Where the dimensions preclude sampling from this position, a sample in the transverse direction is to be taken according to *Fig. 3.7.6.1.2* (position C). If however, the diameter is 200 mm or less, samples are to be taken in the longitudinal direction according to *Fig. 3.7.6.1.2* (position A). Where the finished length of the toothed portion exceeds 1250 mm, one sample is to be taken from each end.

.3 Gear wheel forgings

One sample is to be taken from each forging in the transverse direction according to *Fig. 3.7.6.1.3* (position A or B).

.4 Gear wheel rim forgings (made by expanding)

One sample is to be taken from each forging according to *Fig. 3.7.6.1.4* (position A). Where the finished diameter exceeds 2500 mm or the mass exceeds 3 t, two samples are to be taken according to *Fig. 3.7.6.1.4* (positions A and B).

.5 Pinion sleeve forgings

One sample is to be taken from each forging in the transverse direction according to *Fig. 3.7.6.1.5* (position A or B).
Where the finished length exceeds 1250 mm, one sample is to be taken from each end (positions A and B).

.6 Crankweb forgings

One sample is to be taken from each forging in the transverse direction.

.7 Solid-forged crankshafts

One sample is to be taken in the longitudinal direction from the coupling end of each forging according to *Fig. 3.7.6.1.7* (position A). Where the mass exceeds 3 t samples in the longitudinal direction are to be taken from each end (positions A and B). Where, however, the crankthrows are formed by machining or flame cutting the second sample is to be taken in the transverse direction (position C).

.8 Crankshaft and other forgings with grain flow in the most favorable direction.

The number of samples and the areas for sampling are, in each case, to be specially considered by *ICS Class*.

.9 Forgings subject to carburizing

Unless stated otherwise by *ICS Class*, for both preliminary tests after forging and for final tests after completion of carburizing, duplicate samples are to be taken from positions as detailed above for appropriate forgings, except that irrespective of the dimensions or mass of the forging the samples are to be taken in one direction only. The samples are to be machined to a diameter of D/4 or 60 mm, whichever is less, where D is the finished diameter of the toothed portion.

For preliminary tests after forging the samples are to be given a blank carburizing and heat treatment cycle simulating that which will be subsequently applied to the forging. For the final acceptance tests, the second set of samples is to be blank carburized and heat treated along with the forgings which they represent.

At the discretion of the manufacturer of forgings or gear manufacturer, test samples of larger cross-section may be either carburized or blank carburized, but these are to be machined to the required diameter prior to the final quenching and stress relieving heat treatment.

Alternative procedures for the testing of forgings which are to be carburized may be specially agreed with *ICS Class*.

.10 The mass and the size of the forgings, when they are submitted to quenching and tempering, shall be in correspondence with the condition in which they are before the heat treatment.

Figure 3.7.6.1.1-1 Sampling of pintles forgings and its number

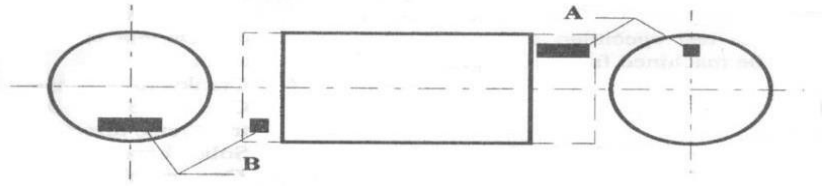


Figure 3.7.6.1.1-2 Sampling of shafting forgings and its number

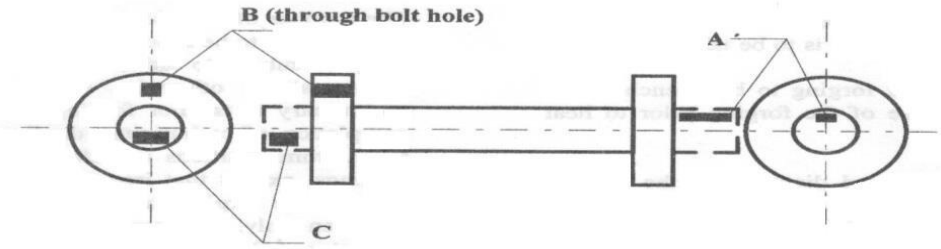


Figure 3.7.6.1.1-3 Sampling of flange forgings and its number

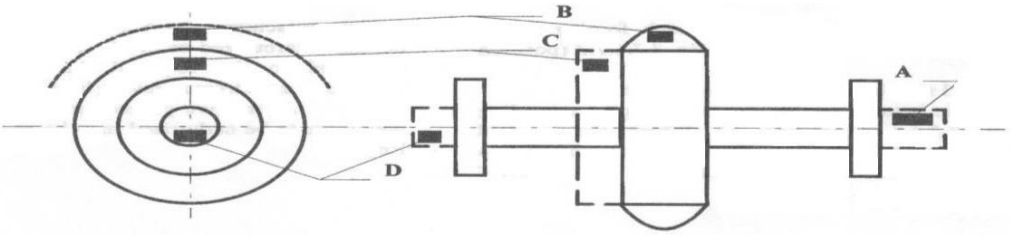


Figure 3.7.6.1.2 Sampling of pinions forgings and its number

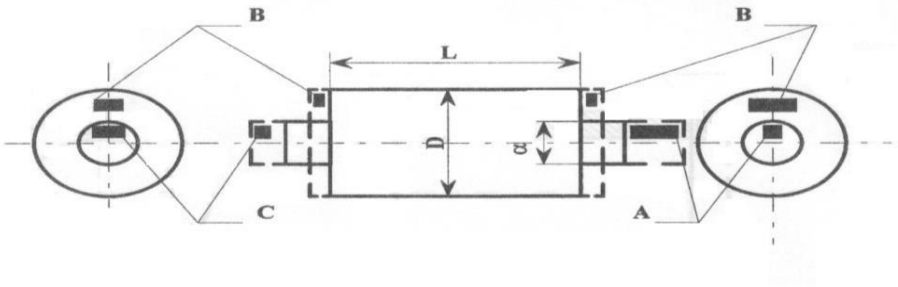


Figure 3.7.6.1.3 Sampling of gear wheel forgings and its number

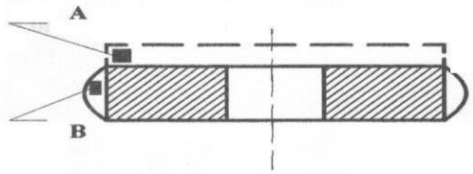


Figure 3.7.6.1.4 Sampling of gear wheels rim forgings and its number

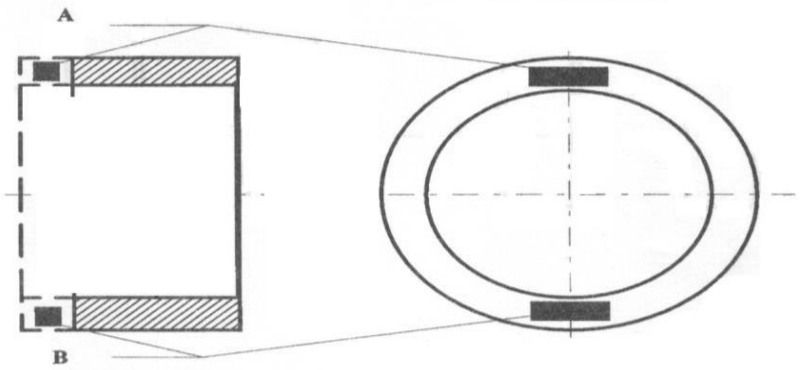


Figure 3.7.6.1.5 Sampling of pinion sleeves forgings and its numbers

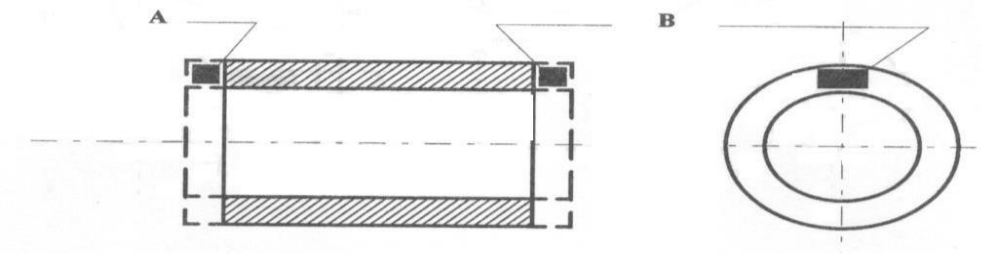
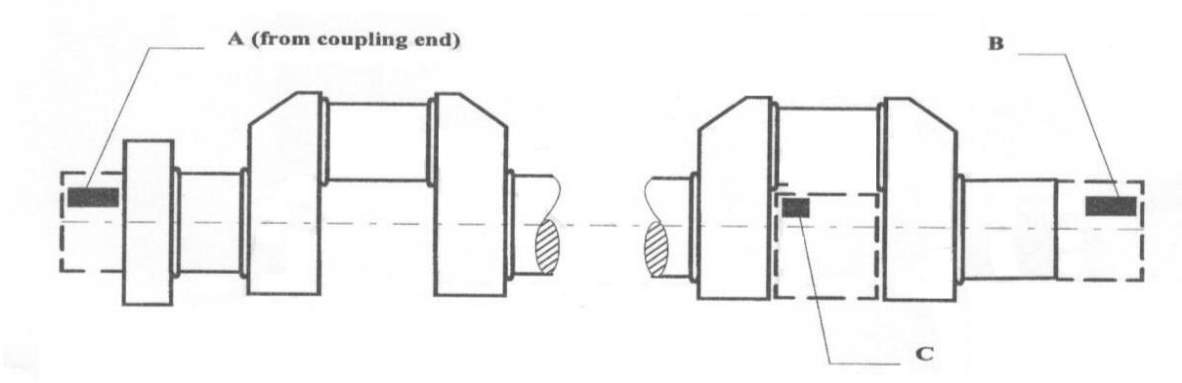


Figure 3.7.6.1.7 Sampling of solid-forged crankshafts and its number



3.7.6.2 Unless expressly provided otherwise, smaller forgings are to be submitted for testing in batches made up of items having approximately the same dimensions and mass, coming from the same heat and heat-treated in the same furnace charge. Test specimens may be prepared either from one of the forgings of the batch or from separately forged samples.
The scope of testing is set down in accordance with *Table 3.7.6.2*.

Table 3.7.6.2 Scope of testing for smaller forgings

Mass of forging, in kg	Number of forgings (batch) for the first set of specimens for tensile and impact testing
1	2
≤ 25	250
> 25 ≤ 50	100
> 50 ≤ 100	50
> 100 ≤ 200	25
> 200 ≤ 500	10
> 500 ≤ 1000	5
NOTE: Where the number of forgings exceeds the specified number by 50% or more, a new batch should be formed.	

3.7.6.3 When a forging is subsequently divided into a number of components, then the number of tests required is to be related to the total length and mass of the original multiple forging provided that the components thus obtained are heat treated together in the same furnace charge.

3.7.6.4 A batch testing procedure may also be used for hot rolled bars, not exceeding 250 mm in diameter, used instead of forgings. A batch is to consist of:

- either material from the same rolled length provided that where this is cut into individual lengths, these are all heat treated in the same furnace charge;
- or rolled bars of the same diameter and cast, heat treated in the same furnace charge and with a total mass not exceeding 2,5 t.

3.7.6.5 *ICS Class* may require hardness tests on the following:

- Gear forgings after completion of heat treatment of the gear teeth. The hardness is to be determined at four positions equally spaced around the circumference of the surface where teeth will subsequently be cut. Where the finished diameter of the toothed portion exceeds 2500 mm, the above number of test positions is to be increased to eight. Where the width of a gear wheel rim forging exceeds 1250 mm, the hardness is to be determined at eight positions at each end of the forging.
- Small crankshaft and gear forgings which have been batch tested. In such cases the hardness test is to be carried out on each forging.
- Forgings which have undergone induction hardening, nitriding or carburizing.

The results of such tests are to comply with the approved specification.

3.7.7. Inspection

3.7.7.1 All forgings are to be presented to the Surveyor for visual examination. Where applicable, this is to include the examination of internal surfaces.

The forgings are to be free from defects which would be prejudicial to their proper application.

3.7.7.2 When required by the relevant parts of the Rules or by Register approved technical documentation, the forgings, including those to be welded, are to undergo appropriate non-destructive testing according to the procedure approved by *ICS Class*.

3.7.7.3

Magnetic particle or dye penetrate testing is to be carried out when the forgings are in the finished condition. Acceptance standards for defects are to be to the satisfaction of *ICS Class* and in accordance with Register approved technical documentation.

Ultrasonic examination, when required by the relevant parts of the Rules or Register approved technical documentation, is to be carried out in accordance with *3.7.8* following the final heat treatment and at the stage when the forgings have been machined to a condition suitable for this type of examination (including the final machining).

3.7.7.4 Surface imperfections are permitted within machining allowances only. Small surface imperfections revealed through visual examination or by non-destructive testing may be removed by local grinding or by chipping and grinding. Complete elimination of these imperfections is to be proved by magnetic particle or dye penetrant examination.

3.7.7.5 In general, repairs by welding should be restricted to the rectification of defects of the minor nature in areas of low working stresses. Full details of the proposed repair and subsequent inspection procedures are to be approved by *ICS Class*. After welding the location of all repairs and the results of inspection are to be shown in a drawing or sketch of the forging.

