This booklet has since the main revision (October 2008) been amended, most recently in October 2009. See the reference to "Amendments and Corrections" on the next page.
FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

DNV Offshore Codes consist of a three level hierarchy of documents:

— Offshore Service Specifications. Provide principles and procedures of DNV classification, certification, verification and consultancy services.

— Offshore Standards. Provide technical provisions and acceptance criteria for general use by the offshore industry as well as the technical basis for DNV offshore services.

— Recommended Practices. Provide proven technology and sound engineering practice as well as guidance for the higher level Offshore Service Specifications and Offshore Standards.

DNV Offshore Codes are offered within the following areas:

A) Qualification, Quality and Safety Methodology
B) Materials Technology
C) Structures
D) Systems
E) Special Facilities
F) Pipelines and Risers
G) Asset Operation
H) Marine Operations
J) Wind Turbines
O) Subsea Systems

Amendments and Corrections

Whenever amendments and corrections to the document are necessary, the electronic file will be updated and a new Adobe PDF file will be generated and made available from the Webshop (http://webshop.dnv.com/global/).
CHANGES

• General

Being class related, this document is published electronically only (as of October 2008) and a printed version is no longer available. The update scheme for this category of documents is different compared to the one relevant for other offshore documents (for which printed versions are available).

For an overview of all types of DNV offshore documents and their update status, see the “Amendments and Corrections” document located at: http://webshop.dnv.com/global/, under category “Offshore Codes”.

• Main changes as of October 2008:

This standard replaces Certification Note 2.6 (August 1995) - “Certification of Offshore Mooring Chain”.

The following is amended:

— specification for stud less chain is no longer tentative
— requirements to grade R4S and to R5 included
— mechanical tests of test coupons taken from full scale accessories
— scope of survey for chain and accessories
— “approval of manufacturer” programme has been removed.

See DNV Standard. for Certification No.2.9.

• Main changes as of October 2009

Since the previous edition (October 2008), this document has been amended, latest in October 2009. All changes have been incorporated. The changes are considered to be of editorial nature, thus no detailed description has been given.
CONTENTS

CH. 1 INTRODUCTION ................................................................. 7
Sec. 1 Introduction ...................................................................... 9
A. General .................................................................................. 9
A 100 Introduction ...................................................................... 9
A 200 Scope and application ....................................................... 9
B. Normative References ............................................................ 9
B 100 General ............................................................................ 9
B 200 Reference documents ...................................................... 9
C. Definitions ............................................................................. 9
C 100 Verbal forms .................................................................... 9
C 200 Terms ............................................................................ 10

CH. 2 TECHNICAL PROVISIONS ............................................. 11
Sec. 1 Materials .......................................................................... 13
A. General Requirements .......................................................... 13
A 100 Scope ............................................................................ 13
A 200 Manufacture .................................................................... 13
A 300 Chemical composition ....... 13
A 400 Heat treatment ............................................................. 13
A 500 Mechanical testing ....................................................... 13
A 600 Inspection ..................................................................... 14
A 700 Repair .......................................................................... 14
A 800 Identification ................................................................ 14
A 900 A 900 Records ......................................................... 14
B. Rolled Steel Bars ................................................................... 14
B 100 Scope ............................................................................ 14
B 200 Manufacture ................................................................... 14
B 300 Chemical composition ................................................. 14
B 400 Condition of supply and heat treatment ......................... 14
B 500 Mechanical testing ....................................................... 14
B 600 Hydrogen embrittlement testing ..................................... 14
B 700 Dimensions and tolerances ............................................ 15
B 800 Inspection ..................................................................... 15
B 900 Repair .......................................................................... 15
C. Steel Forgings ....................................................................... 15
C 100 Scope ............................................................................ 15
C 200 Manufacture ................................................................... 15
C 300 Chemical composition .................................................. 15
C 400 Heat treatment ............................................................. 15
C 500 Mechanical testing ....................................................... 15
C 600 Inspection ..................................................................... 15
C 700 Repair .......................................................................... 15
D. Steel Castings ................................................................------- 15
D 100 Scope ............................................................................ 15
D 200 Manufacture ................................................................... 15
D 300 Chemical composition .................................................. 15
D 400 Heat treatment ............................................................. 16
D 500 Mechanical testing ....................................................... 16
D 600 Inspection ..................................................................... 16
D 700 Repair .......................................................................... 16
E. Materials for Studs .................................................................. 16
E 100 Scope ............................................................................ 16

E 200 Chemical composition ...................................................... 16
Sec. 2 Mooring Chain Cables and Accessories ....................... 18
A. General Requirements .......................................................... 18
A 100 Scope ............................................................................ 18
A 200 Inspection ..................................................................... 18
A 300 Repair .......................................................................... 18
A 400 Identification ............................................................... 18
A 500 Records ........................................................................ 18
B. Mooring Chain ..................................................................... 18
B 100 Scope ............................................................................ 18
B 200 Design ......................................................................... 18
B 300 Manufacture .................................................................. 18
B 400 Welding of studs .......................................................... 18
B 500 Heat treatment ............................................................. 18
B 600 Proof load testing ......................................................... 19
B 700 Breaking load testing .................................................... 19
B 800 Mechanical testing ....................................................... 19
B 900 Dimensions and tolerances ............................................ 20
B 1000 Inspection ................................................................... 20
B 1100 Repair ......................................................................... 21
B 1200 Identification ............................................................. 21
C. Chain Accessories ............................................................... 21
C 100 Scope ............................................................................ 21
C 200 Design ......................................................................... 21
C 300 Proof load testing ......................................................... 21
C 400 Breaking load testing .................................................... 21
C 500 Mechanical testing ....................................................... 21
C 600 Dimensions and tolerances ............................................ 22
C 700 Inspection ..................................................................... 22
C 800 Repair .......................................................................... 22
C 900 Identification ............................................................... 22

CH. 3 CERTIFICATION AND CLASSIFICATION ..................... 25
Sec. 1 Certification and Classification - Requirements ................ 27
A. General .............................................................................. 27
A 100 Introduction .................................................................. 27
A 200 Certification and classification principles ......................... 27
A 300 Assumptions ................................................................. 27
A 400 Documentation requirements .......................................... 27
B. Certification and Classification Requirements ....................... 27
B 100 General ........................................................................ 27
B 200 Information to be supplied by the purchaser ....................... 27
B 300 Design verification ......................................................... 27
B 400 Approval of manufacturers ............................................ 27
B 500 Survey during manufacture ............................................ 27
B 600 Certification of materials ............................................... 27
B 700 Certification of mooring chain and accessories ............... 28

App. A Scope of Survey for Mooring Chain ......................... 29
App. B Scope of Survey for Mooring Chain Accessories .......... 30
CHAPTER 1

INTRODUCTION

CONTENTS

Sec. 1 Introduction ................................................................................................................................. 9
SECTION 1
INTRODUCTION

A. General

A 100 Introduction

101 This offshore standard contains criteria, technical requirements and guidance on materials, design, manufacture and testing of offshore mooring chain and accessories.

102 The standard has been written for general world-wide application. Governmental regulations may include requirements in excess of the provisions by this standard depending on the size, type, location and intended service of the offshore unit or installation.

103 The objectives of this standard are to:

— provide an internationally acceptable standard of safety by defining minimum requirements for offshore mooring chain and accessories
— serve as a contractual reference document between manufacturers and purchasers
— serve as a guideline for designers, suppliers, purchasers and regulators
— specify procedures and requirements for offshore mooring chain and accessories subject to DNV certification and classification.

104 This standard is divided into three main chapters:

— Chapter 1: Section 1 with general information, scope, definitions and references
— Chapter 2: Sections 1 and 2 with technical provisions for materials and chain cables
— Chapter 3: Section 1, Appendix A and B giving specific procedures and requirements applicable for certification and classification of materials and chain cables in accordance with this standard. Also, requirements to design verification are given.

A 200 Scope and application

201 The mooring chain and accessories specified herein are intended for position mooring applications such as: mooring of mobile offshore units, mooring of floating production units, mooring of offshore loading systems, and mooring of gravity base structures during fabrication.

