CLASS PROGRAMME

Approval of manufacturers

DNVGL-CP-0243 Edition May 2016

Rolled ferritic steel products
FOREWORD

DNV GL class programmes contain procedural and technical requirements including acceptance criteria for obtaining and retaining certificates for objects and organisations related to classification.

© DNV GL AS May 2016

Any comments may be sent by e-mail to rules@dnvgl.com

This service document has been prepared based on available knowledge, technology and/or information at the time of issuance of this document. The use of this document by others than DNV GL is at the user’s sole risk. DNV GL does not accept any liability or responsibility for loss or damages resulting from any use of this document.
CHANGES - CURRENT

This is a new document.
# CONTENTS

**Changes - current**........................................................................................................................................3

**Section 1 General**..................................................................................................................................5
  1 Objective........................................................................................................................................5
  2 Scope and application.......................................................................................................................5
  3 Request for approval......................................................................................................................7
  4 References.......................................................................................................................................7

**Section 2 Documentation requirements**...............................................................................................9
  1 Manufacturing summary..................................................................................................................9
  2 Reheating.......................................................................................................................................9
  3 Rolling...........................................................................................................................................9
  4 Programmed rolling.......................................................................................................................9
  5 Heat treatment (if applicable).........................................................................................................9
  6 Special recommendations for cold/hot working and welding (if applicable)..............................10
  7 Welding (if applicable)..................................................................................................................10
  8 Records, test facilities and procedures.......................................................................................10
  9 Test results and records................................................................................................................11

**Section 3 Approval Testing**..................................................................................................................13
  1 Test product and testing scope......................................................................................................13
  2 Testing requirements.....................................................................................................................13

**Appendix A Approval range based on tested grade**........................................................................21

**Appendix B Approval of boiler and pressure vessels steel grades based on approval of hot rolled structural steel grades**........................................................................................................24

**Appendix C Examples of the scope of testing for example grades in different product categories**...........................................................................................................................................25

**Changes – historic**................................................................................................................................28
SECTION 1 GENERAL

1 Objective
The objective of this class programme (CP) is to provide a description for which the Society bases its approval of manufacturers intending to supply rolled ferritic steel products in accordance with RU SHIP Pt.2 or other applicable standards provided by the Society.

2 Scope and application
This programme is applicable for the approval of material manufacturers of:
— Rolled ferritic steel products,
as referred in the Society's rules and standards. For a description of general requirements, conditions and procedures related to the approval, please refer to DNVGL CP 0346 which shall be applied in combination with this programme.
This programme is applicable for the approval of manufacturers of products indicated in Table 1 as given in RU SHIP Pt.2, and relevant parts of other applicable DNV GL rules and standards.

Table 1 Range of approval:

<table>
<thead>
<tr>
<th>Application areas as per RU SHIP Pt.2 Ch.2</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RU SHIP Pt.2 Ch.2 Sec.2 [3]</td>
<td>Rolled steel for structural application – Normal strength steel</td>
</tr>
<tr>
<td>RU SHIP Pt.2 Ch.2 Sec.2 [4]</td>
<td>Rolled steel for structural application – High strength steel</td>
</tr>
<tr>
<td>RU SHIP Pt.2 Ch.2 Sec.2 [5]</td>
<td>Rolled steel for structural application – Extra high strength steel</td>
</tr>
<tr>
<td>RU SHIP Pt.2 Ch.2 Sec.2 [6]</td>
<td>Plates with through thickness properties</td>
</tr>
<tr>
<td>RU SHIP Pt.2 Ch.2 Sec.3 [2]</td>
<td>Rolled steel for boilers, pressure vessels and special applications - Steel for boilers and pressure vessels</td>
</tr>
<tr>
<td>RU SHIP Pt.2 Ch.2 Sec.3 [3]</td>
<td>Rolled steel for boilers, pressure vessels and special applications - Steel for low temperature service</td>
</tr>
<tr>
<td>RU SHIP Pt.2 Ch.2 Sec.6</td>
<td>Rolled bars intended for machining into components of simple shape, e.g. shafts, bolts, studs and other components</td>
</tr>
<tr>
<td>RU SHIP Pt.2 Ch.2 Sec.7</td>
<td>Bars for chain cables</td>
</tr>
</tbody>
</table>