3.7.8. Ultrasonic testing

3.7.8.1 The ultrasonic testing of the forgings is to be carried out in accordance with *2.2.9.2*.

3.7.9. Marking

3.7.9.1 The marking of steel forgings is to be in accordance with *1.4*.

3.8 Steel castings

3.8.1 General provisions

3.8.1.1 Steel castings subject to supervision of *ICS Class*, when produced in conformity with the relevant parts of the Rules, are to be manufactured and tested in accordance with the requirements stated below.

3.8.1.2 These requirements are applicable to carbon and carbon-manganese steel castings used in hull and ship machinery construction.

3.8.1.3 The requirements for castings to be used at low or high temperature, as well as for alloy steel castings with special properties (corrosion resistance, heat resistance, high temperature, oxidation resistance, etc.) will be specially considered by *ICS Class* in each case. The documents submitted to *ICS Class* for approval are to contain detailed information on the chemical composition, mechanical and special properties, heat treatment procedures and scope of testing the castings.

3.8.1.4 When two or more castings are joined by welding to form a composite item, the chemical composition of steel and the welding procedure are to be subjected to approval by *ICS Class*. *ICS Class* may require technological tests of the welded joints to be carried out.

3.8.2 Chemical composition

3.8.2.1 The chemical composition of a particular type of steel will be established proceeding from the mechanical and special properties required.

3.8.2.2 For carbon and carbon-manganese steel castings the chemical composition of ladle samples is to comply with the following overall limits in per cent:

- Carbon 0,40 max
- Silicon 0,60 max
- Manganese from 0,50 to 1,60
- Sulphur 0,040 max
- Phosphorus 0,040 max
- Copper 0,30 max
- Chromium 0,30 max
- Nickel 0,40 max
- Molybdenum 0,15 max

3.8.2.3 Unless otherwise required, suitable grain-refining elements may be used at the discretion of the manufacturer. The content of such elements is to be reported in the ladle analysis.

3.8.3 Mechanical properties

3.8.3.1 Proceeding from the minimum tensile strength required, the yield stress, elongation, reduction of area and the results of impact testing for carbon and carbon manganese steel castings are to conform to *Table 3.8.3*.

Table 3.8.3 Mechanical properties of carbon and carbon-manganese steel castings

Tensile strength R_m, MPa	**Yield stress, R_{eH} or R_{po2},** MPa	**Elongation A_5,** %	**Reduction of area *Z*,** %	**Impact testing results**		
				Impact energy *KV*, J	**Impact energy *KU*,** J	**Impact toughness *KCU*,** J/cm^2
minimum						
1	2	3	4	5	6	7
400	200	25/28	40/45	25/31	25/30	50/60
440	220	22/26	30/45	20/28	22/27	44/54
480	240	20/24	27/40	18/25	20/25	40/50
520	260	18/22	25/40	15/20	17/22	34/44
560	300	15/20	20/35	12/18	15/20	30/40
600	320	13/18	20/35	10/18	12/17	24/34

NOTES:

.1 The elongation, reduction of area, impact energy and impact toughness mentioned in the denominator are established for castings of main components (crankshafts, turbine parts, propellers, etc.). The application of these standards is to be regulated by the rules.

.2 The tensile strength values obtained at tensile testing are not to exceed the required minimal values by more than 150 MPa and for castings mentioned in Note 1, by more than 120 MPa.

.3 If not specially required by *ICS Class*, impact energy KV or impact toughness (KCU) is to be determined by means of impact testing at the manufacturer's discretion. These are determined on specimens in accordance with *Fig. 2.2.3.1-2* and *2.2.3.1-1*, respectively.

.4 For intermediate tensile strength values the minimal values of yield stress, elongation, reduction of area and impact energy or impact toughness may be determined by linear interpolation.

3.8.4 Supply conditions

3.8.4.1 To ensure the required structure and mechanical properties, the castings are to undergo heat treatment. The procedure of heat treatment is to be chosen by the manufacturer proceeding from the chemical composition of steel and the purpose and shape of the castings. The following conditions are to be observed:

.1 The tempering temperature is to be not less than 500º C.

.2 The stress relief heat treatment of castings for components such as crankshafts and engine bedplates, where dimensional stability and freedom from internal stresses are important, is to be carried out at a temperature of not less than 550º C followed by furnace cooling to 300º C.

.3 If a casting is reheated or any straightening operation is performed after the final heat treatment, a subsequent stress relieving heat treatment may be required by *ICS Class*.

3.8.5 Sampling

3.8.5.1 Sampling may be effected directly from the casting or the test samples may be cast to it. They are to have a thickness not less than 30 mm.

The use of separately cast samples is permitted in which case the dimensions of the sample are to correspond to the casting dimensions.

3.8.5.2 Where two or more test samples are to be provided for a casting, they are to be cast at locations as widely separated as possible.

3.8.5.3 The samples are to be heat treated together with the castings which they represent.

3.8.6 Scope of testing

3.8.6.1 At least one test sample is to be provided for each casting. Where large castings are made from two or more casts, which are not mixed in a ladle prior to pouring, two or more test samples are to be provided corresponding to the number of casts involved.

Where the casting is of complex design or where the finished mass exceeds 10 t, at least two test samples are to be provided.

3.8.6.2 A batch testing procedure may be adopted for castings. A batch is to consist of castings of approximately the same size and shape made from one cast and heat treated in the same furnace charge. For batch testing separately cast test samples may be used or one of the castings out of those comprising the batch.

3.8.6.3 At least one tensile test specimen and one set of impact test specimens are to be taken from each test sample.

3.8.7 Inspection

3.8.7.1 The castings submitted for inspection and control testing are to be cleaned, de-gated, free of risers and burrs, etc.

The castings are to be free from defects which would be prejudicial to their proper application in service.

3.8.7.2 According to the requirements stated in the rules or following the instructions of a Surveyor the castings are to undergo non-destructive testing. The testing procedure and the allowances for defects are to be in conformity with documentation approved by *ICS Class*.

3.8.7.3 Surface defects lying within machining allowances may be removed by machining.

3.8.7.4 Defects may be repaired by welding in accordance with *Chapter 14, rule 5.6.3*. Prior to carrying out weld repairs of large-sized defects, alloy steel castings, castings for crankshafts and for other main components are to be pre-heated in accordance with *3.8.4*; if required by the Surveyor, the welded spots should be subjected to non-destructive testing.

3.8.8 Marking

3.8.8.1 The marking of steel castings is to be in accordance with *1.4*.

3.9 Spheroidal or nodular graphite iron castings

3.9.1 General provisions

3.9.1.1 As defined in the relevant chapters of the rules, all spheroidal or nodular graphite iron castings subject to supervision of *ICS Class* during their manufacture, are to be tested in accordance with the requirements of the following paragraphs.

3.9.1.2 These requirements are applicable to spheroidal or nodular graphite iron castings used in hull and ship machinery construction. The purpose of the castings is to be established proceeding from their properties at room temperature.

3.9.1.3 The requirements for castings intended for service at low or elevated temperatures will be specially considered by *ICS Class* in each case. In this case, detailed information on the chemical composition, mechanical and special properties, heat treatment, methods and scope of testing the castings is to be submitted to *ICS Class*.

3.9.1.4 Where castings of the same type are regularly produced in quantity, alternative procedures for testing and scope of testing may be adopted subject to approval of *ICS Class*, provided that the manufacturer verifies the continued efficiency of the manufacturing technique and the quality of castings.

3.9.2 Chemical composition

3.9.2.1 The chemical composition is left to the discretion of the manufacturer who is to ensure that it is suitable for obtaining the mechanical properties specified for the castings.

When required by *ICS Class*, the chemical composition of ladle samples is to be reported.

3.9.3 Mechanical properties

3.9.3.1 The mechanical properties of the castings are to conform to *Table 3.9.3. 1*.
While affecting the tensile test of the casting material the tensile strength and elongation are to be determined.

The minimum required tensile strength is to be stated in the agreed technical documentation for the casting, but in no case shall it exceed the limits detailed in *Table 3.9.3.1*. Additional requirements of the relevant chapters of the rules are also to be complied with.

For intermediate tensile strength values the minimum values of elongation and yield stress may be determined by linear interpolation.

Table 3.9.3.1 Mechanical properties of the spherical graphite iron castings

Structure	**Tensile strength R_m ,** MPa	**Upper yield stress R_{eH} or $R_{p0,2}$,** MPa	**Elongation A_5,** %	**Brinell hardness**
1	2	3	4	5
Ferrite	370	230	17	120 ... 180
Ferrite	400	250	12	140 ... 200
Ferrite/perlite	500	320	7	170 ... 240
Ferrite/perlite	600	370	3	190 ... 270
Perlite	700	420	2	230 ... 300
Perlite structure or structure after tempering	800	480	2	250 ... 350

3.9.3.2 Where impact testing is required, the standards and type of specimen are to be approved by *ICS Class*.

3.9.3.3 The microstructure of the castings is to include not less than 90 per cent of spherical or nodular graphite. No flaked graphite is permitted.

3.9.4 Supply conditions

3.9.4.1 The castings are to be supplied in either as the cast or heat treated condition.
The necessity of heat treatment and the relevant procedure is to be determined by the manufacturer on the basis of chemical composition, purpose and shape of the castings.

For the purpose of structure refining or stress relieving, obligatory heat treatment may be required by *ICS Class*. The heat treatment for stress relieving is to follow the heat treatment for structure refining and to precede the machining.

3.9.4.2 Where it is proposed to locally harden the surfaces of a casting, full details of the proposed procedure and specification are to be submitted to *ICS Class* for consideration.

3.9.5 Sampling

3.9.5.1 The test samples may be either gated to the casting or separately cast. The dimensions of the samples, when cast separately, are to be in accordance with *Figs 3.9.5.1-1*, *3.9.5.1-2* and *3.9.5.1-3*; the sample length *l* is to be chosen proceeding from the type of the machine for tensile testing.

Subject to approval by *ICS Class*, the samples may have variable dimensions or they may be taken directly from one of the castings forming the batch.

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 not to be stripped from the moulds until the metal temperature is below 500º C.

Figure 3.9.5.1 Samplings for performing mechanical tests of spheroidal graphite iron castings

Figure 3.9.5.1-1

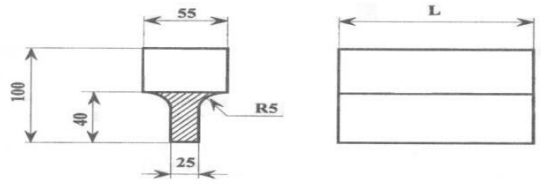


Figure 3.9.5.1-2

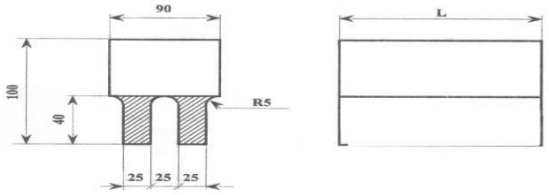
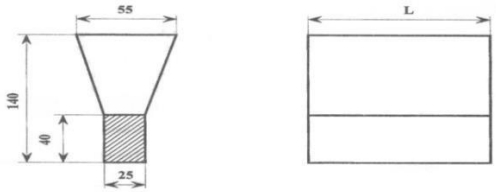


Figure 3.9.5.1-3



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

3.9.5.3 Samples for metallographic examination may conveniently be taken from the tensile test specimens, but separately cast samples may be prepared provided that they are taken from the ladle towards the end of the casting period.

3.9.6 Scope of testing

3.9.6.1 At least one sample is to be taken from each casting. If metal from several ladles is used for a casting, one sample is to be taken from each ladle.

3.9.6.2 A batch testing procedure may be adopted for castings with the fettled mass of 1 t 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 t of fettled castings in the batch.

3.9.6.3 At least one tensile test specimen is to be prepared from each test sample and, where required, a set of impact test specimens.

3.9.6.4 Where the castings are subject to pressure testing for tightness, both the working and test pressure is to be stated in the technical documentation.

3.9.7 Inspection

3.9.7.1 The castings are to be submitted for inspection and control testing in cleaned and de-gated condition, free from risers, etc.

3.9.7.2 The castings are to be free from defects which would be prejudicial to their application in service. In general, repairing of defects by welding is not permitted. Subject to approval by the Surveyor, surface imperfections may be removed by grinding. Where there is reason to suspect the soundness of the casting, examination by suitable non-destructive testing procedure may be required.

3.9.8 Marking

3.9.8.1 The marking of spheroid graphite iron castings is to be in accordance with *1.4*.

3.10 Gray iron castings

3.10.1 General provisions

3.10.1.1 All gray iron castings subject to supervision of *ICS Class*, as defined in the relevant chapters of the Rules, are to be manufactured and tested in accordance with the requirements of the following paragraphs.

3.10.1.2 The present requirements apply to gray iron castings used in hull and ship machinery construction.

3.10.1.3 Where castings of the same type are regularly produced in quantity, the manufacturer may adopt alternative procedures for, and scope of, testing subject to approval of *ICS Class* and provided that the continued efficiency of the manufacturing technique and the quality of castings is verified.

3.10.2 Chemical composition

3.10.2.1 The chemical composition is left to the discretion of the manufacturer, who is to ensure that it is suitable for obtaining the mechanical properties specified for the castings.

When required by *ICS Class*, the chemical composition of ladle sample is to be reported.

3.10.3 Mechanical properties

3.10.3.1 When carrying out the tensile test of the casting material (according to *2.2.2.4*) the tensile strength is to be determined. The specified minimum tensile strength is to be stated in the technical documentation for the casting, but in no case shall it be less than 200 MPa. Any additional requirements of the relevant chapters of the Rules are also to be complied with.

3.10.4 Heat treatment

3.10.4.1 Castings may be supplied in either as the cast or heat treated condition.

The necessity of heat treatment and the relevant procedure is to be determined by the manufacturer on the basis of chemical composition, purpose and shape of the castings.

