



RULES FOR
CLASSIFICATION OF

**SHIPS / HIGH SPEED, LIGHT CRAFT AND
NAVAL SURFACE CRAFT
NEWBUILDINGS**

MATERIALS AND WELDING

PART 2 CHAPTER 1

**GENERAL REQUIREMENTS
FOR MATERIALS**

JULY 2007

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CHANGES IN THE RULES

General

The present edition of the Rules includes additions and amendments decided by the Board in June 2007, and supersedes the January 2003 edition of the same chapter.

The rule changes come into force as indicated below.

This chapter is valid until superseded by a revised chapter. Supplements will not be issued except for an updated list of minor amendments and corrections presented in Pt.0 Ch.1 Sec.3. Pt.0 Ch.1 is normally revised in January and July each year.

Revised chapters will be forwarded to all subscribers to the Rules. Buyers of reprints are advised to check the updated list of Rule chapters printed in Pt.0 Ch.1 Sec.1 to ensure that the chapter is current.

Main changes coming into force 1 January 2008

• Sec.2 Testing Procedures

This section has been revised to incorporate changes in the amended IACS UR W2 and to improve user-friendliness.

- Sub-section element B100 has been amended with respect to the use of alternative tensile test pieces. Amendments are mainly editorial.
- Sub-section element B300 has been editorially amended to clarify the procedure for impact testing. The requirement for subsize test pieces with width 2.5 mm has been deleted.

Corrections and Clarifications.

In addition to the above stated rule requirements, a number of corrections and clarifications have been made in the existing rule text.

Comments to the rules may be sent by e-mail to rules@dnv.com

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SECTION 1

MANUFACTURE, SURVEY AND CERTIFICATION

A. General

A 100 Scope

101 This Section specifies general requirements for manufacture, survey and certification of materials used for the construction or repair of hulls, equipment, boilers and pressure vessels and machinery of vessels classed or intended for classification by the Society.

Appropriate specific requirements are given in Ch.2.

102 Materials which shall comply with these requirements are defined in the relevant design and construction parts of the rules.

103 Materials which comply with national or proprietary specifications may be accepted provided such specifications give reasonable equivalence to the requirements of Ch.2 or are otherwise specially approved.

A 200 Information to be supplied by the purchaser

201 The purchaser shall supply the manufacturer with all information necessary to ensure that survey and certification can be carried out in accordance with these rules. This applies particularly where optional or additional conditions are specified in the relevant construction rules.

A 300 Approval of manufacturers

301 Materials delivered with NV or works certificate shall be manufactured at works which have been approved by the Society. Approved manufacturers are published on DNV Exchange on the Internet.

302 In order to be approved, the manufacturer is required to demonstrate and submit documentation to the effect that the necessary manufacturing, testing and inspection facilities are available and are supervised by qualified personnel. The manufacturer is also to carry out a test programme and submit the results.

303 Detailed programmes for approval testing are given in Standards for Certification No. 2.9.

304 When a manufacturer has more than one works, the approval is only valid for the works which carried out the test programme.

B. Testing and Inspection

B 100 Survey during manufacture

101 The surveyor shall be given the opportunity to inspect and check at any time all plants and equipment used in the manufacture and testing.

The manufacturer shall assist the surveyor to enable him to verify that approved processes are adhered to and to witness the selection and testing as required by the rules.

102 Prior to the testing and inspection, the manufacturer shall provide the surveyor with the technical specifications of the order and any conditions additional to the rule requirements.

B 200 Chemical composition

201 The chemical composition of samples taken from each ladle of each cast shall be determined by the manufacturer in an adequately equipped and competently staffed laboratory and shall comply with the appropriate requirements of Ch.2.

202 The manufacturer's declared analysis will be accepted subject to occasional checks if required by the surveyor.

B 300 Heat treatment

301 All materials shall be supplied in a condition complying with the appropriate requirements of Ch.2.

302 Heat treatment shall be carried out in properly constructed furnaces which are efficiently maintained and have adequate means for control and recording of temperature. The furnace dimensions shall be such as to allow the material to be uniformly heated to the specified temperature.