The product(s) used for approval testing (see Sec.3) will place limitations on the range of approval. The approval will be limited to:
— each steel grade listed below
— each product category, see Table 1
— each kind of product form (plates, strips/coil, sections, bars etc.)
— particular processing route and manufacturing variables
— maximum tested thickness or diameter.
Approval of one product form will not cover other product forms (example: round/flat bars will not cover sections). However, approval for one grade of steel may also cover approval of lower strength or toughness grades without additional approval testing. This is based on certain approval principles as given in App.A.
Approval is given to the following typical product categories:
— hot rolled structural steels
— normal strength
— high strength
— extra high strength
— boilers and pressure vessel steels
— carbon and carbon-manganese
— alloy
— steels for low temperature service
— fine grained carbon-manganese
— nickel alloy
— strips/coil
— bars for anchor chain cables and accessories
— round bars
— carbon and carbon-manganese
— alloy

Approval is given to the following typical manufacturing variables in processing route:
— steelmaking process (BOC, EAF etc.) and secondary refining (LF, VD, VAD or VOD etc.)
— deoxidation (killed etc.)
— fine grain practice (singly or any combination of Al, Nb, V & Ti)
— casting method (CC or IC)
— dimensions of starting material
— reduction ratio
— condition of supply (AR, NR, N, TM or QT etc.)

When applicable, approval will be given for the following additional conditions:
— steel grades with specified through thickness properties, ‘Z’ grade (Z25 or Z35). See Sec.3 [2.9]
— steel grade(s) of improved weldability, ‘W’ grade(s) (example VL EW36 etc.)
— rolled round bars intended to be machined into components (as a substitute for forged bars) for which requirements reduction ratio, sampling, and acceptance criteria for mechanical properties requirements and NDE/inspection shall be according to RU SHIP Pt.2 Ch.2 Sec.6 Steel forgings. Approval test scope is given in this approval program
— steels intended for high heat input welding ≥ 50 kJ/cm shall be specially approved. Approval is given on the approval of manufacturer certificate using a high heat input welding notation, e.g. D32-W200, indicating approval of steel grade D32 for welding by heat input ≤ 200 kJ/cm. See Sec.3 [2.8]
— steel plates intended for ‘cold formed plating’ may be specially approved for applications where cold forming with theoretical deformation exceeding the limits given in RU SHIP Pt.3 Ch.3 Sec.1 [2.7] subject to additional testing (e.g. strain age testing etc.) for which test scope shall be agreed on case by case basis
— steel plates with prequalified CTOD properties of GCHAZ after welding. For this case, the manufacturer may apply for special approval to add suffix ‘COD’ to the approved grades. Test scope and acceptance criteria for COD grades are given in DNVGL CP 0348
— selected steel grades according to relevant international standards, for which approval justification and test scope shall be agreed on case by case basis.

Starting material /semi-finished steel products shall be produced at works approved by the Society:
— when steel rolling mill operates their own steel making and produce their semi-finished steel products (slabs/ingots/etc.), the manufacturer shall also use a separate approval programme DNVGL CP 0242, ‘Semi-finished steel products’ to approve these facilities
— when raw materials for steel rolling mill (slabs/ingots/etc.) are not produced at the rolling mill, the semi-finished steel products shall be procured from DNV GL approved steelmaker.
The manufacturer’s own heat treatment facilities shall be evaluated and approved by the Society, either under this approval programme, or as approved "heat-treatment workshop" based on the approval programme DNVGL CP 0351. Where heat treatment is performed by a sub supplier, the sub supplier shall be approved by the Society as heat treatment workshop in accordance with DNVGL CP 0351.

Manufactures of specially designed rolled steel products for application in container ships, corrosion resistant steels for cargo oil tanks, structural hollow sections and works carrying out decoiling of strip/coiled products are not covered by this programme, but need separate approval according to following approval programs:

- DNVGL CP 0348, Rolled steel products for application in container ships including grades with BCA and COD properties - additional requirements for steel rolling mill, where relevant
- DNVGL CP 0429, Corrosion resistant steels for cargo oil tanks
- DNVGL CP 0347, Steel hollow sections (including pipes for structural applications)
- DNVGL CP 0349, Decoiling workshop.