For the purpose of structure refining or stress relieving, obligatory heat treatment may be required by *ICS Class*. The heat treatment for stress relieving is to follow the heat treatment for structure refining and to precede the machining.

3.10.5 Sampling

3.10.5.1 The test samples may be separately cast and are to have the form of cylindrical bars 30 mm in diameter.

Subject to approval by *ICS Class*, the samples of variable dimensions may be used; they may be gated to or taken directly from the castings.

Separately cast test samples are to be cast in moulds made from the same type of material as used for the castings and are not to be stripped from the moulds until the metal temperature is below 500º C.

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

3.10.5.3 One tensile test specimen is to be prepared from each sample.

3.10.6 Scope of testing

3.10.6.1 From each casting at least one sample is to be taken. Where metal from several ladles is used for a casting, one sample is to be taken from each ladle.

3.10.6.2 Batch testing procedure may be adopted for castings with the fettled mass of 1 t or less. All castings in the batch are to be of similar type and dimensions, and cast from the same ladle of metal. One separately cast test sample is to be provided for each multiple of 2 t of fettled castings in the batch.

3.10.6.3 Where the castings are subjected to pressure testing for tightness, both the working and the test pressure are to be stated in the technical documentation.

3.10.7 Inspection

3.10.7.1 The castings are to be submitted for inspection and control testing in cleaned and de-gated condition, free from risers, etc.

3.10.7.2 The castings are to be free from defects which would be prejudicial to their proper application in service. In general, repairing of defects by welding is not permitted. At the discretion of the Surveyor, small surface blemishes may be removed by local grinding. Where these are reason to suspect the soundness of the casting, examination by suitable non-destructive testing procedures may be required.

3.10.8 Marking

3.10.8.1 The marking of gray iron castings is to be in accordance with *1.4*.

3.11 Malleable cast iron

3.11.1 General provisions.

3.11.1.1 Malleable cast iron may be used for the manufacture of parts for hull and ship machinery construction that are submitted to supervision of *ICS Class* and are intended to operate at a temperature not exceeding 300º C and the working pressure not exceeding 2 MPa.

3.11.2 Chemical composition and mechanical properties

3.11.2.1 The chemical composition, mechanical properties and scope of testing of items made of malleable cast iron are to be agreed with *ICS Class* in each case.

3.12 Steel castings for propellers

3.12.1 General provisions

3.12.1.1 The requirements apply to castings for all-cast propellers blades and hubs of propellers with detachable blades and controllable-pitch propellers manufactured of carbon, low-alloy and alloy steel. Applicable requirements of *3.8* are also to be fulfilled.

3.12.1.2 Alloy steel the chemical composition and mechanical properties of which differ from those required by *3.12.2* and *3.12.3* is to be approved by *ICS Class*, and the corrosion fatigue test results are to be submitted for the steel. The corrosion fatigue limit on the basis of 10^8 cycles is to be not less than 75 Mpa.

3.12.2 Chemical composition

3.12.2.1 The chemical composition is to be in accordance with *Table 3.12.2*.

3.12.2.2 For all the steel grades, the *S* and *P* content is not to exceed 0,035% of each element.

3.12.3 Mechanical properties

3.12.3.1 The mechanical properties of steel for propellers are to be determined during the testing of specimens machined, on the option of *ICS Class*, either from separately cast samples or samples cast to the hub or the flange portion of the blade, and they are to be in accordance with *Table 3.12.3*.

3.12.4 Supply conditions

3.12.4.1 Propeller castings are to be heat treated in conformity with *Table 3.12.3*.

3.12.4.2 The heat treatment for stress relieving is not to detrimentally affect the mechanical properties of the casting metal and its corrosion resistance.

3.12.4.3 The heat treatment procedure should be chosen by the manufacturer.

Table 3.12.2 Steel castings for propellers

Grade	Material	Content of elements, %						
		C	Si	Mn	Cr	Ni	Mo	Cu
1	Carbon steel	According to *3,8*						
2	Low-alloy steel	Max 0,22	Max 0,5	Max 2,0	Max 0,9	Max 2,0	-	Max 1,5
3	Alloy steel (martensite-ferrite class)	Max 0,12	Max 0,6	Max 1,0	13,0 ÷ 17,0	Max 2,0	Max 0,2	Max 1,5
4	Alloy steel (martensite-austenite class)	Max 0,8	Max 0,6	Max 2,0	13,5 ÷ 17,0	3,0 ÷ 5,0	Max 1,0	Max 1,5
5	Alloy steel (austenite class)	Max 0,12	Max 2,0	Max 1,6	16,0 ÷ 20,0	8,8 ÷ 11,0	Max 0,5	-

Table 3.12.3 Mechanical properties of the steel for propellers

Grade	Tensile test				Impact test		Condition of supply
	R_m, MPa	R_{eH} or $R_{p\ 0,2}$, MPa	A_5, %	Z, %	Impact energy KV, J	Temperature, °C	
	minimum						
1	According to *3.8*						Normalization and tempering
2	450	350	20	45	-	-	Normalization and tempering or quenching and tempering
3	550	380	19	40	21	- 10	
4	750	600	17	45	21	- 10	
5	450	175	30	50	-	-	Austenization

3.12.5 Sampling

3.12.5.1 Separately cast samples are to be taken from the same ladle as the casting and heat treated in the same furnace charge.

3.12.5.2 For each casting or batch of castings one sample should be taken for specimen machining purposes, and for propeller castings of more than 4,0 m in diameter, two samples should be taken.

3.12.6 Number of tests

3.12.6.1 Each propeller casting is to be submitted for testing.

Castings of less than 1,0 m in diameter made from metal of one and the same cast and heat treated in the same furnace charge may be submitted in batches. A batch is to include not more than five castings.

3.12.6.2 For a casting or batch of castings the following tests should be made:

- tensile test at least on one specimen;
- impact test at least on one set of specimens.

When required by *ICS Class*, microstructure should be controlled.

3.12.7 Inspection

3.12.7.1 The castings are to be submitted for the survey with their surface prepared both for the visual inspection and non-destructive testing.

3.12.7.2 The surface of the castings is to undergo dye penetrate or magnetic particle testing. The pressure and suction surfaces of the blade as well as the transition zone between blade and hub or between blade and flange is to undergo compulsory testing by one of the above methods.

3.12.7.3 When required by *ICS Class*, the castings should undergo non-destructive testing to reveal internal defects.

The number of test and the testing procedure as well as dimensions of permissible defects is to be in accordance with technical documentation agreed with *ICS Class*. Defects that are revealed may be removed by machining or welding. The dimensions, number and location of defects that need not be removed, defects that are to be machined away and those that are to be welded, should be determined on agreement with *ICS Class*.

3.12.7.4 Defect elimination and the areas welded are subject to non-destructive testing.

The dimensions and location of the welded defects should be indicated in the drawing attached to the propeller casting certificate.

3.12.8 Marking

3.12.8.1 The marking of steel castings for propellers is to be in accordance with *1.4*.

3.13 High strength steel for welded structures

3.13.1 General provisions

3.13.1.1 The present requirements apply to weldable plates and wide flats of high strength steel up to 70 mm thick subject to the manufacture supervision of *ICS Class* and intended for the manufacture of hull structures and other welded structures. On agreement with *ICS Class*, the requirements may be applied to rolled products more than 70 mm thick of shapes other than above, for instance, sections, pipes in structures, etc.

Proceeding from the minimum yield stress guaranteed, the steel is subdivided into six strength levels 420, 460, 500, 550, 620 and 690 N/mm^2. Proceeding from the impact test temperature, four Grades A, D, E and F have been established for each strength level.

Steel, of which the mechanical properties, chemical composition, etc. differ from the above, shall be subjected to special consideration by *ICS Class*.

3.13.2 Chemical composition

3.13.2.1 The chemical composition of steel is to be determined by the manufacturer from each cast or ladle in an adequately equipped laboratory with a qualified staff. The chemical composition of steel should be in accordance with specifications approved by *ICS Class* and the limiting values set in *Table 3.13.2*.

Table 3.13.2 Chemical composition of steel

Steel grade	Maximum element contents %				
	C	**Si**	**Mn**	**P**	**S**
D, E	0,20	0,55	1,70	0,035	0,035
F	0,18	0,55	1,60	0,025	0,025

The content of alloying and grain-refining elements is to be in accordance with specification approved by *ICS Class*.

3.13.3 Mechanical properties

3.13.3.1 For the purpose of tensile and impact testing, the mechanical properties of steel should be in accordance with *Table 3.13.3*.

Table 3.13.3 Mechanical properties with maximum thickness of 70 mm

Steel grade	Tensile test			Impact test		
	Min. yield stress R_{eH} or $R_{p0,2}$, MPa	Tensile strength R_m MPa	Elongation A_5, (min.) %	Test temperature, °C	Impact energy *KV*, (min.) J	
					longitudinal specimen	transverse specimen
D 420 E 420 F420	420	530 ÷ 680	18	- 20 - 40 - 60	41	27
D 460 E 460 F 460	460	570 ÷ 720	17	- 20 - 40 - 60	41	27
D 500 E 500 F 500	500	610 ÷ 770	16	- 20 - 40 - 60	41	27
D 550 E 550 F 550	550	670 ÷ 830	16	- 20 - 40 - 60	41	27
D 620 E 620 F 620	620	720 ÷ 890	15	- 20 - 40 - 60	41	27
D 690 E 690 F 690	690	770 ÷ 940	14	- 20 - 40 - 60	41	27

3.13.4 Supply conditions

3.13.4.1 The steel is to be quenched and tempered. The present requirements do not comprise the steels hardened by aging.

3.13.5 Sampling

3.13.5.1 The axes of specimens to undergo the tensile test should be perpendicular to the direction of the last rolling except for wide flats 600 mm or less wide, sections and bars for which the orientation of specimen is determined on agreement with *ICS Class*. As a rule, flat tensile specimens should be machined in such a way that the rolled surface is preserved on one side at least. If tensile testing is effected on cylindrical specimens the axes of the latter should be 1/4 of the thickness dimension from the surface or as close to that position as possible.

3.13.5.2 Unless otherwise agreed with *ICS Class*, the impact testing of steel plates and wide flats more than 600 mm in width is to be effected on specimens prepared in accordance with *2.2.3.1-2* the longitudinal axis of which is perpendicular to the direction of rolling (transverse specimens). Where rolled products of another cross-sectional shape are concerned the impact testing should be effected on longitudinal specimens.

3.13.6 Scope of testing

3.13.6.1 Each plate (rolled length) should undergo tensile and impact testing after heat treatment.

For rolled products quenched and tempered in continuous females, the scope of testing, including the number of specimens and the direction of their cutting out, is to be determined on the basis of specification approved by *ICS Class*, after special consideration. Out of each test sample, at least one tensile specimen and three impact test specimens should be machined.

3.13.6.2 When required by *ICS Class*, tensile testing should be carried out on specimens with their longitudinal axes perpendicular to the plate surface and the reduction of cross-sectional area should be determined.

3.13.7 Inspection

3.13.7.1 Rolled products are to be in accordance with all the requirements of *3.2.7* taking the provisions below into consideration.

When surface defects are eliminated by grinding, the thickness of the rolled products at the ground spot should not exceed permitted tolerances. When required by the Rules, the rolled products should undergo the ultrasonic examination in conformity with standards approved by *ICS Class*.

3.13.8 Marking

3.13.8.1 The marking of rolled products should be effected in conformity with *1.4* and *3.2.8*. The Surveyor to *ICS Class* should be provided with documentation in the necessary number as per *1.3.4.2*.

3.13.8.2 If required by *ICS Class*, the documentation is to be provided separately for each steel grade and strength level.

3.14 Z-Steel

3.14.1 General provisions

3.14.1.1 Z-steel intended for the manufacture of hull-structural components subject to the manufacturer supervision of *ICS Class* is to be produced and tested under *ICS Class* supervision and in conformity with the requirements below.

3.14.2 Chemical composition

3.14.2.1 In carbon and carbon-manganese steel, the content of basic elements and impurities is to be in accordance with standards approved by *ICS Class* or with other technical documentation and the maximum values given in *Table 3.14.2.1*.

Table 3.14.2.1 Maximum contents of elements (%)

C	Si	Mn	P	S
0,18	0,5	1,6	0,01	0,01

3.14.2.2 The chemical composition of steel may be adopted according to *3.2.2, 3.5.2.1* or *Table 3.13.2* provided the content of phosphorus and sulphur complies with *Table 3.14.2.1*.

3.14.2.3 Z-steel should be fully killed and fine grain treated. The content of grain refining elements should be determined on the basis of standards approved by *ICS Class* or other technical documentation.

3.14.3 Mechanical properties

3.14.3.1 After a tensile test of Z-steel specimens the longitudinal axis of which is transverse to the direction of rolling, the reduction of area (Z_z) should not be less than 25%.

3.14.3.2 The mechanical properties of steel and impact test results should comply with the requirements of *Tables 3.2.2-1, 3.2.2-2, 3.5.2.2* or *3.13.3*.

3.14.4 Supply conditions

3.14.4.1 Z-steel should comply with the requirements of *3.2.4, 3.5.2.3* or *3.13.4*.

3.14.5 Sampling and testing

3.14.5.1 For the purpose of Z-steel testing, samples should be taken from each end of the rolling, and from these samples tensile test specimens, a set of impact test specimens and a set of specimens for tensile testing in the through-thickness direction should be prepared.

The procedure of specimen's preparation and tensile testing in the through-thickness direction shall be approved by *ICS Class*.

For the reduction of area (Z_z), the average of three tensile tests is to be adopted, not being lower than the required value.