202 Mooring chain links covered are common stud links and common stud less links, connecting common links (splice links), enlarged links and end links.

203 Mooring chain accessories covered are detachable connecting links (shackles), connecting plates (triplates etc), end (anchor) shackles, swivels and swivel shackles.

B. Normative References

B 100 General

101 The standards in Table B1 include provisions which, through reference in this text, constitute provisions of this offshore standard. Latest issue of the standards shall be used unless otherwise agreed.

102 Other recognised standards may be used provided it can be demonstrated that these meet or exceed the requirements of the standards in Table B1.

103 Any deviations, exceptions and modifications to the design codes and standards shall be documented and agreed between the supplier, purchaser and verifier, as applicable.

B 200 Reference documents

201 Applicable reference documents are given in Table B1.

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM E112</td>
<td>Test Methods for Determining Average Grain Size</td>
</tr>
<tr>
<td>ASTM E381</td>
<td>Method of Macro-etch Testing Steel Bars, Billets, Blooms and Forgings</td>
</tr>
<tr>
<td>ISO 4967</td>
<td>Steel – Determination of content of non-metallic inclusions – Micrographic method using standard diagrams</td>
</tr>
<tr>
<td>ASTM A255</td>
<td>Standard Test Methods for Determining Hardenability of Steel</td>
</tr>
<tr>
<td>DNV-OS-B101</td>
<td>Metallic materials</td>
</tr>
<tr>
<td>ISO 9712</td>
<td>Non-destructive testing Qualification and certification of personnel</td>
</tr>
<tr>
<td>EN 473</td>
<td>Non destructive testing - Qualification and certification of NDT personnel - General principles</td>
</tr>
<tr>
<td>SNT-TC-1A (ASNT)</td>
<td>Personnel Qualification and Certification in Non-destructive Testing</td>
</tr>
<tr>
<td>EN 10228-1/3</td>
<td>Non-destructive testing of steel forgings</td>
</tr>
<tr>
<td>ASTM A275</td>
<td>Standard Practice for Magnetic Particle Examination of Steel Forgings</td>
</tr>
<tr>
<td>ASTM A388</td>
<td>Standard Practice for Ultrasonic Examination of Heavy Steel Forgings</td>
</tr>
<tr>
<td>ASTM E709</td>
<td>Standard Guide for Magnetic Particle Examination</td>
</tr>
<tr>
<td>ASTM A609</td>
<td>Standard Practice for Castings, Carbon, Low-Alloy and Martensitic Stainless Steel, Ultrasonic Examination Thereof</td>
</tr>
<tr>
<td>ISO 1704</td>
<td>Ships and marine technology – Stud-link anchor chains</td>
</tr>
<tr>
<td>API Spec 2F</td>
<td>Specification for mooring chain</td>
</tr>
<tr>
<td>ASTM E587</td>
<td>Practice for Ultrasonic Angle-Beam Examination by the Contact Method</td>
</tr>
<tr>
<td>ASME IX</td>
<td>Welding and Brazing Qualifications</td>
</tr>
<tr>
<td>EN 287</td>
<td>Approval testing of welders - Fusion welding</td>
</tr>
<tr>
<td>EN 288</td>
<td>Specification and approval of welding procedures for metallic materials</td>
</tr>
<tr>
<td>ISO 9606</td>
<td>Approval testing of welders - Fusion welding</td>
</tr>
<tr>
<td>ASTM A488</td>
<td>Practice for Steel Castings, Welding, Qualifications of Procedures and Personnel</td>
</tr>
</tbody>
</table>

C. Definitions

C 100 Verbal forms

101 Shall: Indicates requirements strictly to be followed in order to conform to this standard and from which no deviation is permitted.

102 Should: Indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required. Other possibilities may be applied subject to agreement.

103 May: Verbal form used to indicate a course of action permissible within the limits of the standard.

104 Agreement, agreed or by agreement: Unless otherwise indicated, agreed in writing between manufacturer and purchaser.
C 200 Terms

201 **Purchaser:** The owner or another party acting on his behalf, who is responsible for procuring materials, components or services intended for the design, fabrication or modification of a unit or installation.

202 **Manufacturer:** The party who is contracted to be responsible for planning, execution and documentation of manufacturing.
CHAPTER 2

TECHNICAL PROVISIONS

CONTENTS

<table>
<thead>
<tr>
<th>Sec.</th>
<th>Materials</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sec. 1</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Sec. 2</td>
<td>Mooring Chain Cables and Accessories</td>
<td>18</td>
</tr>
</tbody>
</table>
A. General Requirements

A 100 Scope

101 Sub-section A specifies the general requirements for rolled steel bars, steel forgings and steel castings to be used in the manufacture of offshore mooring chain and accessories. Specific requirements are given in B to D. If the specific requirements differ from these general requirements, the specific requirements shall prevail. Separate requirements for materials for studs are given in E.

102 The steels concerned are classified by specified minimum ultimate tensile strength into five grades: R3, R3S, R4, R4S and R5.

A 200 Manufacture

201 The steels shall be manufactured by an electric or one of the basic oxygen processes or any other approved process involving secondary refining. Steel grades R4S and R5 shall be vacuum degassed.

202 The steels shall be killed and fine grain treated. The austenite grain size shall be 5 or finer in accordance with ASTM E112. The fine grain size requirement shall be deemed to be fulfilled if the steels contain Al, Nb, V or Ti, either singly or in any combination, as follows: When Al is used singly, the minimum total content shall be 0.020% or, alternatively, the Al to N ratio shall be minimum 2.1. When Al and Nb are used in combination, the minimum total Al content shall be 0.015% and the minimum Nb content shall be 0.010%. When Al and V are used in combination, the minimum total Al content shall be 0.015% and the minimum V content shall be 0.030%.

203 For steel grades R4S and R5, the following information shall be supplied by the manufacturer to the mooring chain or accessory manufacturer and the results included in the chain documentation:

a) Each heat shall be examined for non-metallic inclusions according to ISO 4967 or equivalent. The level of inclusions shall be quantified and assessed to be sure inclusion levels are acceptable for the final product.

b) A sample from each heat shall be macro etched according to ASTM E381 or equivalent to be sure there is no injurious segregation or porosity.

c) Jominy hardening ability data according to ASTM A255 or equivalent shall be supplied with each heat.

204 The manufacturer shall ensure that effective manufacture and process controls are implemented in production. Where deviation from the controls occurs and this could produce products of inferior quality, the manufacturer shall investigate to determine the cause and establish countermeasures to prevent its recurrence. Investigation reports to this effect shall be made available to the purchaser on request.

A 300 Chemical composition

301 Specifications for chemical composition shall be agreed between the manufacturer and purchaser. Steel grades R4, R4S and R5 shall contain a minimum of 0.20% molybdenum.

302 The chemical composition of each heat shall be determined on a sample taken preferably during the pouring of the heat and shall comply with the specified limits. When multiple heats are tapped into a common ladle, the ladle analysis shall apply.

303 The composition shall be determined after all alloying additions have been made and sufficient time allowed for such an addition to homogenize.

304 Elements designated as residual and impurity elements in the individual specifications shall not be intentionally added to the steels. The content of such elements shall be reported.

305 Adequate controls shall be in place to prevent accumulation of harmful elements such as tin, antimony and arsenic in the final product.

A 400 Heat treatment

401 Materials shall be heat treated for mechanical properties as specified in B to D. Heat treatment shall be carried out in a properly constructed furnace which is efficiently maintained and has adequate means for temperature control and is fitted with recording-type pyrometers. The furnace dimensions shall be such as to allow the whole furnace charge to be uniformly heated to the necessary temperature.

402 Sufficient thermocouples shall be connected to the furnace charge where it is composed of forged or cast components. Thermocouples should be connected by capacitor discharge welding.

403 Records shall identify the furnace used, furnace charge, date, temperature and time at temperature.

404 The manufacturer shall ensure that the specified heat treatment is adhered to. Where deviation from the specified heat treatment occurs, the manufacturer shall ensure that affected products are tested or submitted to reheat treatment and that an investigation is carried out according to A204.