3 Request for approval

When applying for AoM, the manufacturer shall indicate/list the material grades to be covered by the approval, including manufacturing method, dimensions and heat treatment/delivery conditions as per [3].

A list or table shall be provided, which shall include:

- type of products (sections, plates, strip/coil, round bars)
- grades selected for testing
- other grades to be included in the certificate (covered by tested grades, see App.A)
- quality class for through thickness properties, if applicable (Z25 or Z35)
- range of applicable product sizes (width, length, thickness, diameter etc.)
- specification for chemical composition containing the range (minimum and maximum limits) and the aim analyses for all the specified elements including the grain refining and micro alloying elements Al, Nb, V, Ti and B, if applicable
  - aim maximum \( C_{eq} \) and \( P_{cm} \)
  - reference to DNV GL rules for the applicable chemical composition, mechanical properties and heat treatment (if applicable) or recognised standards (recognition of other standard shall be agreed in advance)

- manufacturing variables related to processing route:
  - steelmaking process (BOC, EAF etc.)
  - secondary refining (LF, VD, VAD or VOD etc.)
  - deoxidation practice
  - fine grain practice (singly or any combination of Al, Nb, V & Ti)
  - casting method (CC or IC)
  - condition of supply (AR, NR, N, TM or QT etc.)
  - reduction ratio

- manufacturing/sourcing details and dimensions of semi-finished products used:
  - where any part of the manufacturing process is assigned to other companies or other manufacturing plants, additional information shall be included
  - in case raw materials for rolled products (slabs/ingots/etc.) are delivered from other manufacturers: a list of raw material suppliers and a copy of their approved certificate.

4 References
Table 2 References

/1/ ASTM E 208, Test Method for Conducting Drop-Weight Test to Determine Nil-Ductility Transition Temperature of Ferritic Steels

/2/ ASTM E112, Standard Test Method for Determining Average Grain Size

/3/ EN 10160, Ultrasonic testing of steel and flat product of thickness equal or greater than 6 mm (reflection method)

/4/ ASTM A578, Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications

/5/ JIS Z3158, Method of γ-groove weld cracking test


/7/ ISO 4136, Destructive tests on welds in metallic materials -- Transverse tensile test
SECTION 2 DOCUMENTATION REQUIREMENTS

1 Manufacturing summary
Manufacturer shall submit information about the specific manufacturing process and related production records for products for which approval is requested. Documentation shall include manufacturer’s metallurgical specifications related the rolling process as described in this section.

2 Reheating
The following documentation shall be submitted:
— type of furnace and dimensions
— heating source
— sketch indicating the positions of thermocouples
— accuracy and calibration status of temperature control devices
— reheating temperature and soaking/holding time in furnace
— description of reheating temperature and hold time.

3 Rolling
The following documentation shall be submitted:
— capacity of the rolling stands with respect to plate thickness, length and width, and/or section size
— details of starting material and grade, including dimensions
— rolling schedule and time interval between passes
— temperature and thickness at the beginning and at the end of the each pass
— reduction ratio for each pass and total reduction ratio, including method for calculation of reduction ratio
— descaling treatment during rolling
— finish rolling temperature
— cooling conditions/stacking method after final rolling
— type and speed of accelerated cooling, if any
— for coils:
  — minimum inner diameter
  — maximum outer diameter.

4 Programmed rolling
For products delivered in the normalised rolling (NR) or thermo-mechanical rolled (TM) condition, the following additional information on the programmed rolling schedules shall be given:
— description of the rolling process
— control standards for typical rolling parameters used for the different thickness and grades of steel
— specified normalising temperature, re-crystallization temperature and Ar₃ temperature, and the methods used to determine them
— aimed and obtained microstructure and grain size.

5 Heat treatment (if applicable)
The following documentation shall be submitted:
— type of furnace and dimensions
— heating source
— sketch indicating the positions of thermocouples
— working zone dimension, sketch of working zone
— accuracy and calibration status of temperature control devices
— furnace uniformity test report
— furnace loading plan and procedure
— heat treatment procedures, specifying temperatures and holding times, and where applicable, information about heating and cooling rates, quenching medium and cooling medium after tempering
— any re-heat treatment procedure to be given, if applicable
— method of cleaning after heat treatment
— for products delivered in the normalised (N) or quenching and tempering (QT) condition, the following additional information on the programmed rolling schedules shall be given:
  — heat treatment specification and procedures, specifying temperatures and holding times, and where applicable, information about heating and cooling rates, quenching medium and cooling medium after tempering
  — heat treatment charts from approval tests
  — specified normalising temperature, re-crystallization temperature and Ar₃ temperature and the methods used to determine them
  — aimed and obtained microstructure and grain size.