3.14.5.2 In the case of pieces having the thickness 50 mm and above, an additional set of three impact specimens should be prepared and tested, the specimens being cut out in such a way that their longitudinal axis shall coincide with the middle of the piece thickness.

SECTION 4
Copper and copper-base alloys

4.1 Semi-finished products of copper and copper-base alloys

4.1.1 General provisions

4.1.1.1 These requirements apply to semi-finished copper and copper-base products (rolled, forged, drawn, press-formed, etc.) and castings which are used in shipbuilding and marine engineering, and the manufacture of which is subject to *ICS Class* supervision.

4.1.2 Chemical composition and mechanical properties

4.1.2.1 The chemical composition and mechanical properties of copper and copper-base alloy products such as pipes, plates, bars, rolled sections, forgings and castings are to meet the requirements of appropriate standards or specifications approved by *ICS Class*.

When selecting copper-base alloys, one should consider the required level of mechanical properties at indoor or higher temperatures, corrosion resistance, and other properties determined by their application.

4.1.3 Supply conditions

If, in the process of manufacture, parts made of copper and copper-base alloys are subjected to heat treatment, the type of heat treatment is to be reported to *ICS Class* and stated in the material certificate. Rolled products made of CuZn alloys (brasses) are to be annealed for stress relieving.

4.1.4 Sampling

4.1.4.1 Tensile test samples are to be cut from sheet material transversely to the direction of rolling (forging), and from tubes, rods, sections and forgings - longitudinally to the direction of rolling.

4.1.4.2 Tubes, rods and sections with a diameter (or thickness) of 40 mm and less may be subjected to tensile tests in the rough condition.

Forging samples may be forged separately or forged on the forgings. The samples are to have the same degree of upsetting as the forging in its highest loaded cross-section.

4.1.4.3 Casting samples may be cast separately, gated to the casting or taken directly from its body. In any case, the samples are to be cut after the final heat treatment (in the supply condition).

4.1.5 Scope of testing

4.1.5.1 If not otherwise specified, the following samples are to be selected from each lot:

.1 For determination of chemical composition (heat analysis).
.2 For determination of mechanical properties (R_{eH}, R_m, A_5).
.3 For fabrication testing.

The scope of testing for semi-finished products (rolled products, forgings, castings) should be determined according to standards recognized by *ICS Class*.

4.1.5.2 CuZn alloy tubes for heat exchangers should be subjected to the following tests:

.1 Nitrogen, mercuric nitrate or ammonia treatment according to the requirements of appropriate standards (one specimen per lot).
.2 Flattening (two specimens cut from two tubes, $H = 3$t).
.3 Expanding (two specimens from two tubes,

with the angle of mandrel taper α = 45°, and the expansion degree of 30 per cent).
.4 Microstructure checks (one specimen per lot).

Average grain diameter shall be 0,01 to 0,05 mm.

4.1.5.3 Tubes are to be subjected to hydraulic testing; the test pressure should be determined by standards or specifications previously agreed with *ICS Class*.

4.1.5.4 The test pressure for heat exchanger tubes is to be 5 MPa, and for tubes (bushes) on the propeller shaft lining, 2 Mpa.

4.1.5.5 Substitution of non-destructive inspection for hydraulic testing shall be, in each case, subjected to special consideration by *ICS Class*.

4.1.6 Inspection

4.1.6.1 Products submitted for *ICS Class* inspection shall comply with the requirements of corresponding standards or specifications on the basis of which they are accepted.

4.1.6.2 The products should not have defects which are detrimental for their intended use.

4.1.7 Marking

4.1.7.1 The marking of products is to be in accordance with *1.4*.

4.2 Propeller castings

4.2.1 General provisions

4.2.1.1 These requirements apply to castings intended for all-cast propellers, blades and hubs of propellers with detachable blades and controllable pitch propellers.

4.2.2 Chemical composition

4.2.2.1 The chemical composition is to comply with the requirements of *Table 4.2.2*.

4.2.2.2 If not otherwise specified, the zinc content in alloys of grades 1 and 2 as calculated by *Formula 4.2.2* shall not be higher than 45%.

$$C_{Zn} = 100 - \frac{100 \cdot \%Cu}{100 + A};\% \qquad (4.2.2)$$

Where:

A = is the algebraic sum of the following alloy elements:
1 x % Sn
5 x % Al
- 0,5 x % Mn
- 2,3 x % Ni
- 0,1 x % Fe

The α-phase content in grades 1 and 2 alloys determined as the average of five measurements, must be not less than 25%.

The alloys with chemical composition differing from that specified in *Table 4.2.2* are to be subjected to approval by *ICS Class*.

4.2.3 Mechanical properties

4.2.3.1 The mechanical properties of alloys for propellers, when test specimens machined from separately cast samples are tested, are to comply with the requirements of *Table 4.2.3*.

4.2.3.2 When test specimens are machined from cast-on samples or taken directly from the castings, their mechanical properties may be less than those indicated in *Table 4.2.3*, by a value, however, not exceeding 30 per cent.

4.2.4 Sampling

4.2.4.1 Separately cast samples for determining the mechanical properties of alloys for propellers are to be taken from each ladle and are to have dimensions as shown in *Fig. 4.2.4*.

4.2.4.2 On agreement with *ICS Class*, samples prepared with approved standards may be permitted.

4.2.4.3 If agreed with *ICS Class*, the test samples for control tests may also be taken directly from the castings or cast on to them.

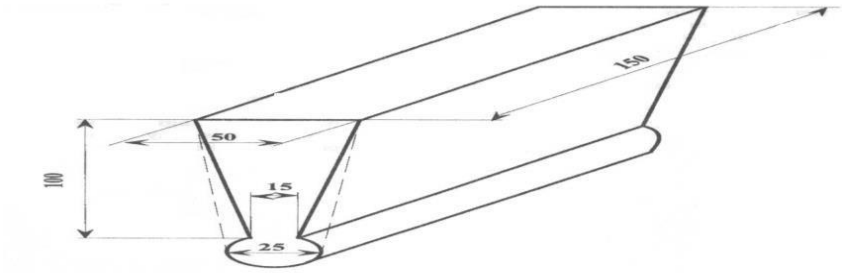
Table 4.2.2 Chemical composition of copper alloys for propellers

Grade	Chemical composition, %								Total content of residual elements
	Cu	Al	Mn	Ni	Fe	Zn	Sn	Pb	
							maximum		
1	55 ÷ 62	0,5 ÷ 3,0	0,5 ÷ 4,0	≤ 1,0	0,5 ÷ 2,5	Remainder	1,5	0,5	On agreement with the Register
2	50 ÷ 57	0,5 ÷ 2,0	1,0 ÷ 4,0	2,5 ÷ 8,0	0,5 ÷ 2,5	Remainder	1,5	0,5	
3	77 ÷ 82	7,0 ÷ 11,0	0,5 ÷ 4,0	3,0 ÷ 6,0	2,0 ÷ 6,0	≤ 1,0	0,1	0,03	
4	70 ÷ 80	6,5 ÷ 9,0	8,0 ÷ 20,0	1,5 ÷ 3,0	2,0 ÷ 5,0	≤ 6,0	1,0	0,05	

Table 4.2.3 Mechanical properties of alloys for propellers

Grade	Yield stress R_{eH} or $R_{p0,2}$, MPa	Tensile strength R_m, MPa	Elongation A_5, %
	minimum		
1	175	440	20
2	175	440	20
3	245	590	16
4	275	630	18

Figure 4.2.4 Sample for determining the mechanical properties of alloys for propellers and its dimensions



SECTION 5
Aluminum alloys

5.1 Wrought aluminum alloys

5.1.1 General provisions

5.1.1.1 The present requirements apply to aluminum alloy forgings, stampings, bars, sections, panels and plates of more than 1,5 mm in thickness, intended for ship's hull and machinery construction and subject to supervision of *ICS Class* during manufacture.

5.1.1.2 Application of alloys with chemical composition and mechanical properties differing from those indicated in *Table 5.1.2* and *5.1.3* are to be in each case subjected to special consideration by *ICS Class*.

Semi-finished products made of aluminum alloys are to be manufactured at works recognized by *ICS Class*.

These products shall be submitted to certification.

5.1.2 Chemical composition

5.1.2.1 The chemical composition of wrought aluminum alloys is to meet the requirements stated in *Table 5.1.2*.

The total contents of residual elements not indicated in the table is not to exceed 0,1 per cent.

On agreement with *ICS Class*, titanium and zirconium may be partially or fully substituted by other grain-refining elements.

5.1.3 Mechanical properties

The mechanical properties of semi-finished products manufactured of wrought aluminum alloys are to meet the requirements stated in *Table 5.1.3*.

Table 5.1.2 Chemical composition of wrought aluminum alloys

Grade	Chemical composition, %									
	Basic elements			Other elements						
	Mg	Mn	Al	Ti	Zr	Si	Fe	Cu	Zn	Cr
							Maximum			
1	2,7 - 3,8	0,6 max	Remainder	0,2 max	-	0,80 max	0,50	0,1	0,2	0,35
2	4,0 - 4,9	0,3 - 1,0	"	0,2 max	-	0,40 max	0,40	0,1	0,2	0,35
3	4,3 - 5,8	0,2 - 0,8	"	0,02 - 0,2	-	0,50 max	0,50	0,1	0,2	0,35
4	5,5 - 6,5	0,8 - 1,1	"	-	0,02 - 0,2	0,40 max	0,40	0,1	0,2	-
5	5,8 - 6,8	0,5 - 0,8	"	0,02 - 0,1	-	0,40 max	0,40	0,1	0,2	-
6	0,4 - 1,5	0,2 - 1,0	"	0,20 max	-	0,6 - 1,6	0,50	0,1	0,2	-

Table 5.1.3 Mechanical properties of wrought aluminum alloys

Grade	Type of semi-finished product	Mechanical properties (minimum)		
		R_m, MPa	$R_{p0,2}$, MPa	A_5, %
1	Plates	200	80	15
	Sections	180	80	12
2	Plates:			
	t ≤ 10 mm	270	120	17
	t > 10 mm	260	110	15
	Sections	260	110	12
3	Plates:			
	t ≤ 10 mm	270	125	15
	t > 10 mm	260	120	13
	Sections, bars	250	120	15
4	Plates:			
	t ≤ 5 mm	310	155	15
	t > 5 mm	330	175	12
	Sections, bars, panels	330	205	11
5	Forgings, stampings	280	125	8
6	Plates, forgings (cold hardened)	200	100	14

5.1.4 Heat treatment

5.1.4.1 Preceding from the required mechanical properties the semi-finished products made of aluminum alloys are to be delivered in hot- rolled, hot-pressed or annealed condition. The condition of delivered products is to be stated in the maker's certificate.

The use of semi-finished products in semi-cold-worked or cold-worked condition for welded structures is subject to special consideration by *ICS Class*.

Technological operations involving local heating, cold hardening or deformation of the structures are not to affect the properties of the semi-finished products, according to the use for which they are intended.

5.1.5 Samples for testing

5.1.5.1 Samples are to be taken so that the longitudinal axes of the test specimens are directed as follows:

- For plates and flats less than 25 mm in thickness - transverse to the direction of the fibers.
- For bars and sections: along the direction of the fibers.
- For panels: along the direction of the fibers.

5.1.5.2 For forgings, stampings plates and flats thicker than 25 mm the position of samples, their dimensions and the procedure of cutting out specimens, are to be approved by *ICS Class*. In the case of forgings, the samples are to be forged to them or a forging may be used as a sample.

5.1.5.3 Cutting out of samples and machining of test specimens are to be carried out in such a manner as to avoid a possible change of alloy properties due to heating or hardening.

The tensile test is to be carried out on specimens in accordance with *2.2.2*.

5.1.6 Scope of testing

5.1.6.1 Semi-finished products made of aluminum alloys are to be submitted for testing in batches. A batch is to consist of semi-finished products of the same grade, dimensions and treated condition. The forgings or stampings of a batch are to be heat treated in one and the same charge. The mass of a batch consisting of plates and panels is not to exceed 2 t, and that of a batch of sections and bars, 1 t.

5.1.6.2 For the purpose of testing, not less than three semi-finished products are to be taken from each batch, from a batch of forgings or stampings - not less than one semi finished product. From each semi-finished product, not less than one specimen for tensile testing is to be taken.

5.1.6.3 If the test results are unsatisfactory, the testing is to be repeated according to *1.3.4.2*. The specimens for retesting are to be taken from other semi-finished products of the same batch. If are obtained good results in the retesting, the batch may be accepted.

5.1.7 Inspection

5.1.7.1 Plates, sections, forgings, stampings and panels are to be free of defects which may affect their application.

5.1.7.2 All the semi-finished products in a batch are to undergo visual inspection. The maker is to guarantee the appropriate quality of their surface. The removal of surface defects may be permitted only on agreement with *ICS Class*.

5.1.7.3 *ICS Class* reserves the right to require metallographic examination and non-destructive testing of the semi-finished products to ensure that no internal defects are present.

5.1.8 Marking

5.1.8.1 Plates, sections, bars, forgings, stampings and panels are to be marked in accordance with *1.4*.

5.1.8.2 The maker is to apply a system of marking symbols which would enable the Surveyor to trace the whole procedure of manufacturing the material and to identify the batch it belongs to.

5.2 Cast aluminum alloys

5.2.1 General provisions

5.2.1.1 The requirements of the present Chapter apply to parts and structures of cast aluminum alloy used in hull and ship machinery construction and manufactured under the supervision of *ICS Class*.

5.2.2 Chemical composition and mechanical properties

5.2.2.1 The chemical composition and mechanical properties of items cast of aluminum alloys are to meet the requirements of *Table 5.2.2*.