A 500 Mechanical testing

501 Products shall be grouped in test units and sampled for mechanical testing as detailed in B to D. Test material from which test pieces are prepared shall be of equivalent cross section and be fully representative of the sample product and, where appropriate, shall not be cut, or partially cut from the sample product leaving a ligament, until heat treatment has been completed. Test material and test pieces shall not be separately heat treated in any way.

502 Test material and test pieces shall be marked to identify them with the products represented.

503 For each test unit, one tensile and three Charpy V-notch test pieces shall be taken. Rolled steel bars and steel forgings shall be tested in the longitudinal direction. The longitudinal axis of test pieces shall be located one-third of the radius or, in the case of non-cylindrical sections, one-sixth of the diagonal from the outer surface.

504 The preparation of test pieces and the procedures used for mechanical testing shall comply with the relevant requirements of DNV-OS-B101.

505 The materials shall comply with the mechanical properties specified in Table E1.

506 If the results from tensile testing do not meet the specified requirements, two further tensile tests may be made from the same sample. If both of these additional tests are satisfactory, the test unit may be accepted.

507 If the results from a set of three impact test pieces do not meet the specified 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.

508 Where forgings or castings and the associated test material are submitted to re-heat treatment, they may not be austenitised more than twice. All the tests previously per-
formed shall be repeated after re-heat treatment and the results must meet the specified requirements.

A 600 Inspection

601 Materials are subject to visual inspection, non-destructive testing (NDT) and measurements of dimensions as detailed in B to D. The manufacturers shall prepare written procedures for NDT. NDT personnel shall be qualified and certified according to ISO 9712, EN 473, SNT-TC-1A or equivalent. NDT operators shall be qualified to at least level I.

602 NDT shall be performed in accordance with the general practice of recognised standards, e.g.:

Magnetic particle testing (MT) of forgings:
— EN 10228-1, ASTM A275, using wet continuous magnetization technique

Ultrasonic testing (UT) of forgings:
— EN 10228-3, ASTM A388

Magnetic particle testing (MT) of castings:
— ASTM E709, using wet continuous magnetisation technique

Ultrasonic testing (UT) of castings:
— ASTM A609

603 MT of forged or cast accessories shall be carried out after proof load testing. Where a forging or casting is delivered in an intermediate condition for subsequent processing and final MT by the purchaser, the manufacturer should perform suitable intermediate inspections taking into consideration the quality level required in finished condition. In such cases the extent of testing and acceptance criteria shall be agreed between manufacturer and purchaser. See also C600, D600, and Sec.2 C.

604 UT of forgings or castings shall be carried out at an appropriate stage after the final heat treatment for mechanical properties, e.g. after proof load testing of finished accessories.

A 700 Repair

701 Surface defects may be removed by grinding as detailed in B to D. The resulting grooves shall have a bottom radius of approximately three times the depth and shall be blended into the surrounding surface to avoid any sharp contours. Complete elimination of the defective material shall be verified by suitable NDT.

702 Except as provided for steel castings, repair by welding is not permitted.

A 800 Identification

801 Each bar, forging, or casting shall be suitably identified with at least the following:

a) identification number, heat number or other marking that will enable the history of the item to be traced,

b) steel grade designation.

A 900 Records

901 The manufacturer shall maintain traceable records of the following and present them to the purchaser on request:

a) steelmaking process and chemical composition

b) heat treatment

c) mechanical testing
d) inspection
e) repair.

B. Rolled Steel Bars

B 100 Scope

101 These requirements are supplementary to A and apply to hot rolled steel bars to be used in the manufacture of offshore mooring chain and accessories.

B 200 Manufacture

201 Bars shall be made from ingots or continuous cast blooms or billets. Ingots shall be cast in chill moulds with the larger cross-section up, and with efficient feeder heads. Sufficient discard shall be made to ensure soundness in the finished bar. Surface and skin defects, which may be detrimental during the subsequent working and forming operations, shall be removed.

202 The rolling reduction ratio shall be at least 5:1. The rolling reduction ratio shall be calculated as the ratio average cross-sectional area of the cast material to cross-sectional area of the finished bar.

B 300 Chemical composition

301 The chemical composition shall comply with the agreed specification.

B 400 Condition of supply and heat treatment

401 Unless otherwise agreed, the bars shall be delivered in the as-rolled condition.

402 For mechanical testing and hydrogen embrittlement testing, bar material shall be tested in the condition of heat treatment used for the chain as advised by the chain manufacturer.

B 500 Mechanical testing

501 A test unit shall consist of bars of the same nominal diameter, made from the same heat of steel, and with a total mass not exceeding 50 tonnes.

502 Test material shall consist of a suitable length cut from one bar in each test unit. The test material shall be heat treated in full cross-section, see 402.

503 For each test unit, one tensile and three Charpy V-notch test pieces shall be taken. For Charpy V-notch impact testing, the notch shall be cut in a face of the test piece which was originally approximately perpendicular to the rolled surface.

504 The mechanical properties shall comply with the values given in Table E1.

B 600 Hydrogen embrittlement testing

601 For grade R3S, R4, R4S and R5, each heat of steel shall be tested for hydrogen embrittlement by slow strain rate tensile testing. Samples shall be taken from two bars representing the front end and tail end of the billet string in case of continuous casting, or two ingots in case of ingot casting.

602 Two tensile test pieces shall be taken from the central region of each bar. The test pieces shall have a diameter of 20 mm, or alternatively 14 mm. One test piece shall be tested within three hours after machining for a 20 mm diameter test piece, or 1.5 hours for a 14 mm diameter test piece. The other test piece shall be tested after baking at 250°C for four hours for a 20 mm diameter test piece, or two hours for a 14 mm diameter test piece. The test pieces shall be loaded at a strain rate not exceeding 0.0003 per second until fracture occurs.

603 As an alternative to testing within the time limits given in 602 the test pieces may be cooled to –60°C immediately after machining and kept at that temperature for a maximum period of five days before testing.

604 The reduction of area values shall be determined. The ratio Z1 to Z2, where Z1 is the value without baking and Z2 is the value after baking, shall not be less than 0.85. Alternatively, the ratio shall not be less than 0.80 provided Z1 is at least 50%.
If the results do not meet the specified requirements, the bar material may be subjected to a hydrogen degassing treatment. The embrittlement tests shall be repeated after degassing and the results must meet the specified requirements.

**B 700 Dimensions and tolerances**

**701** The tolerances on diameter and roundness shall be in accordance with Table E2. Measurements shall be made on at least 1% of the bars.

**B 800 Inspection**

**801** All bars supplied in a machined (peeled) condition shall be visually inspected. All bars supplied without machining shall be tested for longitudinal imperfections by magnetic or electrical methods in accordance with the general practice of recognised standards.

**802** All bar material shall be subjected to ultrasonic testing at an appropriate stage of manufacture.

**803** All bars shall be free from injurious pipe, cracks, seams, laps or other imperfections which, due to their nature, degree or extent, will interfere with the use of the bars.

**B 900 Repair**

**901** Defects may be removed by grinding to a depth of 1% of the nominal bar diameter.

### C. Steel Forgings

**C 100 Scope**

**101** These requirements are supplementary to A and apply to steel forgings to be used in the manufacture of chain accessories. Additional requirements for the finished accessories are given in Sec.2 C.

**C 200 Manufacture**

**201** Forgings shall be made from ingots or continuous cast blooms or billets. Ingots for forgings shall be cast in chill moulds with the larger cross-section up, and with efficient feeder heads. Adequate top and bottom discs shall be made to ensure freedom from piping and harmful segregations in the finished forgings. Surface and skin defects, which may be detrimental during the subsequent working and forming operations, shall be removed.

**202** The material shall be progressively hot worked by hammer or press, and shall be forged as close as practical to the finished shape and size.

**203** The reduction ratio shall be calculated with reference to the average cross-sectional area of the cast material. Where an ingot is initially upset, this reference area may be taken as the average cross-sectional area after this operation. The total reduction ratio shall be at least 3:1. For forgings made by upsetting, the length after upsetting is to be not more than one-third of the length before upsetting or, in the case of an initial forging reduction of at least 1.5:1, not more than one-half of the length before upsetting.