6 Special recommendations for cold/hot working and welding (if applicable)
The following documentation shall be submitted:
— cold and hot working recommendations, i.e. if needed in addition to the normal practice used in the shipyards and workshops (in particular for products delivered in the NR or TM condition)
— minimum and maximum heat input if different from the ones usually used in the shipyards and workshops (10 - 50 kJ/cm).

7 Welding (if applicable)
— Description of welding shop in case repair or production welding is involved:
  — equipment
  — qualifications of welders and welding supervisors
  — welding procedure specifications (WPS)
  — the production welding shall be qualified by welding procedure tests. Reports on welding procedure qualification tests (WPQR)
  — unless otherwise agreed with the Society, the scope of the welding procedure tests shall comply with DNV GL rules for classification: Ships, RU SHIP Pt.2 Ch.4 and documented as described in approval of welding workshop (WWA) programme DNVGL CP 0352.

8 Records, test facilities and procedures
The following documentation shall be submitted:
— visual inspection: relevant templates for recording, and a few records of previously performed visual inspections of same or similar products
— details and description of relevant in-house testing facilities and calibration details, test procedures and qualification of testing personnel
— NDT procedures, equipment for NDT including calibration details, and qualification of personnel for NDT
— information about and procedures for important manufacturing and testing routines, such as cutting and macrographic inspection of products etc.
9 Test results and records

Additional requirements for reporting of test results:

— Chemical composition:
  — a summary of the sampling practices and methods for chemical analysis is to be submitted
  — the chemical composition shall be reported in percentage by mass
  — the carbon equivalents $C_{eq}$ and $P_{cm}$ (see RU SHIP Pt.2 Ch.1 Sec.2 [3.2]) shall be reported
  — the report shall give the specified limits and the measured content of all the required elements.

— Tensile test:
  — yield (or proof) stress, tensile strength, elongation and, in case of round specimens - reduction of area, shall be included in the report
  — stress–strain curves shall be included in the report.

— Elevated temperature tensile test:
  — yield (or proof) stress, tensile strength, elongation and reduction of area shall be reported.

— Charpy V-notch impact toughness test:
  — the heat number, test piece location and orientation, test temperature and absorbed energy (average and single values), fracture appearance, lateral expansion and percentage crystallinity shall be reported and the results shall be plotted in the form of transition curves.

— Strain age testing:
  — the heat number, test piece location and orientation, test temperature and absorbed energy (average and single values), fracture appearance, lateral expansion and percentage crystallinity shall be reported and the results shall be plotted in the form of transition curves.

— Metallographic examination:
  — high quality photomicrographs showing the microstructure at 100x and 500x magnification shall be presented with a brief description. The magnification shall be indicated on the micrographs by a line symbol, e.g. with length of 0.5 mm or 100 µm. Arrows or letters may be used to identify features referred to in the report
  — a short description of the microstructure shall be provided with each micrograph
  — the ferrite grain size shall be reported, except for steels supplied in quenched and tempered condition. Ref. ASTM E112
  — the applied etching methods for the metallographic examination shall be stated in the report.

— Drop weight test:
  — the report shall contain information about test equipment, specimen preparation, specimen type, electrode used: type and manufacturer
  — the report shall give information showing that testing has been carried out in compliance with the given testing standard
  — the ductile-brittle transition temperature shall be determined and photographs of the tested specimens shall be enclosed to the test report
  — the drop weight energy used and the hardness of the weld deposit shall be reported,

— Weldability test:
  — all relevant records and test results shall be submitted
  — a welding procedure qualification test report (WPQR) in accordance with RU SHIP Pt.2 Ch.4 Sec.5 shall be included in the report, and shall unless otherwise agreed or where this is not required by the rules, also include the following for each assembly:
    — a sketch of the weld joint depicting groove dimensions number of passes
— the welding parameters including consumables designation and diameter, pre-heating temperatures, interpass temperatures, heat input, number of passes, etc.
— the location of fracture for cross-weld tensile tests shall be reported
— the Charpy V-notch test temperature and energy values
— macro-photo of the weld cross section showing also the hardness indentations shall be included in the test report.