5.2.2.2 When casting is carried out under pressure or chill is employed, *ICS Class* may require higher values of mechanical properties. In this case, the mechanical properties required and the sampling procedure to be used is to be agreed with *ICS Class*.

5.2.2.3 The use of alloys with chemical composition and mechanical properties differing from those indicated in *Table 5.2.2* is to be, in each case, subjected to special consideration by *ICS Class*.

5.2.2.4 For new alloys having a modified chemical composition, *ICS Class* may require a check of corrosion resistance.

5.2.3 Heat treatment

5.2.3.1 If castings of aluminum alloys are heat treated the type of heat treatment is chosen by the maker and recorded in the material certificate.

5.2.4 Sampling

5.2.4.1 The samples may be cast on to the castings or cast separately. The sample thickness is to be not less than the minimum wall thickness of the casting. Whenever possible, the cooling of the samples will be carried out in conditions similar to the cooling of castings.

5.2.4.2 In the case of castings for parts operating under high loads the thickness of the samples is not to be less than the thickness of the highest loaded zone of the castings and it is to be specified in the drawing.

Table 5.2.2 Chemical composition and mechanical properties of cast aluminum alloys

Grade	Chemical composition, %		Condition of supply	Mechanical properties (minimum)			
	Basic elements	Allowable residual elements		$R_{p0,2}$, MPa	R_m, MPa	A_5, %	*HB*
1	Mg 2,0 - 4,5	Cu 0,10	Untreated	70	140	3	50
	Si 0,05 - 1,3 Mn 0,05 - 0,6 Al - remainder	Fe 0,50 Zn 0,20 Ti 0,20	Solution-treated with slow cooling down	125	210	1	65
2	Mg 4 - 6 Si 0,5 - 1,3 Mn 0,05 - 0,5 Al - remainder	Cu 0,10 Fe 0,50 Zn 0,10 Ti 0,20	Untreated	80	150	2	55
3	Mg 9 - 11,5 Si 1,3 Máx Mn Máx Al - remainder	Cu 0,10 Fe 0,50 Zn 0,10 Ti 0,15	Solution-treated and hardened	145	270	8	60
4	Si 7 - 11	Cu 0,10	Untreated	90	150	2	50
	Mn 0,15 - 05 Mg 0,5 Máx Al - remainder	Fe 0,60 Zn 0,30 Ti 0,15	Solution-treated with slow cooling down	165	200	1,5	70
5	Si 10 - 13,5 Mn 0,5 Máx	Cu 0,10 Fe 0,60	Untreated	70	150	2	50
	Al - remainder	Zn 0,30 Ti 0,15	Solution-treated and hardened	80	160	3	50

5.2.5 Scope of testing

5.2.5.1 Depending on their application, the castings of aluminum alloys are to be divided into test groups and tested accordingly within the scope indicated in *Table 5.2.5*. The scope of testing for castings with cast-on samples is to be agreed with *ICS Class*.

5.2.5.2 Tensile tests are conducted to determine the yield stress, tensile strength and elongation, but in certain cases, *ICS Class* may agree to omit the yield stress determination.

5.2.5.3 When castings for small-size pistons are checked, *ICS Class* may also allow to omit the tensile test being satisfied with the hardness test alone.

5.2.6 Inspection

5.2.6.1 The castings are to be submitted for inspection in the fettled condition with spruces, heads and burrs removed. They are to be free of any defects detrimental to their application and strength. Surface defects within the dimensional tolerances may be either ignored or removed by machining.

5.2.6.2 Certain casting defects may be repaired by welding, the procedure of which is to be agreed with *ICS Class*.

5.2.6.3 If the material of the castings is tested for soundness by hydraulic pressure, the casting drawing is to contain information on the working pressure in the tested space and on the test pressure employed at testing. The test pressure value is to be selected on the basis of the requirements of the relevant Chapters of the Rules or on agreement with *ICS Class*.

5.2.6.4 ICS may require non-destructive testing to be conducted on castings intended for items which operate under high loads.

5.2.7 Marking

5.2.7.1 The marking of the castings is to be in accordance with *1.4*.

SECTION 6
Plastics and materials of organic origin

6.1 General provisions

6.1.1 The present Section contains requirements for plastics and materials of organic origin used in hull and ship machinery construction, for the manufacture of parts and structures which are subject to supervision of *ICS Class*.

The requirements of the present Section apply also plastics and organic materials used for structures and items which are not subject to supervision of *ICS Class*, if their application has considerable effect on the safety of the ship as a whole.

6.1.2 General requirements

6.1.2.1 All plastics and materials of organic origin are to satisfy the following requirements unless there are special provisions regarding them in this Section:

.1 Their combustibility, flame spread and ignitability is to be assessed in conformity with *Chapter 6, Subsection 1.6.*
.2 They are not to give off explosion-hazardous vapors even at temperatures above those at which they are to be efficient.
.3 They are to ensure reliable operation of items and structures on the open deck at temperatures from -40 to+ 70 ºC and, in the inner spaces of the ship, at temperatures from –10 to + 70 ºC unless their service conditions provide for lower or higher operating temperatures.
.4 They are to resist embitterment and reduction of mechanical properties in service by more than 30 per cent in comparison with the original values.
.5 They are to resist decay and destruction by fungi and not to affect adversely the materials they come in contact with.

6.2 Glass-reinforced plastics

6.2.1 General provisions

6.2.1.1 The present requirements apply to glass- reinforced plastic used for the manufacture of ship structures and items which are subject to supervision of *ICS Class*.

6.2.1.2 The methods of manufacture of glass-reinforced plastics are to be subjected to approval by *ICS Class*.

6.2.2 Properties

6.2.2.1 For the manufacture of glass-reinforced plastics polyester resins should be used as binders.

Epoxy and other resins may be used only with permission of *ICS Class*.

The Manufacturers are to provide *ICS Class* with data on the properties of resins such and degree of cure, as well as other characteristics. A manual for storing and handling of the resins is also to be submitted.

Addition of pigments and other coloring agents adversely affecting the resin properties is not permitted; pigments may be added only into decorative layer.

The method of manufacture of glass-reinforced plastics and the conditions of their curing (temperature, humidity, time, etc.) are to meet the specifications according to which the approval has been issued.

6.2.2.2 Only low-alkaline glass in the form of mats, fabrics, roving, and chopped roving (having a length of 2,5 cm and over), the alkalinity of which is less than 1 per cent on conversion to Na_2O is to be used as reinforcing material.

Single glass filaments are to have a diameter ranging from 5 to 15 μm.

The reinforcing material is to be treated with a water-repellent adhesive compound ensuring a secure bond between the glass fibers and the resins.

In glued mats the adhesive is to be well soluble in the resin without any adverse effect on its properties.

The rapid solution of glue in the resin is not to result in the mat collapsing before completion of the molding process.

For each batch of the reinforcing material the manufacturer is to provide a certificate containing the following data:

- manufacturer;
- material;
- alkalinity;
- size of single glass filaments;
- type of cloth;
- size and finish;
- binder for mat.

6.2.2.3 The mechanical properties of glass-reinforced plastics are to be established on agreement with *ICS Class* depending on the types of reinforcement adopted for manufacture.

The action of sea water, petroleum products and ageing is not to reduce the mechanical properties of glass-reinforced plastics by more than 25 per cent in comparison to the original values.Ç

6.2.2.4 The percentage content of glass fibers in glass-reinforced plastics by mass is established on agreement with *ICS Class* according to the purpose and service conditions of the structure or item. In structures and items subject to loads this contents is not to be less than 25 per cent.

The maximum glass-fiber content for reinforcing with mats is not to exceed 35 per cent.

6.2.3 Sampling

6.2.3.1 Samples for specimens on which to determine physical and mechanical properties are to be taken from the test material provided immediately by the same technique, of the same components, and with the same glass fiber contents.

6.2.3.2 Specimens for tensile test and those for determining glass contents by mass are to be prepared from samples having approximate dimensions 500 x 400 mm x thickness, and specimens intended for compression test- from samples having thickness 10 - 12 mm.

6.2.3.3 It is permitted to use the shape and size of specimens as stipulated by national standards. Position of samples in relation to the molded item is to be agreed with the surveyor to *ICS Class*.

6.2.3.4 Samples may be taken from the surplus material to be tolerated on the molded item, and in well, founded cases, by request of *ICS Class* immediately form the molded item.

Sampling is to be done after the physical and mechanical properties of the glass-reinforced plastic have become stable. The time required for obtaining the above stable properties is to be indicated by the manufacturer of the binding material and determined during the approval test of the glass, reinforced plastic. The tensile module and tensile strength of the glass-reinforced plastic may be determined, on agreement with *ICS Class*, by non-destructive methods.

6.2.4 Scope of tests

6.2.4.1 When testing glass-reinforced plastics, the tensile, compression and bend strength, tensile module and relative contents of glass by mass are to be determined.

ICS may also require determination of the shear module and shear strength in the plate plane, as well as the relative glass contents by volume.

The values of the mechanical properties are to be determined as mean values of the test results obtained on 5 specimens taken from one sample in both the warp and weft direction

6.2.4.2 In case of unsatisfactory test results the following conditions are to be observed:

.1 If unsatisfactory results are obtained on one or two specimens, the tests are to be repeated on a double number of specimens.

.2 If unsatisfactory results are obtained on three or more specimens, *ICS Class* may require the test to be repeated on specimens, *ICS Class* may require the test to be repeated on specimens cut out directly from the item.

.3 If unsatisfactory results are obtained at repeated testing on one specimen at least, the items are to be rejected.

6.2.4.3 At approval tests of glass-reinforced plastics the degree of ageing is to be determined as set forth in *2.3.6*, resistance to petroleum products in accordance with *2.3.7* and the sea water resistance in accordance with *2.3.8*. Each of the above tests is to be to be carried out on three specimens.

To check the quality of a glass-reinforced plastic ready for use *ICS Class* may require accelerated tests to be carried out for determination of the wet strength by 3 hour boiling of the specimen in fresh water. The edges of the specimen may be covered with resin for this test if they are isolated in the finished item.

6.2.5 Inspection

6.2.5.1 Glass-reinforced plastic items are to be free from delaminating, voids, extraneous inclusions and other defects adversely affecting their intended use.

If *ICS Class* has doubts as to the freedom from internal defects, it may require testing by either destructive or non-destructive methods. The ultrasonic testing procedure is to be agreed with *ICS Class*.

6.3 Rubberized textiles

6.3.1 General provisions

6.3.1.1 The present requirements apply to rubberized textiles subject to supervision of *ICS Class* and intended for the manufacture of the structures operating under pressure.

6.3.1.2 Rubberized textiles are to be approved by *ICS Class*.

6.3.1.3 Rubberized textiles are to be manufactured and tested in compliance with the standards approved by *ICS Class* at the works which are recognized by *ICS Class*.

6.3.2 Properties

6.3.2.1 The properties of the rubberized textiles are to comply with the *Table 6.3.2.1*.

Table 6.3.2.1 Requirements for rubberized textiles

Tear strength, kN/5 cm		**Breaking elongation** %		**Tear propagation strength** N		**Coating adhesion** N/cm
warp	weft	warp	weft	warp	weft	
minimum		maximum		minimum		
1	2	3	4	5	6	7
2,0		35		40		10
NOTES: By agreement with *ICS Class* the tensile tests may be reduced up to the strength of the layers of a specific structure, but not less than four circular stresses, which may appear in pipes filled with gas to the opening pressure of the safety valves.						

6.3.2.2 After ageing and bend test, the change of tensile strength in laminated textiles must not be more than 10% of that before ageing, and the difference of dimensions along the warp and weft before and after ageing must not be more than 2%.

When the adhesive joints of laminated textiles are tensile-tested before ageing, the rupture must occur in the base material.

6.3.2.3 No stickiness, cracks, delaminations or color modifications should be observed on the surface of laminated textiles after testing for bending, ageing, creasing and shape stability after ageing, oil resistance, cold resistance, resistance to ozone and sea water.

6.3.2.4 The coloring agents applied should not detrimentally affect the properties of the base material

6.3.3 Sampling

6.3.3.1 Samples for specimens are to be taken from each batch of the rubberized materials at a distance of 0,1 m from the edge and not less than 1,0 m from the roll end.

Samples are to be taken not earlier then 24 h after fabrication of the rubberized materials.

6.3.4 Scope of tests

6.3.4.1 Rubberized textiles are to be submitted for tests by batches. The batch consists of one roll fabricated during one manufacturing cycle.

6.3.4.2 For each batch tensile tests to determine breaking elongation as stated *2.3.2.2*, and tear propagation strength in accordance with *2.3.2.3* on ten specimens (five from the warp and five from the weft), delamination tests according to *2.3.2.4* on three specimens and air permeability tests in compliance with *2.3.13* on two specimens are to be carried out.

A test has to be performed to determine the material mass according to approved standards.

6.3.4.3 For the approval of rubberized textiles, in addition to the tests referred to in *6.3.4.2*, shall be carried out tensile test after ageing according to *2.3.10.2*, bend tests according to *2.3.5.3* and also the tests of bond joints of rubberized textiles before and after ageing according to *2.3.2.5* on ten specimens (five from the warp and five from the weft). Other tests that shall be performed are those referred to creasing and stability of shape after ageing according to *2.3.10.3*, oil resistance according to *2.3.11*, sea water resistance according to *2.3.12*, cold resistance according to *2.3.14* and resistance to ozone according to *2.3.15*.