**204** Welding to forgings is not permitted. This includes the welding of brackets, bosses, or attachments.

**C 300 Chemical composition**

**301** The chemical composition shall comply with the agreed specification.

**C 400 Heat treatment**

**401** Forged accessories in grade R3 and R3S shall be supplied in the normalised, normalised and tempered, or quenched and tempered condition. Grade R4, R4S and R5 shall be supplied in the quenched and tempered condition. Quenched and tempered accessories with diameter over 120 mm shall receive an annealing or normalising heat treatment prior to quenching and tempering.

**402** For grade R4, R4S and R5, tempering temperatures shall not be less than 590°C and cooling after tempering shall be in water.

**403** Where forgings are to be quenched and tempered and cannot be hot worked close to shape, they shall be rough machined prior to being subjected to this treatment.

**404** All hot forming operations shall be conducted prior to the final heat treatment. If a forging is subsequently heated for further hot forming, the forging shall be re-heat treated.

**C 500 Mechanical testing**

**501** Forged accessories shall be mechanically tested as given in Sec.2 C.

**C 600 Inspection**

**601** All forgings shall be visually inspected on accessible surfaces. Where applicable, this is to include the inspection of internal surfaces and bores. The surfaces shall be adequately prepared for inspection. Black forgings shall be suitably descaled.

**602** Forgings shall be free from injurious pipe, cracks, seams, laps or other imperfections which, due to their nature, degree or extent, will interfere with the use of the forgings.

**603** All finished accessories are subject to magnetic particle testing, see A600 and Sec.2 C.

**604** Ultrasonic testing shall be carried out on all forgings after the final heat treatment when the surfaces have been brought to a condition suitable for UT. Both radial and axial scanning shall be used when appropriate for the shape and dimensions of the forging being tested. Unless otherwise agreed with the purchaser the entire volume of the forgings shall be tested.

**605** For calibration, reference blocks shall be made from steel that is similar in chemistry and processing history to the production forgings. The distance amplitude curve (DAC) shall be based on 3 mm flat bottom hole. No indications equal to or larger than the reference DAC are acceptable.

**C 700 Repair**

**701** Defects on non-machined surfaces may be removed by grinding to a depth of 5% of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces in order to investigate spurious indications. Welding and weld repairs are not permitted.

### D. Steel Castings

**D 100 Scope**

**101** These requirements are supplementary to A and apply to steel castings to be used in the manufacture of chain accessories. Additional requirements for the finished accessories are given in Sec.2 C.

**D 200 Manufacture**

**201** Castings shall be manufactured according to drawings showing the positions of gates, risers and chills (if used).

**202** Where flame cutting, scarfing or arc-air gouging to remove surplus metal is undertaken, the affected areas shall be either machined or ground smooth.

**D 300 Chemical composition**

**301** The chemical composition shall comply with the agreed specification.
D 400  Heat treatment

401  Cast accessories in grade R3 and R3S shall be supplied in the normalised, normalised and tempered, or quenched and tempered condition. Grade R4, R4S and R5 shall be supplied in the quenched and tempered condition. Quenched and tempered accessories with diameter over 120 mm shall receive an annealing or normalising heat treatment prior to quenching and tempering.

402  For grade R4, R4S and R5, tempering temperatures shall not be less than 590°C and cooling after tempering shall be in water.

D 500  Mechanical testing

501  Cast accessories shall be mechanically tested as given in Sec.2 C.

D 600  Inspection

601  All castings shall be visually inspected on accessible surfaces. Where applicable, this is to include the inspection of internal surfaces and bores. The surfaces shall be adequately prepared for inspection.

602  Castings shall be free from adhering sand, scale, cracks, hot tears or other imperfections which, due to their nature, degree or extent, will interfere with the use of the castings.

603  All finished accessories are subject to MT, see A600 and Sec.2 C.

604  Ultrasonic testing shall be carried out on all castings after the final heat treatment when the surfaces have been brought to a condition suitable for UT. Both radial and axial scanning shall be used when appropriate for the shape and dimensions of the casting being tested. Unless otherwise agreed with the purchaser the entire volume of the castings shall be tested.

605  For calibration, reference blocks shall be made from steel that is similar in chemistry and processing history to the production castings. The distance amplitude curve (DAC) shall be based on 3 mm flat bottom hole for testing to a depth of 25 mm below the surface and 6 mm flat bottom hole for testing the remaining volume. No indications equal to or larger than the reference DAC are accepted.

D 700  Repair

701  Defects on non-machined surfaces may be removed by grinding to a depth of 5% of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces in order to investigate spurious indications.

702  Where the repair entails removal of more than 5% of the diameter or thickness, the defective area shall be repaired by welding. The excavations shall be suitably shaped to allow good access for welding. The resulting grooves shall be subsequently ground smooth and complete elimination of the defective material shall be verified by NDT.

703  Weld repairs are classified as major or minor. A weld repair is considered major when the depth of the groove prepared for welding exceeds 25% of the diameter or 25 mm, whichever is smaller. All other weld repairs are considered minor.

704  Major weld repairs require the approval of the purchaser before the repair is commenced. Proposals for major repairs shall be accompanied by sketches or photographs showing the extent and positions of the repairs. A grain refining heat treatment shall be given to the whole casting prior to major repairs.

705  Minor weld repairs must be recorded on sketches or photographs showing the extent and positions of the repairs.

706  All weld repairs shall be done by qualified welders using qualified procedures. Welders shall be qualified according to EN 287, ISO 9606, ASME IX, ASTM A488 or equivalent. Procedures shall be qualified according to EN 288, ASME IX, ASTM A488 or equivalent with the following additional requirements: Charpy V-notch impact tests with notch locations in weld metal, fusion line and heat affected zone + 2 mm and + 5 mm from fusion line, respectively. Test results shall meet the requirements specified for the parent metal.

707  The welding consumables used shall be of a suitable composition giving a weld deposit with mechanical properties similar to those of the parent castings. Low hydrogen consumables shall be used. Welding consumables shall be stored and handled so as to maintain the hydrogen classification and in accordance with the consumable manufacturer’s recommendations.

708  When repair welding is done after the casting has been heat treated for mechanical properties, the repaired casting shall be given a furnace stress relieving or tempering heat treatment as detailed in the qualified procedure.

709  On completion of heat treatment the weld repairs and adjacent material shall be ground smooth. All weld repairs are subject to NDT as required by 600.

E. Materials for Studs

E 100  Scope

101  These requirements apply to forged or cast steel materials to be used in the manufacture of studs.

E 200  Chemical composition

201  The chemical composition shall be similar to that of the chain link or in compliance with a specification that provides for similar response to heat treatment.

202  The carbon content should not exceed 0.25% or the carbon equivalent (IIW) should not exceed 0.58% if the studs are to be welded in place.
### Table E1 Minimum mechanical properties for chain cable materials

<table>
<thead>
<tr>
<th>Steel grade</th>
<th>Yield stress ( R_e ) N/mm(^2)</th>
<th>Tensile strength ( R_m ) N/mm(^2)</th>
<th>Elongation ( A_5 ) %</th>
<th>Reduction of area ( Z ) %</th>
<th>Temperature (^1) °C</th>
<th>Charpy V-notch Average energy ( J )</th>
<th>Charpy V-notch Single energy ( J )</th>
</tr>
</thead>
<tbody>
<tr>
<td>R3</td>
<td>410</td>
<td>690</td>
<td>17</td>
<td>50 (^2)</td>
<td>0</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>R3S</td>
<td>490</td>
<td>770</td>
<td>15</td>
<td>50 (^2)</td>
<td>-20</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>R4</td>
<td>580</td>
<td>860</td>
<td>12</td>
<td>50 (^3)</td>
<td>-20</td>
<td>50</td>
<td>38</td>
</tr>
<tr>
<td>R4S</td>
<td>700</td>
<td>960</td>
<td>12</td>
<td>50 (^3)</td>
<td>-20</td>
<td>56</td>
<td>42</td>
</tr>
<tr>
<td>R5</td>
<td>760</td>
<td>1000</td>
<td>12</td>
<td>50 (^3)</td>
<td>-20</td>
<td>58</td>
<td>44</td>
</tr>
</tbody>
</table>

\(^1\) For grade R3 and R3S, testing may be carried out at either 0°C or -20°C.
\(^2\) For cast accessories, the minimum value shall be 40%.
\(^3\) For cast accessories, the minimum value shall be 35%.