— Through thickness test (if applicable):
  — through thickness tensile testing report shall include complete testing details, standards and test methods used, test results and specimen photographs
  — the percentage reduction of area shall be reported for each through thickness tensile test sample and meet the rule requirements
  — ultrasonic inspection report confirming compliance with requirements given in EN 10160 Level S1/E1 or ASTM A578 Level C.

— Residual stresses in strip/coil (if applicable):
  — assessment report.

— Visual examination:
  — report/record for visual inspection, dimensional measurements and surface condition.

— Non-destructive testing:
  — detailed records of non-destructive testing with clear conclusions written by qualified personnel shall be submitted, giving the extent of testing, methods of testing, acceptance criteria, and qualification of the NDT operator.
SECTION 3 APPROVAL TESTING

1 Test product and testing scope

1.1 General
Test products shall be selected so that the testing will cover and qualify the full range of product types, grades, processing route, dimensions, etc. for which approval is requested, see Sec.1 [3]. The sampling and the testing procedures shall comply with the relevant requirements in the DNV GL rules. E.g. the reduction ratio and testing sample positions for rolled bars for machinery application, with diameter over 50 mm shall be in accordance with RU SHIP Pt.2 Ch.2 Sec.6 Steel forgings.

1.2 Extent of approval testing
Testing shall be carried out on two test products from two different heats for:
- each steel grade
- each product category, see Sec.1 Table 1
- each kind of product form (plates, strips/coil, sections, bars etc.)
- each specific manufacturing processing route (e.g. steel making, rolling process etc., see Sec.1 [2]).
The first heat shall represent maximum product thickness (dimension) and the second heat should represent an average thickness (dimension). The second heat may be replaced by a typical dimension/weight of the manufacturer's product portfolio.
It should be noted that some tests are only performed on products of maximum thickness as described in the scope of testing in the following sections.
The products selected for testing shall represent:
- for ingot cast material: one test sample from the top end corresponding to the top of the first ingot from the ladle, and one from the bottom end of the product (plate, section, bar etc.)
- for continuous casting: one test from the top end of the product corresponding to the beginning of the cast, and the second test sample from the bottom end of the product (plate, section, bar etc.)
- "end" means the locations on the final product corresponding to the former ends of the ingot/slab/bloom/billet applied for testing, after cutting of discard.
Where two or more material grades shall be covered by the approval testing, the testing may, subject to agreement with the Society, be reduced to one heat per steel type/grade per application area.
Test samples shall be taken out in final delivery condition and shall not be subjected to any separate heat treatment except for bars for anchor chain cables, where testing shall be carried out on samples subjected to heat treatment as for finished anchor chain cables.

2 Testing requirements

2.1 Chemical composition
The following is required:
- both ladle/heat analyses and product analyses
- for all steel grades, the chemical composition as determined by heat and product analysis shall comprise the elements C, Si, Mn, P, S, Cu, Al, Cr, Ni, Mo, V, Nb, Ti, Sn, Sb, As, B and N, as well as any other intentionally added elements and elements designated as residual elements:
- if steel is sourced from a different maker, manufacturer shall request the complete analysis of all the required elements when ordering the semi-finished product.
2.2 Tensile testing

The following is required:

— tensile testing is required for all steel grades and on samples taken from top and bottom of the products, representing two heats
— for plate produced from coil, tensile tests shall be made from top and bottom ends as well as at the approximate centre lap of each coil
— for each plate with delivery condition thermo-mechanical rolling, one additional tensile test shall be made from material in stress relieved condition. The stress relieving temperature shall be at least 580°C with holding time 1 hour per 25 mm thickness, unless otherwise justified
— for each plate with delivery condition normalising rolling, one additional tensile test shall be made from material in normalising condition in order to show that similar steel properties are reproduced by a subsequent furnace normalizing
— alternative test for flat products (plates, wide flats, sheets, etc.) having thickness higher than 40 mm: when the capacity of the available testing machine is insufficient to allow the use of test specimens of full thickness, multiple flat specimens representing collectively the full thickness may be used. Alternatively, two round specimens with the axis located at one quarter and at mid thickness may be taken