6.3.4.4 The tests results are to be in compliance with the requirement stated in *6.3.2*.

6.3.5 Inspection

6.3.5.1 Mechanical damage, recesses, dead fold, textile flaw marks, spots, blisters and porosity are not permitted on the surface of the rubberized textiles

6.3.6 Marking and documentation

6.3.6.1 Rubberized textiles are to be marked in compliance with *1.4*. Additionally, the mass of the material per unit of area is to be defined.

6.4 Foam plastics

6.4.1 General provisions

6.4.1.1. The present requirements apply to foam plastics used for the manufacture of items subject to supervision of *ICS Class*. For filling up the spaces between supporting surfaces of sandwich structures, air chambers of lifeboat and similar hollow spaces, foam plastic types approved by *ICS Class* are to be used.

6.4.1.2. Filling up of hollow spaces is to be done by means of fitting specially manufactured blocks, by foaming on the spot or spraying.

6.4.2. Properties of foam plastics

Table 6.4.2 Physical and mechanical properties of foam plastics

Grade	Type of plastic foam	Density g/cm²	Bending strength MPa	Compression strength, MPa	Young's modulus during the compression MPa	Water absorption after 24 hrs, kg/m²	Service range temperature °C
			Minimum			Maximum	
1	Polystyrene, rigid	0,02 0,06 0,10	0,3 0,8 1,0	0,1 0,4 0,7	20 34 49	0,06 0,03 0,02	±66
2	Polyvinylchloride, rigid	0,12 0,25	1,0 3,3	0,7 2,9	49 145	0,25 0,15	±66
3	Polyurethane, rigid	0,05 0,25	0,2 4,0	0,2 2,9	29 145	0,50 0,03	+ 100 - 60

6.4.2.1 The mechanical properties of foam plastics are to comply with the requirements of *Table 6.4.2*.

6.4.2.2 Under the influence of sea water and petroleum products, the deterioration of foam plastics properties should be within the limits specified in *6.1.2.4*.

6.4.2.3 The foam plastics are to have a closed-cell structure for the most part and are not to shrink with time; the shrinkage strains, if any, are not to exceed the tolerances for linear dimensions.

6.4.2.4 The shrinkage of foam plastics used as cores to fill the hollow spaces is not to result in poor adhesion of the plastics to boundary surfaces.

6.4.3. Sampling

6.4.3.1 The samples are to be cut out of the middle of a foam plastic block for which purpose, a portion with the most uniform cell structure is to be selected.

6.4.4. Scope of tests

6.4.4.1 The compression strength of foam plastics should be determined on three specimens in compliance with *2.3.3.2*. Simultaneously, the maximum loading is to be determined considering that an abrupt failure of the foam plastic structure may occur. The loading is to be reached in approximately one minute.

The apparent density of foam plastics should be determined on three specimens in accordance with *2.3.5*.

The bending strength should be determined on three specimens in accordance with *2.3.7*.

The water absorption should be measured on five specimens in accordance with *2.3.9*.

6.4.2.2 The petroleum product resistance of foam plastics should be determined in accordance with *2.3.11*, sea water resistance in accordance with *2.3.12* and ageing in accordance with *2.3.10*. Each of the tests is to be conducted on three specimens and only at the time when the type approval of the material is affected.

6.4.5. Inspection

6.4.5.1 The structure of the plastic foam on the cross-section is to be checked at the inspection for the closure of cells.

6.5 Deck coverings

6.5.1 Plastics used for covering open decks are to be subjected to approval tests, and those intended for decks of interior spaces are to be tested for combustibility only in accordance with *Chapter 6, Subsection 1.6*.

6.5.2 For the approval of plastics to be used for deck coverings, the manufacturer should submitted to *ICS Class* data on composition and method of application of a the plastic coverings.

6.6 Plastic pipes and fittings

6.6.1 Composition mechanical properties, methods and scope of testing of the plastic pipes and fittings for systems, shall be subjected to special consideration by *ICS Class* in each case.

6.7 Adhesives

6.7.1 Adhesives to be used for joining parts of structure and items operating under load are to have *ICS Class* approval.

SECTION 7
Anchor chain cables

7.1 Anchor chain cables and accessories

7.1.1 General provisions

7.1.1.1 The present requirements apply to the materials of anchor chain cables.

7.1.1.2 Depending on the nominal tensile strength of the chain cable steel used for manufacture, stud link chain cables are subdivided into grades 1, 2 and 3.

For stud less short link chain cables grade 1 and 2 only are applicable.

7.1.2 Materials for chain cables and accessories

7.1.2.1 The rolled steel bars used for the manufacture of chain cables must comply with the requirements of *3.6*.

7.1.2.2 Unless otherwise specified, the material of forged chain cables must comply with the requirements of *3.7*, and that of cast chain cables, with the requirements of *3.8*.

7.1.2.3 The studs are to be made of steel corresponding to that of the chain cable links or from rolled, forged or cast carbon steels.

The use of other materials, e.g. grey or nodular cast iron is not permitted.

7.1.3 Design and manufacture

7.1.3.1 Chain cable links are manufactured by flash butt welding using bar material. Manufacture of the links by drop forging or steel casting is permitted.

Stud less links of 26 mm diameter and below may be manufactured by pressure butt welding.

7.1.3.2 Accessories such as kenter and joining shackles, swivels and swivel shackles are to be forged or cast in steel of at least grade 2.

The welded construction of these parts may also be approved.

7.1.3.3 The design of chain cable links and accessories must comply with specifications approved by *ICS Class* bearing in mind *Figs 7.1.3-1 - 7.1.3-7*, and length of chain cable must comprise an odd number of links.

Where chain cables and accessories are of welded construction, its heat treatment is to be submitted to a special analysis.

7.1.3.4 According to the grade of steel, chain cables and accessories are to be supplied in one of the conditions specified in *Table 7.1.3.4*.

The heat treatment is to be performed before breaking load or proof load testing.

Table 7.1.3.4 Heat treatment of finished chain cables and accessories

Grade	Condition of supply
1	Not regulated (any)
2[1], 3	Normalized, normalized and tempered or quenched and tempered condition.

[1] On agreement with *ICS Class*, a chain may be supplied without heat treatment provided the results of testing in conformity with *7.1.4.3* are satisfactory.

7.1.3.5 The mechanical properties of the material of a finished chain cable and accessories are to be in accordance with *Table 7.1.4.3.3*.

7.1.3.6 Chain cables and accessories are to be manufactured in a manner such as to withstand the proof and breaking loads indicated in *Tables 7.1.4.1.2-1* and *7.1.4.1.2-2* depending on the relevant chain cable grade.

7.1.3.7 All chain links and accessories must have a clean surface consistent with the method of manufacture and be free from cracks, notches, inclusions and other defects impairing the performance of the product. The flashes produced by upsetting or drop forging must be properly removed.

Defects in forgings are to be properly removed and non-permissible minor surface defects may be ground off in a manner such as to ensure a gentle transition to the surrounding surface. A load grinding up to 5 % of the nominal link diameter or item thickness may be permitted.

7.1.3.8 The dimensions of stud chain links and accessories must comply with *Figs 7.1.3-1 - 7.1.3-7* and with approved specifications.

The dimensions of stud less links must comply with the requirements of recognized standards, and they shall be in each case subjected to the special consideration of *ICS Class*.