### Table E2 Dimensional tolerances for rolled bars

<table>
<thead>
<tr>
<th>Nominal bar diameter ( \text{mm} )</th>
<th>Tolerance on diameter ( \text{mm} )</th>
<th>Tolerance on roundness ( d_{\text{max}} - d_{\text{min}} ) ( \text{mm} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>51 – 80</td>
<td>-0 +2.0</td>
<td>1.50</td>
</tr>
<tr>
<td>81 – 100</td>
<td>-0 +2.6</td>
<td>1.95</td>
</tr>
<tr>
<td>101 – 120</td>
<td>-0 +3.0</td>
<td>2.25</td>
</tr>
<tr>
<td>121 – 160</td>
<td>-0 +4.0</td>
<td>3.00</td>
</tr>
<tr>
<td>161 – 210</td>
<td>-0 +5.0</td>
<td>4.00</td>
</tr>
</tbody>
</table>
A. General Requirements

A 100 Scope
101 Sub-section A specifies the general requirements for mooring chain and accessories in grade R3, R3S, R4, R4S and R5. The materials used shall comply with the requirements in Sec. I.

A 200 Inspection
201 Chain and accessories are subject to visual inspection, non-destructive testing (NDT) and measurements of dimensions as detailed in B and C. The manufacturer shall prepare written procedures for NDT. NDT personnel shall be qualified and certified according to ISO 9712, EN 473, SNT-TC-1A or equivalent. NDT operators shall be qualified to at least level I.

A 300 Repair
301 Defects may be removed by grinding as specified in B and C. The resulting grooves shall have a bottom radius of approximately three times the depth and shall be blended into the surrounding surface to avoid any sharp contours. Complete elimination of the defective material shall be verified by suitable NDT.

A 400 Identification
401 Identification marks shall be legible and, as far as possible, permanent throughout the expected service life of the chains and accessories.

A 500 Records
501 The manufacturer shall maintain traceable records of the following and present them to the purchaser on request:
   a) materials, as detailed in Sec. I
   b) manufacture and heat treatment of chain and accessories
   c) proof load testing
   d) breaking load testing
   e) mechanical testing
   f) measurement of dimensions
   g) inspection
   h) repair.

502 The manufacturer is responsible for storing, in a safe and retrievable manner, all records for at least ten years.

B. Mooring Chain

B 100 Scope
101 These requirements are supplementary to A and apply to stud link and stud less mooring chain.

B 200 Design
201 For stud link mooring chain, the form and proportion of links shall be in accordance with ISO 1704. The stud shall be designed to give an impression radius not less than 4 mm and a depth of impression between 2 and 6% of the nominal chain diameter.

202 For stud less mooring chain, the nominal outside length shall be six times nominal diameter and the nominal outside width shall be 3.35 times nominal diameter unless otherwise agreed between manufacturer and purchaser. Links having different proportions must be able to accommodate adjacent links and connectors.

B 300 Manufacture
301 Mooring chains shall be manufactured in continuous lengths by flash butt welding.

302 Blanks for links shall be heated by electric resistance in a furnace. For electric resistance heating, the heating phase shall be controlled by an optical heat sensor. For furnace heating, the temperature shall be controlled and continuously recorded using thermocouples in close proximity to the bars. In both cases, the controls shall be checked at least once every eight hours and records made.

303 The following welding parameters shall be controlled during welding of each link:
   — platen motion
   — current as a function of time
   — hydraulic upset pressure.

The controls shall be checked at least every four hours and records made.

304 Excess flash weld material shall be removed. A clean fusion zone, including the zone where the stud is pressed into the link, shall be maintained. The trimming knives used for flash removal shall be systematically and periodically controlled in order to monitor the degree of deterioration. The knives shall be changed out at regular intervals as specified in the applicable work procedure.

B 400 Welding of studs
401 Studs may be welded for grade R3 and R3S chains. Welding shall be completed before the chain is heat treated. Welding of studs in grade R4, R4S and R5 chain is not permitted.

402 Stud welds shall be made by qualified operators or welders using qualified procedures and low-hydrogen processes or consumables. The stud ends must be a good fit inside the link and the weld shall be confined to the stud end opposite the flash butt weld. The full periphery of the stud end shall be welded. The size of the stud welds shall be according to API Specification 2F.

B 500 Heat treatment
501 Mooring chains shall be heat treated in continuous furnaces. Batch heat treatment is not permitted except for short lengths of chain such as adaptor pieces and chafe chains.

502 Grade R3 and R3S shall be supplied in the normalised, normalised and tempered, or quenched and tempered condition. Grade R4, R4S and R5 shall be supplied in the quenched and tempered condition. Tempering temperatures shall not be less than 570°C and cooling after tempering shall be in water.

503 The temperature uniformity of furnaces shall be checked at least annually during normal furnace operations and whenever production changes to a chain diameter that differs by more than 15% from the previous check. Furnaces shall be checked by a monitoring link similar to the production links and instrumented with two thermocouples; one attached to the surface of the straight portion and one imbedded in the centre of the straight portion. The strip chart recording shall indicate that the surface temperature never exceeds the maximum specified after the core has reached the minimum temperature specified. The combinations of temperatures and soaking times
shall be sufficient to accomplish the heat treatment objectives.

504 Furnaces shall be fully stabilised before the production chain enters. The leading and trailing ends of the production chain shall be provided with sufficient scrap chain to ensure uniform conditions during heat treatment.

505 Furnace zone temperatures, chain speed and quenching water temperature shall be controlled and continuously recorded. The records shall identify each chain length treated.

506 To further control heat treatment of grade R4, R4S and R5 chains exceeding 700 meters length, hardness surveys along the length shall be made every 100 meters provided every heat of steel is represented. Hardness tests shall also be made on each link subjected to mechanical tests. Indentations shall be made at the same place on each link, preferably on the straight portion, after suitable surface preparation. A minimum of five indentations should be made on each link to obtain an average hardness value. Each link not tested for mechanical properties shall have an average value within 15% of the link(s) from the same heat that has been satisfactorily tested for mechanical properties. If the results do not comply, the link with the largest deviation shall be cut out and subjected to mechanical testing. No further action is required if the mechanical properties are met. Hardness surveys shall be recorded.

B 600 Proof load testing

601 Each length of chain shall be proof load tested in the condition of supply and shall withstand the proof load specified in Table C1 without fracture. The applied load may exceed the specified minimum load by up to 15% in order to fasten studs and or to adjust dimensions.

602 In the event of a test failure, two additional breaking load tests shall be made; one from each side of the failed link. The length shall be considered acceptable if both additional tests meet the requirement and if it has been determined by examination that the probable cause of failure is not present in any of the remaining links.

B 700 Breaking load testing

701 Samples of the chain shall be subjected to breaking load testing in the condition of supply and withstand the proof load specified in Table C1. If the re-test fails, the sampling length represented is rejected.

702 A sample consists of at least three links, except that for chain with nominal diameter 100 mm or above, the sample may consist of one link provided that terminations of similar size and geometry providing a good fit are used.

703 Sample links for testing shall be made as part of the chain cable. They may be removed prior to heat treatment provided that:
- each sample is properly identified with the chain represented, and
- each sample is securely attached to the chain and treated with the chain represented.

Where multiple samples are needed to represent a continuous length, these shall be attached to both ends of the chain. Where sub-lengths of chain are temporarily joined for continuous passage through the furnace, samples shall also be attached in-between if the number permits.

704 Each sample shall withstand the breaking load specified in Table C1. It shall be considered acceptable if the samples show no sign of fracture after application of the minimum specified load for 30 seconds. If the capacity of the manufacturer’s testing machine is insufficient, the testing shall be carried out at another place recognised by the purchaser.