303 In the case of very large castings or forgings alternative methods for heat treatment will be specially considered.

B 400 Selection of test material

401 Test material sufficient for the required tests and preferably also for possible retest purposes shall be provided. The test material shall be representative of the test unit or sample product and shall not be separated until all the specified heat treatment has been completed, unless otherwise stated in Ch.2.

402 Where the Society's certification is required, all the test material shall be selected and marked by the surveyor, unless otherwise agreed.

B 500 Definitions relevant to testing

The following definitions apply:

501 Test Unit: The number of pieces or the tonnage of products to be accepted or rejected together, on the basis of the tests to be carried out on sample products.

502 Sample Product: A single forging, casting, plate, tube or other wrought product selected from a test unit.

503 Sample: A sufficient quantity of material taken from the sample product for the purpose of producing one or more test pieces.

504 Test Piece: Part of the sample, with specified dimensions, machined or unmachined, brought to a required condition for submission to a given test.

B 600 Testing

601 The appropriate tests specified in Ch.2 and 3 shall be carried out at the place of manufacture before materials are dispatched. If the necessary facilities are not available at the manufacturer's works, the testing shall be carried out at a recognized testing laboratory.

Where the Society's certification is required, all the testing shall be witnessed by the surveyor, unless otherwise agreed.

602 In the event of any material proving unsatisfactory during subsequent processing or fabrication, such material shall be rejected, notwithstanding any previous certification.

The surveyor may require further tests of materials from affected test units.

B 700 Retesting

701 When the result of any test, other than impact test, fail to meet the requirements, two further tests may be made from the same sample. If both of these additional tests are satisfactory, the test unit may be accepted.

702 When the results from a set of three impact test pieces fail to meet the requirements, three additional test pieces from the same sample may be tested and the results added to those previously obtained to form a new average. If this new average

complies with the requirements and if not more than two individual results are lower than the required average and, of these, not more than one result is below 70% of the specified average value, the test unit may be accepted.

703 If unsatisfactory results are obtained from retests representative of a test unit, the sample product from which the tests were made shall be rejected. The remaining material in the test unit may be accepted provided that two further sample products are tested with satisfactory result.

704 When a test unit is rejected, the remaining sample products in the test unit may be resubmitted individually for test, and those which give satisfactory results may be accepted.

705 At the option of the manufacturer, rejected material may be resubmitted after heat treatment or re-heat treatment, or may be resubmitted as another grade and may then be accepted provided the required tests are satisfactory.

706 If any test piece fails because of faulty preparation, visible defects or (in the case of tensile test) because of fracturing outside the range permitted for the appropriate gauge length, the defective test piece may be disregarded and replaced by an additional test piece of the same type.

B 800 Visual and non-destructive examination

801 All finished material shall have a workmanlike finish and shall be free from internal and surface defects prejudicial to the use of the material for the intended application. Otherwise the material shall comply with the appropriate specific requirements of the subsequent rule chapters.

B 900 Correction of defects

901 When unacceptable defects are found, these shall be removed by appropriate methods and rectified in accordance with the applicable requirements of Ch.2. Shallow grooves or depression resulting from the removal of defects may, at the discretion of the surveyor, be accepted provided that they will cause no appreciable reduction in the strength of the material and that they are suitably smoothed and contoured.

902 Repair of defects by welding is only to be carried out when permitted by the appropriate specific requirements. Proposals to repair a defective material by welding shall be submitted to the surveyor for approval before this work is commenced. Such proposals shall include appropriate details of the extent and position of defects.

The manufacturer may be required to carry out welding procedure qualification tests to demonstrate that satisfactory mechanical properties can be obtained.

C. Identification and Certification

C 100 Identification of materials

101 The manufacturer shall adopt a system of identification which enable all finished material to be traced to the original cast. The surveyor shall be given full facilities for so tracing the materials when required.

102 Before acceptance, all materials which have been tested and inspected with satisfactory results shall be clearly marked by the manufacturer in at least one place with the Society's brand, as furnished by the surveyor, and the following particulars:

- a) Manufacturer's name or trade mark.
- b) Material grade.

c) Identification number, cast number or other marking which will enable the full history of the product to be traced.

d) If required by the purchaser, his order number or other identification mark.