Figure 7.1.3-1 Common link

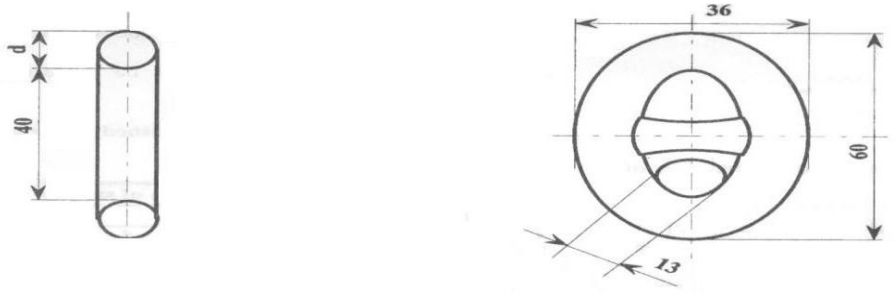


Figure 7.1.3-2 Enlarged link

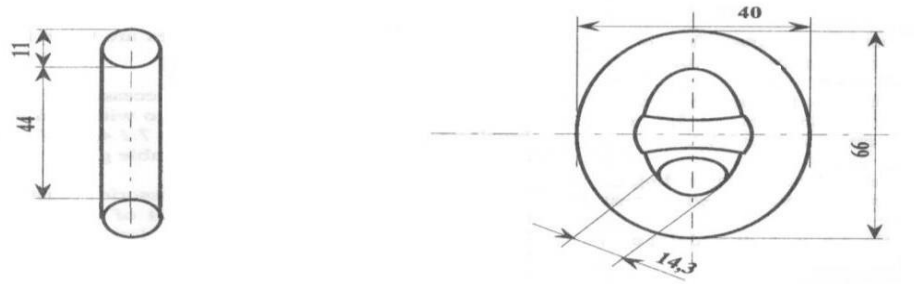


Figure 7.1.3-3 Studless link

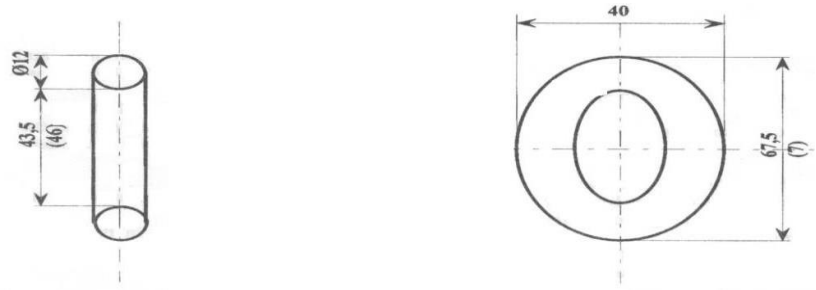


Figure 7.1.3-4 Center shackle

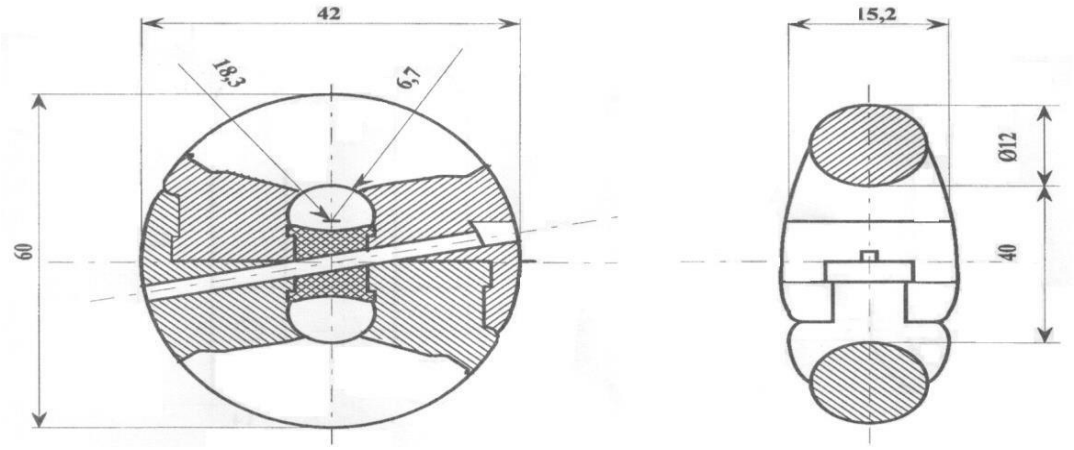


Figure 7.1.3-5 Joining shackle

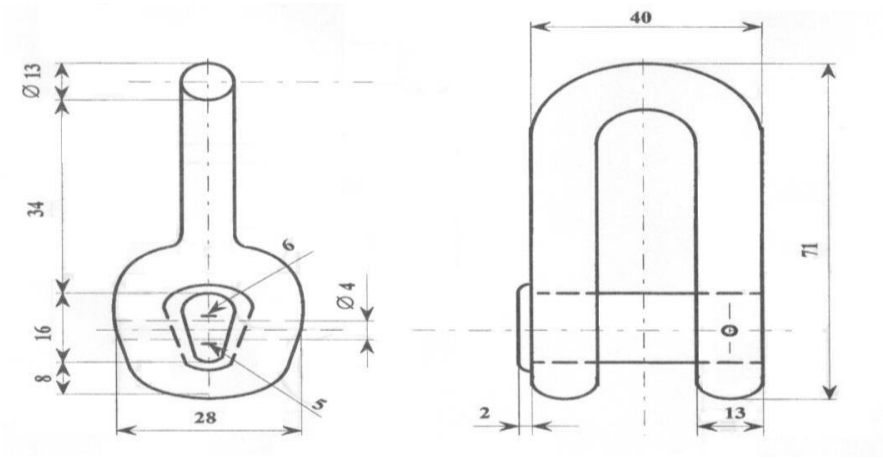


Figure 7.1.3-6 End shackle

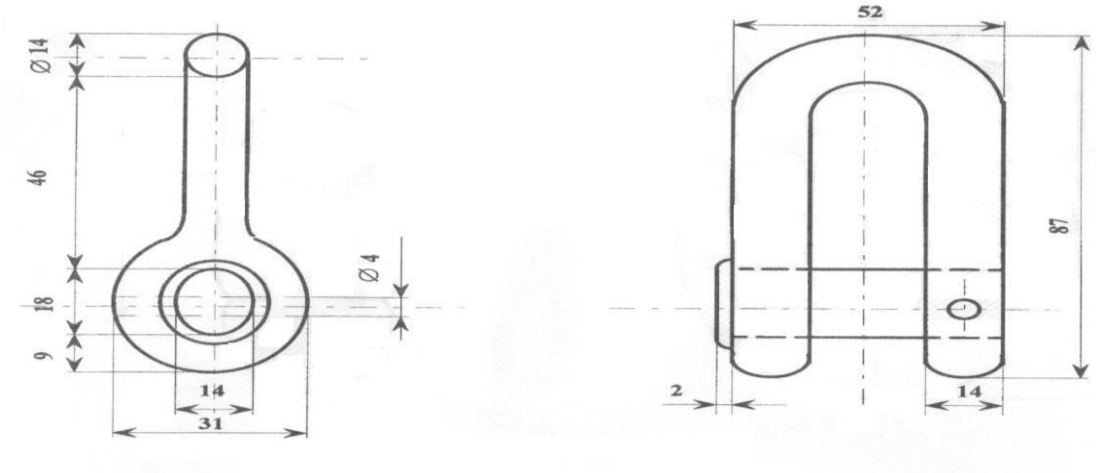
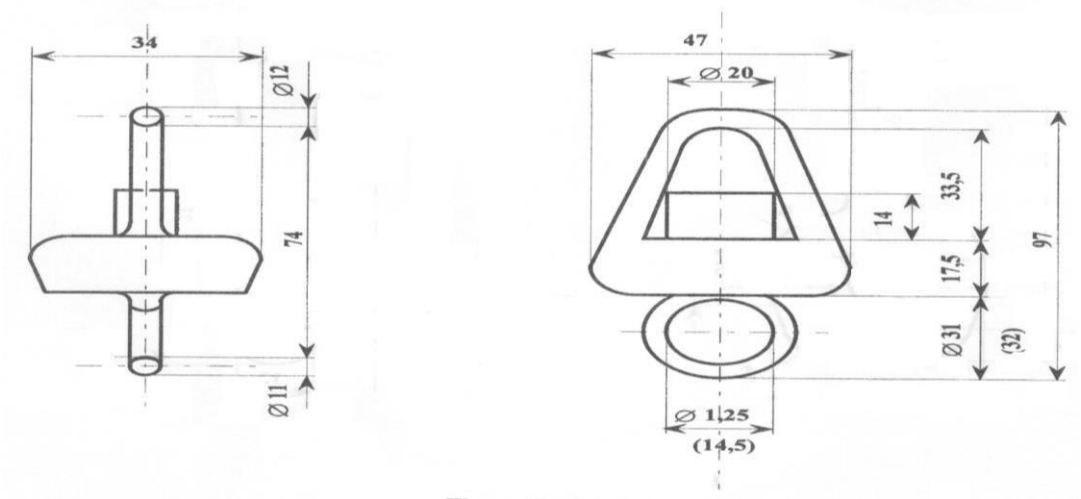


Figure 7.1.3-7 Swivel



7.1.3.9 Allowable tolerances of chain link dimensions

7.1.3.9.1 The diameter tolerances in the elbow outside the link contact area, must comply with the requirements of *Table 7.1.3.9.1*.

Table 7.1.3.9.1 Allowable tolerances of chain link diameter

Nominal link diameter (mm)	**Allowable tolerances** [1] (mm)
Up to 40	-1
Over 40 up to 84	-2
Over 84 up to 122	-3
Over 122	-4
[1] The maximum tolerances are not to exceed 5% of the nominal diameter.	

7.1.3.9.2 The cross-sectional area of the elbow must have no negative tolerances.

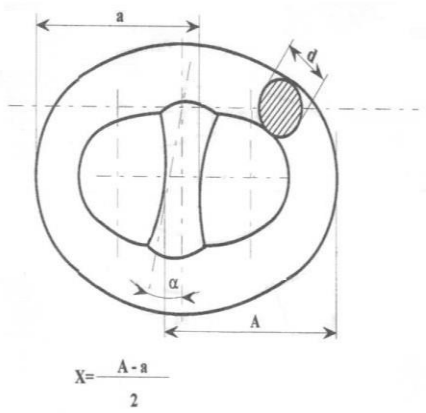
For the purpose of determining the cross-sectional area, the diameter adopted is to be an arithmetic mean of four values measured at points uniformly distributed along the cross section perimeter.

7.1.3.9.3 Allowable tolerance on assembly measured over a length of five links is not to exceed + 2.5 % of the nominal length (measured with the chain under tension after proof load test).

7.1.3.9.4 Studs must be located in the link centrally and perpendicular to the longitudinal axis of the link although the studs of the final flank at each end of any length, may also be located off-center to facilitate the insertion of the center and joining shackles. The following tolerances are permitted provided that the stud fits snugly and its ends lie practically flush against the inside of the link:

- Maximum off-center distance X: *10%* of the nominal diameter *d*.
- Maximum deviation α from the 90º - position: 4º.
- The tolerances are to be measured in accordance with *Fig. 7.1.3.9.4*.

Figure 7.1.3.9.4 Allowable tolerances of studs



7.1.3.10 The following tolerances are applicable in accessories:

- nominal diameter + *5%* ÷ 0;
- other diameter + 2.5%.

7.1.3.11 The welding of studs is to be in accordance with the procedure approved by *ICS Class* subject to the following conditions:

- The studs must be of weldable steel in accordance with *7.1.2.3*.
- The studs are to be welded at one end only, i.e. opposite to the weldment of the link. The stud ends must fit the inside of the link without appreciable gap.
- The welds, preferably in the down hand position, should be executed by qualified welders using suitable welding consumables.
- All welds must be carried out before the final heat treatment of the chain cable.
- The welds must be free from defects liable to impair the proper use of the chain cable. Undercuts, end craters and similar defects should, where necessary, be ground off.

If required by *ICS Class*, a procedure for the welding of chain studs is to be effected.

7.1.4 Testing of finished chain cables

7.1.4.1 Proof and breaking load testing

7.1.4.1.1 All finished chain cables are to be subjected to the tests specified below in the presence of a surveyor to *ICS Class*. For this purpose, the chain cables must be free from paints and anti-corrosion media.

7.1.4.1.2 Each chain cable length (27,5 m) is to be subjected to a loading test at a proof load appropriate to the particular chain cable as shown in *Tables 7.1.4.1.2-1* and *7.1.4.1.2-2*.

7.1.4.1.3 For breaking load testing in accordance with *Tables 7.1.4.1.2-1* and *7.1.4.1.2-2*, sample lengths are taken from the chain cables in conformity with *Table 7.1.4.1.3* which comprise at least three stud links or five studless links. The links concerned shall be made in a single manufacturing cycle together with the chain cable and must be welded and heat treated together with it. Only after this may they be separated from the chain cable in the presence of a surveyor to *ICS Class*.

7.1.4.1.4 If the tensile loading capacity of the testing machine is insufficient to apply one breaking load for chain cables of large diameter, another equivalent testing method shall be agreed with *ICS Class*.

Table 7.1.4.1-1 Test loads for stud link chain cables

Chain diameter, mm	Test loads, in kN, for chain cable grades					
	1		2		3	
	proof load	breaking load	proof load	breaking load	proof load	breaking load
I	2	3	4	5	6	7
11	36	51	51	72	72	102
12,5	46	66	66	92	92	132
14	58	82	82	116	116	165
16	76	107	107	150	150	216
17,5	89	127	127	179	179	256
19	105	150	150	211	211	301
20,5	123	175	175	244	244	349
22	140	200	200	280	280	401
24	167	237	237	332	332	476
26	194	278	278	389	389	556
28	225	321	321	449	449	642
30	257	368	368	514	514	735
32	291	417	417	583	583	833
34	328	468	468	655	655	937
36	366	523	523	732	732	1050

Table 7.1.4.1-1 (Cont)

I	2	3	4	5	6	7
38	406	581	581	812	812	1160
40	448	640	640	896	896	1280
42	492	703	703	981	981	1400
44	538	769	769	1080	1080	1540
46	585	837	837	1170	1170	1680
48	635	908	908	1270	1270	1810
50	686	981	981	1370	1370	1960
52	739	1060	1060	1480	1480	2110
54	794	1140	1140	1590	1590	2270
56	751	1220	1220	1710	1710	2430
58	909	1290	1290	1810	1810	2600
60	969	1380	1380	1940	1940	2770
62	1030	1470	1470	2060	2060	2940
64	1100	1560	1560	2190	2190	3130
66	1160	1660	1660	2310	2310	3300
68	1230	1750	1750	2450	2450	3500
70	1290	1840	1840	2580	2580	3690
73	1390	1990	1990	2790	2790	3990
76	1500	2150	2150	3010	3010	4300
78	1580	2260	2260	3160	3160	4500
81	1690	2410	2410	3380	3380	4820
84	1800	2580	2580	3610	3610	5160
87	1920	2750	2750	3805	3850	5500
90	2050	2920	2920	4090	4090	5840
92	2130	3040	3040	4260	4260	6080
95	2260	3230	3230	4510	4510	6440
97	2340	3340	3340	4680	4680	6690
100	2470	3530	3530	4940	4940	7060
102	2560	3660	3660	5120	5120	7220
105	2700	3850	3850	5390	5390	7700
107	2790	3980	3980	5570	5570	7960
111	2970	4250	4250	5940	5940	8480
114	3110	4440	4440	6230	6230	8890
117	3260	4650	4650	6510	6510	9300
120	3400	4850	4850	6810	6810	9720
122	3500	5000	5000	7000	7000	9990
124	3600	5140	5140	7200	7200	10280
127	3750	5350	5350	7490	7490	10710
130	3900	5570	5570	7800	7800	11140
132	4000	5720	5720	8000	8000	11420
137	4260	6080	6080	8510	8510	12160
142	4520	6450	6450	9030	9030	12910
147	4790	6840	6840	9560	9560	13660
152	5050	7220	7220	10100	10100	14430
157	5320	7600	7600	10640	10640	15200
162	5590	7990	7990	11170	11170	15970

Table 7.1.4.1-2 Test loads for studless link chain cables

Chain grade	Test loads, kN	
	proof load	breaking load
1	0,185 d²	0,370 d²
2	0,260 d²	0,520 d²
NOTE: *d* is the nominal chain diameter, in mm.		

Table 7.1.4.1.3 Scope of chain cable testing

Grade	Manufacturing method	Heat treatment	Number of test specimens taken from every fourth length or 100m of chain cable				
			Breaking load test	Tensile test		Impact test	
				base metal	welded joint	base metal	welded joint
1	Welding	Not requiered	1	-	-	-	-
2	Welding	Normalizing	1	-	-	-	-
		Not requiered	1	1	1 [1]	3	3 [1]
3	Welding	Normalizing, quenching and tempering	1	1	1 [1]	3	3 [1]
2	Casting or forging	Normalizing	1	1	-	3	-
3	Casting or forging	Normalizing, quenching and tempering	1	1	-	3	-
[1] The requirements of *7.1.4.3.1* are to be complied with.							

7.1.4.2 Retests

7.1.4.2.1 Should a breaking load test fail, a further test specimen may be taken from the same length of chain cable and tested. The test shall be considered successful if the requirements are then satisfied.

If the retest fails, the length of chain cable concerned shall be rejected. If the manufacturer so wishes, the remaining three lengths belonging to the unit test quantity may then be individually subjected to test at the breaking load. If one such test fails to meet the requirements, the entire unit test quantity is rejected.

7.1.4.3 Should a proof load test fail, the defective link (links) is (are) to be replaced, a local heat treatment to be carried out on the new link (links) and the proof load test is to be repeated. An investigation is to be made to identify the cause of the failure.

7.1.4.4 Tensile and impact testing of specimens cut out of a finished chain cable.

7.1.4.3.1 In accordance with *Table 7.1.4.1.3*, tensile and impact test specimens are taken from every fourth length of grade 3 chain cables and non- heat-treated grade 2 chain cables.The specimens are cut out as shown in *Fig. 3.6.6* on the link side opposite to the weld.ICS may require the weld-cut specimens to be subjected to tensile testing across the weld and to impact testing with a notch through the weld.

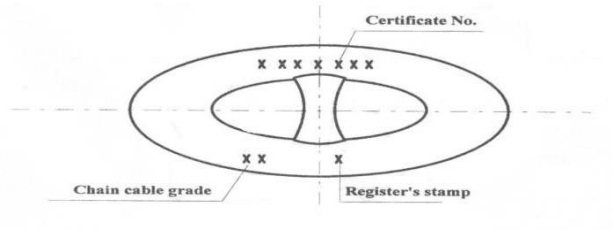
7.1.4.3.2 For the purpose of test specimen preparation, provision should be made for an additional link (or where the chain diameter is small, several links) in a length of chain cable. The additional link is to be manufactured by the same procedure as the specimen for breaking test in accordance with *7.1.4.1.3*.

7.1.4.3.3 The test results must comply with the requirements of *Table 7.1.4.3.3*.

7.1.4.5 Chain cables are to be marked at both ends of each length, and the marking is to include certificate number, chain cable grade and *ICS Class* stamp.

The arrangement of symbols comprising the marking should be in accordance with *Fig. 7.1.4.4*.

Figure 7.1.4.4 Arrangement of the marking at both ends of each chain cable length



7.1.5 Testing of accessories

7.1.5.1 Proof and breaking load testing

All accessories are to be subjected to tests described below in the presence of a surveyor to *ICS Class*. For this purpose, the accessories must be free from paint and anti-corrosion media.

7.1.5.1.1 All accessories are to be subjected to tests described below in the presence of a surveyor to *ICS Class*. For this purpose, the accessories must be free from paint and anti-corrosion media.