705 In the event of a test failure, two further breaking load tests shall be made. The sampling length shall be considered acceptable if both additional tests meet the requirement and if it has been determined by examination that the probable cause of failure is not present in any of the remaining links.

B 800 Mechanical testing

801 Samples of the chain shall be subjected to mechanical testing after proof load testing, except as provided in 802. The frequency of sampling shall be in accordance with Table C2 provided that every heat of steel is represented. End links and enlarged links heat treated with the chain need not be tested provided that common links from the same heat of steel are tested.

802 Prior proof load testing of sample links may be omitted provided it is documented that the properties, when determined after proof load testing, generally equal or exceed those of links without prior proof load testing. Test results from at least three heats of a particular grade shall be provided for this purpose.

803 A sample consists of at least one link. Sample links for testing shall be made as part of the chain cable. They may be removed prior to heat treatment provided that:
- each sample is properly identified with the chain represented, and
- each sample is securely attached to and heat treated with the chain represented.

Where multiple samples are needed to represent a continuous length, these shall be attached to both ends of the chain. Where sub-lengths of chain are temporarily joined for continuous passage through the furnace, samples shall also be attached in-between if the number permits.

804 One tensile and nine Charpy V-notch test pieces shall be taken from each sample, see Figure 1. The tensile test piece and three impact test pieces shall be taken from the side of the link opposite the flash weld. Three impact test pieces shall be taken across the flash weld with the notch centred in the middle. The position of the weld shall be accurately identified by etching with a suitable reagent before cutting the notches. Three impact test pieces shall be taken from the outer bend region, except as provided in 805. The longitudinal axis of the test pieces shall be one third radius below the surface.

805 The frequency of impact testing at the bend may be reduced subject to agreement between the manufacturer and purchaser. In such cases it shall be documented that the requirements are consistently achieved. Test results from at least five heats of a particular grade shall be provided for this purpose.

806 The preparation of test pieces and the procedures used for mechanical testing shall comply with the relevant requirements of DNV-OS-B101. The results shall comply with the mechanical properties specified in Table C3.

807 If the tensile test fails, two further test pieces selected from the same sample shall be tested. If either of the re-tests fails, the sampling length represented is rejected.

808 If the impact test fails, three further test pieces selected from the same sample shall be tested. The values shall be added to those previously obtained to form a new average. This average shall comply with the requirements. No more than two individual results shall be lower than the specified minimum average and no more than one individual result shall be below the specified minimum single value. If the re-test fails, the sampling length represented is rejected.

809 Rejected lengths may be submitted to re-heat treatment after agreement between manufacturer and purchaser. In such cases the tests previously performed shall be repeated and the results must meet the requirements.
The stud position and alignment shall be measured. The outside length and width shall be measured. Tolerances shall not exceed ±2.5%.

The diameter shall be measured at the crown. The average diameter based on two perpendicular measurements must have no negative tolerance and the plus tolerance shall not exceed 5% of nominal diameter. As a result of being bent around the anvil, however, a particular diameter may be smaller than the nominal:

- for nominal diameter up to 84 mm: - 2 mm
- for nominal diameter 85 through 122 mm: - 3 mm
- for nominal diameter 123 through 152 mm: - 4 mm
- for nominal diameter 153 through 184 mm: - 6 mm
- for nominal diameter 185 through 210 mm: - 7.5 mm

The largest diameter at the flash weld area shall be checked. The plus tolerance shall not exceed 15% of nominal chain diameter. As a result of being bent around the anvil, however, a particular diameter may be smaller than the nominal:

- for nominal diameter up to 84 mm: - 2 mm
- for nominal diameter 85 through 122 mm: - 3 mm
- for nominal diameter 123 through 152 mm: - 4 mm
- for nominal diameter 153 through 184 mm: - 6 mm
- for nominal diameter 185 through 210 mm: - 7.5 mm

The diameter shall be measured at the flash weld. The average diameter based on two perpendicular measurements must have no negative tolerance and the plus tolerance shall not exceed 5% of nominal diameter. As a result of being bent around the anvil, however, a particular diameter may be smaller than the nominal.

The stud position and alignment shall be measured. The stud shall be located in the link centrally, and at right angles to the sides of the link. The following tolerances are acceptable provided that the stud fits snugly and its ends lie flush against the inside of the link:

- maximum off-centre distance shall be 10% of the nominal chain diameter
- maximum angular misalignment shall be four degrees.

If one or two links fail to meet tolerance requirements, measurements of the particular dimension shall be made on 20 more links on each side of the affected links. If a third link fails to meet tolerance requirements, measurements of the particular dimension shall be made on all links. Links that fail to meet the requirements shall be rejected, unless otherwise agreed with the purchaser.

B 1000 Inspection

1001 After proof load testing, all links shall be visually inspected and non-destructive tested. Prior to inspection the surfaces shall be cleaned by shot or sand blasting.

1002 All accessible surfaces, including the outer bends, shall be visually inspected. Links shall be free from burns, rough edges, cracks, dents, cuts, distinct trimming marks, and other injurious imperfections. Studs shall be securely fastened; no axial or lateral movement is permitted.

1003 The flash butt welds and the areas gripped by the clamping dies shall be magnetic particle tested (MT). Additionally, for chain with nominal diameter 132 mm or above, 10% of the links distributed over the length shall be tested on all accessible surfaces. Testing shall be performed in accordance with ASTM E709 or another recognised standard using wet continuous magnetisation technique. Links shall be free from:

- relevant linear indications exceeding 1.6 mm in transverse direction
- relevant linear indications exceeding 3.2 mm in longitudinal direction
- relevant non-linear indications exceeding 4.8 mm.

1004 The flash butt welds shall be ultrasonic tested (UT) in accordance with ASTM E587 or another recognised standard using single probe, angle-beam shear waves in the range from 45 to 70°.

Guidance note:

It should be recognised that the single probe technique has limitations as far as testing of the central region is concerned and that flash weld imperfections such as flat spots may have poor reflectivity. However, the central region would normally not contain the typical imperfections that can occur in flash butt welds. Where it is deemed necessary, detectability of imperfections can be improved by using a tandem technique.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

1005 UT equipment shall be calibrated using IIW blocks. The search unit shall be checked for beam exit point and angle of reflection at least once per working shift or 8 hours, whichever comes first.

1006 UT reference blocks shall be made from a chain link that is similar in diameter, surface condition, chemistry, and processing history to the production links. The block shall contain two surface notch reflectors in the plane of the weld oriented 180° apart; one located on the inner surface adjacent to the stud, and one located on the outer surface. The notch shall be maximum 3 mm wide and cut to a depth 4% of nominal diameter or 5 mm, whichever is smaller. The notch shall be cut circular with radius 15 mm. With the search unit positioned, the instrument is calibrated to obtain indication amplitude from both reflectors of approximately 75% of full screen height. The procedure shall be repeated from the other side of the weld.

1007 UT of production links shall be performed by scanning...
along the circumference from both sides of the weld with the amplitude calibration increased by 6 dB. Indications equal to or larger in amplitude to that of the reference notch, when properly corrected for distance, are not accepted.

**1008** Stud welds, if used, shall be visually inspected. The toes of the fillets shall have a smooth transition to the link with no undercuts exceeding 1.0 mm. Additionally, at least 10% of the stud welds distributed through the length shall be liquid penetrant or magnetic particle tested. Cracks, lack of fusion or gross porosity are not accepted. If defects are found, testing shall be extended to all stud welds in that length.

**B 1100 Repair**

**1101** Defects may be removed by grinding to a depth of 5% of the nominal diameter.

**1102** Rejected links shall be cut out and replaced by connecting common links (splice links) or detachable joining shackles.

**1103** Splice links to connect lengths of heat treated chain or to replace cut out links without the necessity for re-heat treatment of the whole length shall be made in accordance with a procedure approved by the purchaser. The manufacture and heat treatment of splice links shall not affect the properties of the adjoining links. The temperature reached by adjoining links shall not exceed 300°C.