103 Where a number of light materials are securely fastened together in bundles the manufacturer may brand only the top piece of each bundle, or alternatively, a firmly fastened durable label containing the brand may be attached to each bundle.

104 The marking is normally made by hard stamping, however, other methods may be accepted.

105 In the event of any material bearing the Society's brand failing to comply with the test requirements, the brand shall be unmistakably defaced by the manufacturer.

C 200 Certification of materials

201 Certification of materials will be based on compliance with all specified tests and inspection. Unless otherwise specially approved, certification shall take place at the manufacturer's works and the surveyor shall attend and witness testing and inspection in accordance with the appropriate requirements of Ch.2.

202 As an alternative to 201, certification may be based on a Manufacturing Survey Arrangement (MSA), subject to approval by the Society.

203 Normally, separate inspection certificates are issued for each grade of material and each product form. The inspection certificate shall include the following particulars:

- a) Purchaser's name and order number and if known the vessel identification for which the material is intended.
- b) Manufacturer's name.
- c) Description of the product, dimensions, weight etc.
- d) Identification of specification or grade of material.
- e) Identification of the cast and product.
- f) Ladle analysis for specified elements.
- g) Results of all specified inspections and mechanical tests.
- h) Condition of supply and where appropriate, details of heat treatment.

204 Where applicable, the manufacturer shall provide the surveyor with inspection certificates or shipping statements for all accepted materials giving at least the particulars detailed in 203. Before the inspection certificates or shipping statements are signed by the surveyor, the manufacturer is required to furnish him with a written declaration stating that the material has been made by an approved process and that it has been subjected to and has withstood satisfactorily the required tests. The following form of declaration will be accepted if stamped or printed on each inspection certificate or shipping statement with the name of the works and signed by an authorized representative of the manufacturer:

"We hereby certify that the material has been made by an approved process and has been satisfactorily tested in accordance with DNV Rules for Classification."

205 When a material is not produced at the works at which it is rolled or forged, a certificate shall be supplied by the maker stating the process of manufacture, the cast number and the chemical composition of ladle samples. The works at which the material was produced must be approved.

SECTION 2 TESTING PROCEDURES

A. General

A 100 Scope

101 This section specifies the requirements for testing machines, test pieces and testing procedures when testing ferrous and nonferrous metals.

102 Alternative test pieces, such as those complying with recognized national and international standards, may be accepted subject to approval by the Society. The same applies to the given testing procedures.

A 200 Testing machines

201 All tests shall be carried out by competent personnel on machines of approved type. The machines shall be maintained in satisfactory and accurate condition and shall be recalibrated at approximately annual intervals by a qualified organization. A record of such calibrations shall be kept available in the test laboratory.

A 300 Preparation of test pieces

301 The preparation of test pieces shall be done in such a manner that test pieces are not subjected to any significant cold straining or heating.

302 If samples are cut from material by flame cutting or shearing, a reasonable margin is required to enable sufficient material to be removed from the cut edges during final machining.

303 Where possible, test pieces from rolled materials shall retain their rolled surface on both sides.

B. Test Methods

B 100 Tensile testing at ambient temperature

101 Symbols related to tensile testing.

R_m = tensile strength
 R_e = yield stress (yield point)
 R_p = yield strength (proof stress)
 R_t = yield strength (proof stress), total elongation
 A = percentage elongation after fracture
 Z = percentage reduction of area.

102 Upper yield stress (R_{eH}) is the highest value of stress measured at the commencement of plastic deformation at yield; often this value is represented by a pronounced peak stress. The test shall be carried out with an elastic stress rate not exceeding 30 N/mm² per sec.

103 When no well-defined yield phenomena exists, either the yield strength at 0.2% non-proportional elongation ($R_{p0.2}$) or the yield strength at 0.5% total elongation ($R_{t0.5}$) shall be determined according to the applicable specification. The test shall be carried out with an elastic stress rate not exceeding 30 N/mm² per sec.