7.1.5.1.2 All accessories are to be subjected to the proof load test at the proof load specified in *Table 7.1.4.1.2-1*.

7.1.5.1.3 For breaking load test in accordance with *Table 7.1.4.1.2-1*, the accessories are to be submitted in batches.

A batch of shackles, swivels, end shackles, and enlarged links should comprise not more than 25 items and one consisting of kenter shackles, should comprise 50 items of the same grade and size which were manufactured from material of the same heat and heat treated in the same furnace charge. Of each batch, one item is subjected to the breaking load test and after testing, the use of such items is not permitted.

7.1.5.1.4 On agreement with *ICS Class*, breaking load test may be waived if:

- Positive results are obtained at the initial testing of the items with the approval of the Manufacturer by *ICS Class*.
- The results of mechanical tests in accordance with *7.1.5.2* are satisfactory for each batch.
- The parts are subjected to suitable non-destructive testing in accordance with a procedure approved by *ICS Class*.

7.1.5.1.5 Notwithstanding the above, the items which have been tested at the prescribed breaking load may be used in service if use is made in manufacture of materials having higher strength characteristics than those specified for the part in question.

7.1.5.2 Mechanical tests

7.1.5.2.1 Of each batch of accessories, one specimen is to be tensile tested and one set of three specimens shall be submitted to impact testing (KV); for that purpose, the specimens shall be taken from an assembly or item as shown in *Fig. 3.6.6*.

7.1.5.2.2 The results of the mechanical tests are to comply with the requirements of *Table 7.1.4.3.3*.

7.1.5.3 Marking

7.1.5.3.1 Each item of accessories is to be marked, and the marking is to include certificate number, grade and *ICS Class* seal.

7.2 Wire ropes

7.2.1 General provisions

7.2.1.1 The present requirements apply to wire ropes used in hoisting gears, life-saving appliances and other naval devices which are subject to the supervision of *ICS Class*.

7.2.1.2 The wire ropes shall be manufactured according to the standards in force and tested in laboratories approved and certified by *ICS Class*.

7.2.2 Manufacture

7.2.2.1 The wire ropes shall be manufactured from circular section wires, coated for precluding the corrosion and with a tensile strength of 1180 to 1770 MPa.

7.2.2.2 The cores of the wire ropes shall be constructed

of organic materials such as manila or synthetic clothes. The wire ropes with a design diameter greater than 12 mm, are to have a core composed by three wires.

7.2.2.3 The wires of complete wire ropes are to be covered with grease. The organic cores are to be pervaded with antiseptic and anticorrosive substances being unsolvable in sea water and keeping unaffected by acids or bases.

The physical and chemical properties of the grease for the wire ropes, are to be suitable to the aforementioned substances.

7.2.3 Sampling

7.2.3.1 During the testing of wire ropes measuring up to 2000 m or less, shall be carried out a control cut. If the wire ropes are greater than 2000 m then is to be considered a control cut at each end.

7.2.3.2 The length of the control cuts for the wire ropes, are to ensure that all the tests previously established be performed.

7.2.4 Scope of testing

7.2.4.1 Each wire rope, after to be manufactured, shall be submitted to a breaking test.

7.2.4.2 The tests are to be performed according to standards previously agreed with *ICS Class*.

For that purpose, the breaking tests of complete wire ropes, shall be performed in a testing machine with a distance between the grips of less than 50 diameters. If the test takes place at the grip, then it shall be repeated.

7.2.4.3 The testing results are to be in compliance with the requirements stated in the standards.

7.2.4.4 If the testing machine has not the power required for performing the tests, then shall be allowed to determine the breaking stress by means of the results of the tensile tests *F*, (kN) of all the wire ropes by means of the formula:

$$F = c \cdot \frac{\sum_{1}^{i} \left[\left(\sum_{m} F \right) \eta \right]}{\sum_{1} \left| \left(\sum_{m} \right)_{z} \right|} \quad (7.2.4.4)$$

Where:

c = Factor which involves the exploitation of the wire rope considering the wire strength. This factor is to be defined or calculated as the relation of the breaking stress of the complete wire rope to the sum of the breaking stresses of all the wires;

i = number of groups having wires with the same diameter;

m = number of wires submitted to tensile stresses of each group, according to its diameters, which comply with the requirements of the standards;

F_m = maximum breaking load applied to the sample, for the tensile test of a wire, kN;

η = number of wires in each group according to its diameter;

z = number of wires submitted to tensile stresses in each group, according to its diameter.

Depending on the use, the number of tensile tests required by the wire ropes may be decreased, in agreement with *ICS Class*, up to 25 % of the total number of wires in the rope.

7.2.5 Inspection

7.2.5.2 According to standards approved by *ICS Class*, the diameter and other parameters of the wire ropes are to be subjected to visual control and measurements.

After removing sheathing strap at the end of wire ropes, shall not be possible to unbraid them, or on the contrary, may be unbraided in such a way that they can recover its original shape.

The diameter of the wire ropes is not exceeding the design diameter in a value greater than 6 %.

7.2.5.3 On the surface of the wire ropes, the twisting, corrosion, wire breakings, etc, are not to be allowed if that impairs their use.

7.2.6 Marking and documentation

7.2.6.1 The marking of the wire ropes is to be performed in conformity with the standards approved by *ICS Class*.

7.3 Ropes of natural and synthetic fiber

7.3.1 The present requirements apply to ropes subject to *ICS Class* supervision, which are intended for cargo handling gear, life-saving appliances and other ship appliances.

7.3.2 The ropes should be manufactured and tested in conformity with standards approved by *ICS Class* and by works recognized by the Society.

The breaking load on a rope is determined by testing the rope as a whole. Testing should be conducted in conformity with standards.

7.3.3 The breaking load on a rope *F*, in kN, may be determined by the following formula:

$$F = c\left(\sum_{1}^{m} F_m\right)n / z$$

Where:

c = yarn efficiency factor for the rope which is to be adopted on the basis of standards or calculated as the ratio of the breaking load on the rope as a whole to the total breaking load on all the yarns making up the rope, both the values being stipulated by the standards;

m = number of yarns, subjected to tensile testing, which conform to standards;

F_m = the greatest load, during the tensile test of a yarn, in kN, after which the specimen breaks;

n = number of yarns in a rope;

z = number of yarns subjected to tensile testing, which is adopted equal to 0,5n for ropes below 80 mm in diameter, 0,3n for ropes of 80 - 115 mm in diameter and 0,1n for ropes over 115 mm in diameter.

7.3.4 A rope of synthetic fiber should undergo testing to determine elongation at breaking.

The mean elongation of a rope at breaking σ_m , in per cent, is to be determined by the formula:

$$\sigma_{cp} = \left(l_p - l_o\right) / l_o 100$$

Where:

l_o = initial length of the rope specimen tested, cm;

l_p = length of the rope specimen submitted to a load equal to the breaking load on the rope as a whole, which is to be in compliance with the standards approved by *ICS Class*.

7.3.5 According to the structure, diameter and other parameters of the rope, are to be carried out visual and dimensional controls in conformity with the standards.

On the surface of a finished rope, no brown spots, mould, burned spots, decay or cinder should be detectable.

The color of the rope should be uniform along its whole length and should not differ from that of the yarn or synthetic fiber of which the rope is manufactured.

7.3.6 The marking of the ropes is to be effected in conformity with standards.

7.3.7 The test results should be entered in the Certificate of Test, the content of which is to be agreed with *ICS Class*.

SECTION 8
Anticorrosive protection

8.1 General provisions

8.1.1 The present requirements shall be applicable to the anticorrosive protection methods of steel constructions, copper and aluminum alloys, combined constructions, as well as materials used for the protection against the corrosion. During the preparation and protection against the corrosion, are to be observed the provisions set out in manuals and instructions.

The anticorrosive protection shall not be subjected to supervision by *ICS Class* except where special requirements are to be fulfilled.

8.2 Metallic coatings for anticorrosive protection

8.2.1 The thickness of anticorrosive protection coatings by means of galvanic protection with zinc or cadmium may be approved according to national

standards in force, but in no case shall be less than the values given in *Table 8.2.1*

Table 8.2.1 Thickness of galvanic protection layers

Group	Corrosive agent	Minimum thickness of the layers of zinc and cadmium (microns)
1	Continuous action of sea water	48
2	Transitory action of sea water	24
3	Sea water spattering effect	12
4	Sea wind effect	6

8.2.2 Upon requirement by *ICS Class* the thickness of the protective layers may be increased, depending on the construction, the pipes and its fittings, as well as the corrosive agent.

8.3 Electrochemical protection

8.3.1 In the electrochemical protection of structures and their elements, the protective anodes may be manufactured with zinc alloys, magnesium, aluminum and steel in accordance with standards approved by *ICS Class*.

8.3.2 The electric resistance of the protective anodes installed on the hull is to be not greater than 0,02 Ω, if it is not foreseen a variable resistance or when it is required a reduction resistance of the protective potential.

8.3.3 When the protective anodes of magnesium alloys are used in the protection of constructive elements of light alloys not painted, shall be protected with screens of non-conductive materials.
For the use of anodes of magnesium alloys in steel or aluminum constructions, shall be provided a reinforcement of the non-corrosive protection by means of additional painting coats, whose total thickness shall be specially considered by *ICS Class*.

8.3.4 In ships intended for the carriage of hidrocarbons, is not permitted the use of electrochemical protection systems by inverse current, as well as the installation of magnesium alloys anodes in the tanks.

The use of protective anodes of magnesium alloys in other places of possible explosive mixtures concentration only shall be permitted on agreement with *ICS Class*.

8.3.5 The aluminum anodes may be used only in the tanks of ships intended for the carriage of hidrocarbons, in places where the potential energy do not exceed 275 J. In these cases, the height where such anodes are arranged, shall be measured from the bottom of the tank up to the center of the anode, having a suitable relation between its mass and the place where shall be installed, including details of the connecting devices.

If the aluminum anodes are placed above horizontal surfaces (bulkhead horizontal girders, cargo battens side stringers, etc. with a width less than 1 m, having besides free wings expanding more than 75 mm over the aforementioned surfaces, then the height where such anodes are arranged shall be measured from these surfaces.

The anodes of aluminum alloys are not to be placed above openings and hatchways because of the risk of dropping over the crew members.

8.3.6 The devices used for the installation of protective anodes in the tanks are to be reliable, ensuring its integrity and the elements for the installation, when even the anodes are completely corroded.

The steel anchoring of the anodes are to be connected to the construction, being suitably welded and in the case where the installation be carried out by means of bolts, then shall be provided lock nuts.

The use of any other connecting device shall be subjected to special consideration by *ICS Class*.

8.4 Anticorrosive protection of the aluminum alloys

8.4.1 The requirements of the present Subsection are to be applicable to the means of anticorrosive protection of aluminum alloys as is referred in *Section 5*.

8.4.2 Before to apply the anticorrosive covering to elements constructed with aluminum alloys, they shall be carefully cleaned removing the grease and other particles.

8.4.3 In order to obtain a suitable attachment between the material protected and the anticorrosive layer using chemical or electrochemical methods, shall be applied previously a priming coat which allow to increase the adherence. Also may be applied a priming coat with quick pigmentation.

8.4.4 If the layer obtained by rusting is considered as non-corrosive protection, then the thickness of this layer shall be adopted depending on the destination of the element, but in all the cases, is to be not less than 15 microns.

8.4.5 The priming of aluminum alloys is to be performed with specially selected paintings, being prohibited the use of paints containing pigments with copper, lead or quicksilver as well as bituminous paints containing phenol.

8.5 Anticorrosive protection of combined structures

8.5.1 In this kind of structures it shall be necessary that the different elements they are composed of be isolated between themselves by means of suitable insulating materials.

8.5.2 The steel elements, including bolts and washers, whose contact with aluminum alloys be unavoidable, are to be protected by means of zinc or cadmium galvanic elements, except those cases where the steel elements are located in the inner part of equipments which contain a permanent oily fog or are tightly closed.

The thickness of the protective layer is to be in compliance with the requirements set forth in the *Table 8.2*, referred to the continuous action of sea water.
In special cases, on agreement with *ICS Class*, may be accepted a smaller thickness of the layer.

8.5.3 The use of chromium or nickel-plated bolts in wet compartments or weatherdeck is not permitted. Besides, shall not be admitted the use of bolts, rivets, etc of copper and its alloys for the connection between themselves of aggregates and parts of aluminum alloys.

8.5.4 It is recommended (if it is possible from the technical point of view) the use of screwed joints in the aluminum alloy structures.

8.5.5 The external screwed joints are to be isolated by means of connecting or covering with protective enamel, in such a way that precludes the penetration of moisture. The use of steel bushings is recommended for the screwed joints when they are submitted to great loads or are frequently unscrewed. The bushings are to be galvanized in a zinc or cadmium base.

8.5.6 An insulation composed of galvanic elements or joints is to be foreseen for the aluminum alloys and woods which may be submitted to damage when they are in contact with acids or other materials.

8.6 Protection of steel structures with non-metallic coverings

8.6.1 The steel constructions shall be carefully cleaned removing oxides, moisture and other elements as required, according to the technology of non-metallic coverings application, before that such constructions be submitted to organic origin coverings (oil paints, lacquers or resinous paints) or inorganic origin coverings (cements and enamels).

8.6.2 The materials used as coverings as well as its application technology, according to the standards in force, are to ensure a suitable adherence with the metal properly protected, as well as a satisfactory strength during its service.

8.6.3 The use of special coverings (epoxy resins used for reducing the thickness of the protected elements of the hull) and the technology of its application shall be subjected to the special consideration of *ICS Class*.

8.6.4 The plastic materials used as coverings of anticorrosive protection, may be applied on protected surface by means of spraying or sizing. The plastic materials used for the protection of shafting, pipes and equipments shall be subjected to supervision and certification by *ICS Class*.