**1104** The use of splice links is restricted to three links, on average, in each 100 m of chain. Each splice link included in a chain shall be proof load tested, measured, inspected, and identified as detailed in 600, 900, 1000, and 1200.

**1105** A second identical splice link shall be made for mechanical testing as detailed in 800. Where a number of splice links are included and these are made in series, the link for mechanical testing may represent five splice links from the same heat of steel.

**1106** Detachable joining shackles to connect lengths of heat treated chain or to replace cut out links shall be in accordance with C. The use of these is subject to the approval of the purchaser in terms of the number and type permitted.

**B 1200 Identification**

**1201** Each length of chain shall be identified with at least the following:
- identification number or other marking that will enable the history of the length to be traced
- chain grade designation
- connecting common links, if used, shall have unique identification numbers.

**1202** The chain shall be marked at the following places:
- at each end
- at intervals not exceeding 100 m
- on connecting common links
- on links next to shackles or connecting common links.

**1203** The identification marks shall be placed on the studs or, in the case of stud less links, on the outside of the link opposite the flash weld. Marking by welding is not permitted on stud less links.

**C. Chain Accessories**

**C 100 Scope**

**101** These requirements are supplementary to A and apply to chain accessories.

**102** Where the manufacture of materials and accessories, heat treatments, machining, testing and inspections involve several parties, the purchaser should establish by contract agreement, at the time of ordering, the responsibility of the various parties for meeting the requirements.

**C 200 Design**

**201** Accessories shall be manufactured in accordance with ISO 1704 or purchaser-approved drawings showing the finished dimensions and the surfaces that will be subjected to significant loading. Accessories of unconventional design shall have their drawings accompanied by calculations or design reports.

**202** Detailed design of Kenter shackles shall be according to API Spec 2F. Machining of Kenter shackles shall result in fillet radius minimum 3% of nominal diameter.

**C 300 Proof load testing**

**301** All accessories shall be proof load tested in the condition of supply and shall withstand without fracture the proof load prescribed in Table C1 for the stud link chain grade and size for which they are intended.

**302** In the event of a test failure, the accessory shall be rejected. Testing of the remaining accessories shall be considered acceptable if they meet the requirement and if it has been determined by examination that the probable cause of failure is not present in any of the remaining accessories.

**C 400 Breaking load testing**

**401** At least one accessory out of every test unit shall be breaking load tested in the condition of supply and shall withstand without fracture the breaking load prescribed in Table C1 for the chain grade and size for which they are intended. It shall be considered acceptable if the samples show no sign of fracture after application of the specified minimum load for 30 seconds.

**402** A test unit shall consist of up to 25 accessories of the same type, grade and size, made from the same heat of steel, and heat treated in the same furnace charge.

**403** For individually produced accessories or less than five produced accessories, alternative testing may be agreed between the manufacturer and purchaser.

**404** Except as provided in 405, accessories that have been breaking load tested shall be discarded and not used as part of an outfit.

**405** Accessories that have been breaking load tested may be used as part of an outfit provided that:
- the accessories are of increased dimensions or alternatively a material with higher strength characteristics is used, and
- it is verified by procedure test that such accessories are so designed that the breaking strength is not less than 1.4 times the breaking load of the chain cable for which they are intended.

**406** In the event of a test failure, two further breaking load tests shall be made. The test unit shall be considered acceptable if both additional tests meet the requirement and if it has been determined by examination that the probable cause of failure is not present in any of the remaining accessories.

**C 500 Mechanical testing**

**501** At least one accessory out of every test unit shall be tensile and impact tested in the condition of supply. Except as provided in 503, test pieces shall be taken from proof load tested or breaking load tested full size accessories. For each test unit, one tensile and three Charpy-V-notch test pieces shall be taken.

**502** A test unit shall consist of up to 25 accessories of the same type, grade and size, made from the same heat of steel, and heat treated in the same furnace charge.
503 For individually produced accessories or less than five produced accessories, alternative to testing full size accessories may be agreed between the manufacturer and purchaser provided that:

— the alternative testing is described in a written procedure, and
— the separately forged coupon have a cross-section and a reduction ratio similar to that of the accessories represented, and
— it is verified by procedure test that coupon properties are representative of accessory properties.

C 600 Dimensions and tolerances

601 After proof load testing, at least one accessory out of every test unit shall be checked for dimensions. Where applicable, the measurements shall include detachable component parts.

602 The diameter must have no negative tolerance. Unless otherwise specified by the purchaser, the plus tolerance on diameter shall not exceed 5% and tolerances on other dimensions shall not exceed plus or minus 2.5%.

603 If an accessory fails to meet the tolerance requirements or if Kenter shackles or similar designs are loose upon reassembly, it shall be rejected and all remaining accessories in the test unit shall be measured.

C 700 Inspection

701 After proof load testing, all accessories shall be visually inspected and non-destructive tested. Prior to inspection the non-machined surfaces shall be cleaned by shot or sand blasting. Where applicable, the accessories shall be dismantled for inspection of internal surfaces.

702 All accessible surfaces shall be visually inspected and be free from burrs, rough edges, cracks, dents, cuts, and other injurious imperfections.

703 All machined surfaces, fillets, abrupt changes in section, and surfaces that will be subjected to significant loading, as indicated on drawings, shall be magnetic particle tested (MT). Testing shall be performed in accordance with standards referenced in Sec.1 A600. Surfaces shall be free from:

— relevant linear indications exceeding 1.6 mm in transverse direction
— relevant linear indications exceeding 3.2 mm in longitudinal direction
— relevant non-linear indications exceeding 4.8 mm.

704 Requirements for ultrasonic testing are given in Sec.1 C600 (forgings) and D600 (castings).

C 800 Repair

801 Defects on non-machined surfaces may be removed by grinding to a depth of 5% of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces in order to investigate spurious indications.

C 900 Identification

901 Each accessory shall be identified in a low stress area with at least the following:

— identification number or other marking that will enable the history of the accessory to be traced
— chain grade designation.

902 Each detachable component part shall be marked with an identifying number to avoid mix-up of parts.

903 Accessories that have been breaking load tested and are used as part of an outfit, as permitted in C400, shall be marked with the grade of chain for which they are intended.

Table C1 Formulas for proof and breaking test loads, weight, and five link length

<table>
<thead>
<tr>
<th>Grade R3</th>
<th>Grade R3S</th>
<th>Grade R4</th>
<th>Grade R4S</th>
<th>Grade R5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proof load, stud link (kN)</td>
<td>0.0156d²</td>
<td>0.0180d²</td>
<td>0.0216d²</td>
<td>0.0240d²</td>
</tr>
<tr>
<td></td>
<td>(44-0.08d)</td>
<td>(44-0.08d)</td>
<td>(44-0.08d)</td>
<td>(44-0.08d)</td>
</tr>
<tr>
<td>Proof load, stud less (kN)</td>
<td>0.0156d²</td>
<td>0.0174d²</td>
<td>0.0192d²</td>
<td>0.0213d²</td>
</tr>
<tr>
<td></td>
<td>(44-0.08d)</td>
<td>(44-0.08d)</td>
<td>(44-0.08d)</td>
<td>(44-0.08d)</td>
</tr>
<tr>
<td>Breaking load (kN)</td>
<td>0.0223d²</td>
<td>0.0249d²</td>
<td>0.0274d²</td>
<td>0.0304d²</td>
</tr>
<tr>
<td></td>
<td>(44-0.08d)</td>
<td>(44-0.08d)</td>
<td>(44-0.08d)</td>
<td>(44-0.08d)</td>
</tr>
<tr>
<td>Weight, stud link (kg/m)</td>
<td>0.0219d²</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(44-0.08d)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Five link length (mm)</td>
<td>Minimum 22d and maximum 22.55d</td>
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<tr>
<td>d is the chain nominal diameter</td>
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Table C2 Frequency of breaking load and mechanical tests