104 For determination of tensile strength (R_m) of ductile materials, the speed of the testing machine during the tensile test shall not exceed that corresponding to a strain-rate at maximum load of 40%/min. For brittle materials, like cast iron the elastic stress rate shall not exceed 2.5 N/mm² per sec.

105 The elongation generally means elongation determined on a proportional gauge length $5.65 \sqrt{S_0}$, or 5 d and has the designation A_5 .

If the material is a ferritic steel of low or medium strength and not cold worked, the elongation may also be measured on a non-proportional gauge length L_0 after agreement with the Society. In that case the required elongation A_0 is calculated from the following formula:

$$A_0 = 2A_5 \left(\frac{\sqrt{S_0}}{L_0} \right)^{0.40}$$

A_5 = the required elongation in % for test piece with gauge length $5.65 \sqrt{S_0}$.

S_0 = the cross-sectional area of the test piece in question.

L_0 = the gauge length in question.

The elongation value is valid if the fracture occurs at least the following distance from the end marks of the gauge length:

Round test piece: 1.25 d

Flat test piece: b + a

106 For the purpose of determining the different designations related to tensile testing, three different types of test pieces may be used: Round, flat and full cross-section test pieces, see Fig. 1.

The following symbols are used:

d = diameter
a = thickness
b = width
 L_0 = gauge length
 L_c = parallel test length
 S_0 = cross-section
R = transition radius
D = external tube diameter
t = plate thickness.

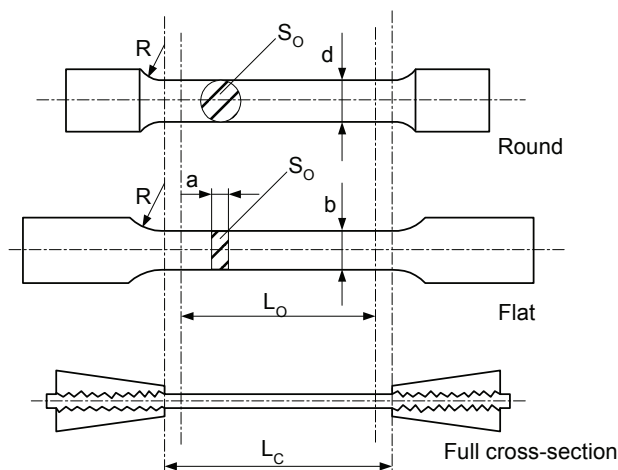


Fig. 1
Tensile test pieces.

107 The gauge length L_0 may be rounded off to the nearest 5 mm, provided that the difference between this length and L_0 is less than 10% of L_0 .

The parallel test length shall be parallel within acceptable tolerances. Tolerances according to ISO 82-1974 will be accepted.

108 For plates, wide flats and sections with thickness 3 mm or more, flat test pieces of full product thickness according to alternatives A and B shall generally be used. When the capacity of the available testing machine is insufficient to allow the use of test piece of full thickness, this may be reduced in thickness by machining one of the rolled surfaces. Alternatively, for materials over 40 mm thickness, proportional round test piece according to alternative C may be used. When round test piece is used it shall be positioned with its axis at one-quarter of the thickness from a rolled surface.

Alternative A, proportional flat test piece:

$$\begin{aligned} a &= t \\ b &= 25 \text{ mm} \\ L_o &= 5.65 \sqrt{S_0} \\ L_c &\cong L_o + 2 \sqrt{S_0} \\ R &= 25 \text{ mm} \end{aligned}$$

Alternative B, non-proportional flat test piece:

$$\begin{aligned} a &= t \\ b &= 25 \text{ mm} \\ L_o &= 200 \text{ mm} \\ L_c &\cong 225 \text{ mm} \\ R &= 25 \text{ mm} \end{aligned}$$

Alternative C, proportional round test piece:

$$\begin{aligned} d &= 10 \text{ mm to } 20 \text{ mm, preferably } 14 \text{ mm} \\ L_o &= 5d \\ L_c &\geq L_o + d/2 \\ R &= 10 \text{ mm} \end{aligned}$$

109 For sheet and strips with thickness t less than 3 mm, flat test piece with the following dimensions shall be used:

$$\begin{aligned} a &= t \\ b &= 12.5 \text{ mm} \\ L_o &= 50 \text{ mm} \\ L_c &\cong 75 \text{ mm} \\ R &= 25 \text{ mm} \end{aligned}$$

110 For forgings, bars, cast steel and nodular cast iron, proportional round test piece according to alternative C in 108 shall be used. The test piece for materials with a specified minimum elongation $A_5 \leq 10\%$ shall have transition radius $R \geq 1.5d$.

111 For propeller casting the diameter shall not be less than 14 mm.

112 For bars of small dimensions a full cross-section test piece may be used.

113 For grey cast iron the test piece shall have dimensions as stipulated in Fig. 2.

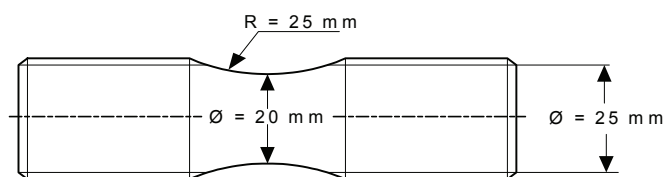


Fig. 2
Grey cast iron test piece.

114 For tubes, test piece according to alternative A or B below shall be used.

Alternative A:

Full cross-section test pieces with plugged ends.

$$L_o = 5.65 \sqrt{S_0}$$

$$L_c \cong L_o + D$$

L_c is the distance between the grips or the plugs, whichever is the smallest.

Alternative B:

Strip

$$\begin{aligned} a &= \text{wall thickness of the tube} \\ b &= 12 \text{ mm} \end{aligned}$$

$$L_o = 5.65 \sqrt{S_0}$$

$$L_c \cong L_o + 2b$$

B 200 Bend testing

201 Flat bend test piece as given in Fig. 3 shall be used. Edges on tension side to be rounded to a radius of 1 to 2 mm.

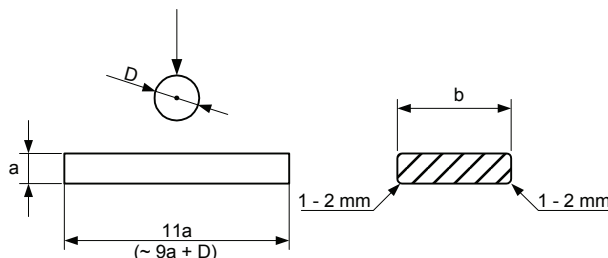


Fig. 3
Bend test piece.

202 For plates, structural sections and sheets, test piece with the following dimensions shall be used:

$$\begin{aligned} a &= \text{as rolled thickness } t \text{ of material} \\ b &= 30 \text{ mm} \end{aligned}$$

If the as rolled thickness t is greater than 25 mm, it may be reduced to 25 mm by machining on the compression side of the bend test piece.

203 For forgings, castings and semi-finished products, test piece with the following dimensions shall be used:

$$\begin{aligned} a &= 20 \text{ mm} \\ b &= 25 \text{ mm} \end{aligned}$$

B 300 Impact testing

301 Impact testing shall be carried out as Charpy V-notch test according to the specification in question. The average value of three test pieces shall be determined and meet the specified minimum requirement. One individual value may be below the specified value, provided that it is not less than 70% of that value.

302 The Charpy V-notch impact toughness is the absorbed energy, expressed in Joule (J), the symbol being KV.

303 The Charpy impact test machine shall be of a type acceptable to the Society having a gap of 40 mm, a striking velocity between 4.5 and 7 m/sec. and a striking energy of 290 ± 10 J for a standard test. The angle between the striking edges of the pendulum shall be 30° with the edge rounded to a radius 2 to 2.5 mm. (Pendulum according to ASTM E 23 will also be accepted.)

The point of impact of the hammer shall be in the centre line of the notch. The scale of the machine shall be calibrated to an accuracy of +0.5% of the machine's maximum striking energy. Impact test machines with a striking energy of less than 290 J are acceptable. In such cases, KV shall be supplemented with an index giving the striking energy.