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<th>Nominal chain diameter (mm)</th>
<th>Maximum sampling interval (m)</th>
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<td>74 - 85</td>
<td>152</td>
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<td>86 - 98</td>
<td>175</td>
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<td>150 - 162</td>
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<td>163 - 175</td>
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<td>187 - 199</td>
<td>370</td>
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<td>200 - 210</td>
<td>395</td>
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Table C1 Formulas for proof and breaking test loads, weight, and five link length

Table C2 Frequency of breaking load and mechanical tests
### Table C3 Minimum mechanical properties for chain cables

<table>
<thead>
<tr>
<th>Grade</th>
<th>Yield stress $R_e$ N/mm²</th>
<th>Tensile strength $R_m$ N/mm²</th>
<th>Elongation $A_5$ %</th>
<th>Reduction of area $Z$ %</th>
<th>Temperature ¹) °C</th>
<th>Charpy V-notch Base</th>
<th>Charpy V-notch Weld</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Average energy J</td>
<td>Single energy J</td>
<td>Average energy J</td>
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<tr>
<td>R3</td>
<td>410</td>
<td>690</td>
<td>17</td>
<td>50 ²)</td>
<td>0</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-20</td>
<td>40</td>
<td>30</td>
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<tr>
<td>R3S</td>
<td>490</td>
<td>770</td>
<td>15</td>
<td>50 ²)</td>
<td>0</td>
<td>65</td>
<td>49</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-20</td>
<td>45</td>
<td>34</td>
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<tr>
<td>R4</td>
<td>580</td>
<td>860</td>
<td>12</td>
<td>50 ³)</td>
<td>-20</td>
<td>50</td>
<td>38</td>
</tr>
<tr>
<td>R4S</td>
<td>700</td>
<td>960</td>
<td>12</td>
<td>50 ³)</td>
<td>-20</td>
<td>56</td>
<td>42</td>
</tr>
<tr>
<td>R5</td>
<td>760</td>
<td>1000</td>
<td>12</td>
<td>50 ³)</td>
<td>-20</td>
<td>58</td>
<td>44</td>
</tr>
</tbody>
</table>

¹) For grade R3 and R3S, testing may be carried out at either 0°C or -20°C.
²) For cast accessories, the minimum value shall be 40%.
³) For cast accessories, the minimum value shall be 35%.
CHAPTER 3

CERTIFICATION AND CLASSIFICATION

CONTENTS

<table>
<thead>
<tr>
<th>Sec.</th>
<th>Certification and Classification - Requirements</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>App. A</td>
<td>Scope of Survey for Mooring Chain</td>
<td>29</td>
</tr>
<tr>
<td>App. B</td>
<td>Scope of Survey for Mooring Chain Accessories</td>
<td>30</td>
</tr>
</tbody>
</table>
SECTION 1
CERTIFICATION AND CLASSIFICATION - REQUIREMENTS

A. General

A 100 Introduction

101 As well as representing DNV's recommendations on safe engineering practice for general use by the offshore industry, the offshore standards also provide the technical basis for DNV classification, certification and verification services.

102 A complete description of principles, procedures, applicable class notations and technical basis for offshore classification is given by the DNV offshore service specifications for classification, see Table A1.

<table>
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<th>Table A1 DNV Offshore Service Specifications</th>
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<tr>
<td>DNV-OSS-101</td>
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<tr>
<td>DNV-OSS-102</td>
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</table>

A 200 Certification and classification principles

201 Mooring chain and accessories will be certified or classified based on the following main activities:

— design verification
— approval of manufacturers
— survey during manufacture.

A 300 Assumptions

301 Any deviations, exceptions and modifications to the design codes and standards given as recognised reference codes shall be documented and approved by DNV.

302 Aspects of the design and construction provisions of this standard which are stated to be specially considered, agreed upon, or may be accepted are subject to DNV approval when the standard is used for classification purposes.

303 DNV may accept alternative solutions found to represent an overall safety level equivalent to that stated in the requirements of this standard.

A 400 Documentation requirements

401 Documentation requirements shall be in accordance with the NPS DocReq (DNV Nauticus Production System for documentation requirements) and DNV-RP-A201.

B. Certification and Classification Requirements

B 100 General

101 The following requirements shall be applied in conjunction with the technical requirements in Ch.2 of this standard when used for certification or classification purposes.

B 200 Information to be supplied by the purchaser

201 The purchaser shall supply the manufacturer with all information necessary to ensure correct material and certification. This applies particularly where optional or additional conditions are specified.

B 300 Design verification

301 Mooring chain cables and accessories shall be designed according to requirements given in Ch.2 Sec.2 B200 and C200, respectively. Where designs differ from this, the drawings and calculations shall be submitted to DNV for approval.

Guidance note:
Design requirements are given in DNV-OS-E301.
---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

302 Design approval shall be documented by design verification report (DVR), type approval certificate or approval letter.

B 400 Approval of manufacturers

401 Materials, chain cables and accessories shall be manufactured at works which have been approved by DNV. Approved manufacturers are published on DNV Exchange on the Internet.

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

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

B 500 Survey during manufacture

501 Survey during manufacture of mooring chain and accessories shall be based on attending tests and inspections, monitoring manufacturing, and review of records. The scopes of survey are defined in Appendix A and B.

502 The scopes defined in Appendix A and B are typical and adjustments may be permitted or required based on considerations such as:

— complexity and size of a delivery
— previous experience with equipment type
— maturity and effectiveness of manufacturer’s quality system
— degree of subcontracting.

B 600 Certification of materials

601 Rolled steel bars shall be delivered with DNV certificates giving the following particulars for each test unit which has been accepted:

— purchaser's name, order number and vessel identification, where known
— manufacturer's name
— number and dimensions of bars and steel grade
— identification marking of bars
— heat number and chemical composition
— results of mechanical tests
— details of heat treatment of test material
— results of any supplementary and additional test requirements specified.

602 Semi-finished steels such as billets, blooms and forged bars intended for chain cable accessories shall be delivered with the manufacturer’s certificates giving the following particulars for each test unit which has been accepted:

— purchaser's name, order number and vessel identification, where known
— manufacturer's name
— number and dimensions of semi-finished products and steel grade
— identification marking of products
— heat number and chemical composition
— details of heat treatment
— results of any supplementary and additional test requirements specified.

603 Materials for studs shall be delivered with the manufacturer’s certificates or test reports.

B 700 Certification of mooring chain and accessories

701 Mooring chain and accessories shall be delivered with DNV certificates giving the following particulars for each test unit which has been accepted:
— purchaser's name, order number and vessel identification, where known
— manufacturer's name
— description of products and dimensions
— grade of chain, method of manufacture, condition of supply and reference to material certificate
— identification marking
— results of proof load test, breaking load test and mechanical tests
— confirmation of dimensional measurements and inspections.
## APPENDIX A

### SCOPE OF SURVEY FOR MOORING CHAIN

<table>
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<th>Activity or item</th>
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<td>- Inspection and test plan</td>
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<td>- Works approval status</td>
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<td>- Design approval status</td>
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<td>- Test machines calibration status</td>
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<td>Ch.2 Sec.1</td>
<td>M/R</td>
<td>- Certificates and traceability</td>
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<td>M/R</td>
<td>- Procedure compliance</td>
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<td>- Records</td>
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<td>- Procedure compliance</td>
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<td>- Witness in beginning, then monitoring</td>
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### Definitions

**Hold point (H)**
A point where DNV shall be present for supervision or survey. Advance notification to DNV shall be given in writing or any other agreed system of notification. Work shall not proceed beyond a hold point without DNV present or, in exceptional cases where presence is waived, without first obtaining written authorisation from DNV.

**Witness point (W)**
A point where DNV may be present for supervision or survey, at their discretion. Advance notification to DNV shall be given in writing or any other agreed system of notification. Work may proceed beyond a witness point with or without DNV present.

**Monitoring (M)**
Intermittent monitoring or surveillance of any stage of the work in progress including, but not limited to, checking compliance with procedures/instructions for manufacture, testing and inspection, observing workmanship, traceability, etc.

**Review (R)**
Examination of records of activities performed or results achieved.
## APPENDIX B

### SCOPE OF SURVEY FOR MOORING CHAIN ACCESSORIES

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