For example, KV145 indicates that a striking energy of 145 J has been used.

304 Samples may be flame-cut but the notch shall not be closer to a flame-cut edge than 25 mm. The notch shall be made in a single cut by a special milling cutter. The cutter shall be kept sharp so that the shape of the notch is correct and cold working at the base is avoided as far as possible. The cutter shall be systematically checked at intervals not exceeding 100 test pieces.

305 Dimensions and tolerances for Charpy V-notch test pieces shall be as given in Table B1.

Table B1 Charpy V-notch test pieces.		
Dimensions	Nominal	Tolerances
Length	55 mm	0.60 mm
Width		
- standard test piece	10 mm	± 0.11 mm
- subsize test piece	7.5 mm	± 0.11 mm
- subsize test piece	5 mm	± 0.06 mm
Thickness	10 mm	± 0.06 mm
Angle of notch	45°	$\pm 2^\circ$
Depth below notch	8 mm	± 0.05 mm
Root radius	0.25mm	± 0.025 mm
Distance of notch from ends of test piece	27.5 mm	± 0.42 mm
Angle between plane of symmetry of notch and longitudinal axis of test piece	90°	$\pm 2^\circ$

306 Standard Charpy V-notch test pieces with width 10 mm shall be used, except when the thickness of the material does not permit this size. In such cases the largest obtainable of the subsize test pieces with width 7.5 mm or 5 mm shall be used. The required energy values are then reduced to 5/6 and 2/3 of tabulated values, respectively. Impact tests are generally not required when the material thickness is less than 6 mm.

307 The temperature of the test piece at the moment of breaking shall be the specified temperature within $\pm 2^\circ\text{C}$.

Test temperature shall be stated in the certificate.

Guidance note:

The required temperature tolerance is usually obtainable by immersing the test piece for at least 2 minutes in an agitated liquid bath having the specified test temperature, and have the test piece broken within 5 seconds after withdrawal from the bath.

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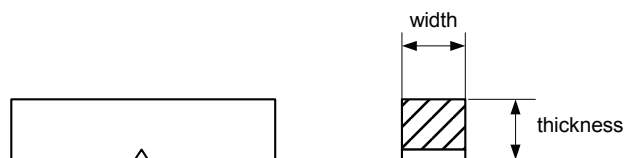


Fig. 4
Charpy V-notch test piece.

B 400 Drop-weight testing

401 For material with thickness t equal to or greater than 16 mm, drop-weight test pieces for the determination of nil ductility transition temperature shall comply with specifications given in ASTM E208, and have one of the following sizes:

No. 1: 25 by 90 by 360 mm

No. 2: 19 by 50 by 130 mm

No. 3: 16 by 50 by 130 mm.

For material thicknesses below 16 mm down to and including 12 mm, a test piece machined down to 12 mm thickness shall be used. For material thicknesses below 12 mm down to and including 10 mm, the thickness of the test piece shall be that of the material. Other dimensions and requirements for test piece with thickness below 16 mm shall be as for test piece no. 3 above, except that a stop distance of 2.3 mm shall be used.

402 The test pieces may be cut with their axes either transverse or longitudinal to the final rolling direction of the material, but the orientation shall be the same for all test pieces.

403 The sides of the test pieces shall be saw-cut or machined. The distance from a flame-cut surface shall be min. 25 mm.

The machining of the test piece to prescribed thickness shall be on the compression side only.

404 Two test pieces shall be tested at the prescribed test temperature. Both test pieces shall exhibit a non-break performance, i.e. the nil ductility transition temperature shall be below the test temperature.

405 The drop-weight test shall be carried out and evaluated according to ASTM E208.

B 500 Determination of grain size

501 Where the austenitic grain size is specified, it shall be determined according to methods described in recognized standards. At least one sample shall be taken from finished material from each ladle. For rolled products the sample is preferably to be taken from the thickest piece rolled. The grain size numbers refer to the ASTM scale described in ASTM E112.

B 600 Other testing

601 Testing not described in item 100—600 may be required for certain products. In such cases testing shall be carried out in accordance with procedures approved by the Society.