2.3 Elevated temperature tensile testing

The following is required:

— for rolled steel intended for application at elevated temperatures, tensile test on at least two round tensile test specimens shall be performed (from top and bottom of the product). Test temperature is 300°C, or as agreed

2.4 Impact testing

Impact testing is required for all steel grades on samples taken from the products representing two heats as described below:

— for flat products (plates, wide flats, sheets, etc.) longitudinal and transverse Charpy V-notch impact tests shall be made from both ends of each sample product
— for flat products (plates, wide flats, sheets, etc.) having thickness higher than 40 mm an additional set of impact specimens shall be taken with the axis located at mid-thickness
— for long products (sections, narrow flats, bulb flats, bars etc.), longitudinal Charpy V-notch impact tests shall be taken from both ends of each sample product
— for strip/plate produced from coil: longitudinal and transverse Charpy V-notch impact tests shall also be made from the approximate centre lap of each coil in addition to both ends
— one set of 3 Charpy V-notch impact specimens is required for each impact test
— to establish transition curve tests on both longitudinal and transverse samples, testing shall be carried out for at least four different temperatures with 20°C increments. Starting from specified test temperature for the grade, at 20°C and 40°C below, and at 20°C above that specified test temperature
— the following exceptions applies:
  — grade VL A (≥ 6 mm) shall be tested at –20°C, 0°C and +20°C
  — grade VL 9Ni shall be tested at –196°C and -165°C
  — for rolled round bars not intended for hull structural application, e.g. intended for machinery components or bars for chain cable application, the products shall be tested at 0°C and -20°C
— the impact energy values at all temperatures and test positions shall comply with corresponding specified requirements given by the rules with the following exceptions:
  — test results corresponding to test temperature below the specified temperature is for information
— for VL A grade with thickness less than or equal to 50 mm, average energy values shall be min. 27 J at +20°C
— C and C-Mn steel bars for machinery applications, made according to DNV GL rules, and bars for chain cable grade VL K1, shall comply with average energy 27 J at 0°C

2.5 Strain age testing
Strain age testing is required on samples taken from the top end of the products representing two heats for all steel grades and all products with the following exceptions:
— not required for bars for anchor chain cables and accessories
— not required round bars for machinery applications
— not required for Mo or CrMo grades (ref. RU SHIP Pt. 2 Ch.2 Sec.3 [2]).
Longitudinal Charpy V-notch tests shall be performed on the sample material in the following conditions:
— 5% strained
— 5% strained and aged at 250°C for 1 hour
— for plates with thickness higher than 40 mm one additional set of strain age impact specimens shall be taken with the axis located at mid-thickness
— one set of 3 Charpy V-notch impact specimens is required for each impact test
— tests shall be carried out at specified test temperature for the grade as well as 20°C above and 20°C below the specified test temperature. The following exceptions applies:
— grade VL A (≥ 6 mm) shall be tested at –20°C, 0°C and +20°C
— grade VL 9Ni shall be tested at –196°C
— the impact energy values at all temperatures shall comply with corresponding specified requirements given in the rules with the following exceptions:
— test results corresponding to test temperature below the test temperature specified by the rules are for information
— for VL A grade with thickness less than or equal to 50 mm average energy values shall be min. 27J at +20°C

2.6 Metallographic examination
The following is required:
— metallographic examination for all steel grades on samples taken in longitudinal and transverse directions from the top end of the products representing two heats
— the micrographs shall be representative of the full thickness. At least three thickness locations shall be represented: near the surface, one quarter and mid-thickness of the product
— high quality photomicrographs showing the microstructure at 100x and 500x magnification shall be presented with a brief description. The magnification shall be indicated on the micrographs by a line symbol, e.g. with length of 0.5 mm or 100 µm. Arrows or letters may be used to identify features referred to in the report
— the ferrite grain size shall be measured, except for steels supplied in quenched and tempered condition. Ref. ASTM E112.

2.7 Drop weight testing
Drop weight testing is required for flat products (plates, wide flats, sheets, etc) on samples taken from the top end of the products representing one heat of maximum thickness (≥16 mm) for the following grades:
— E and F grades in any strength level of hot rolled structural steels
— all grades of carbon-manganese and nickel alloy steels for low temperature service.
Drop weight testing is not required for:
- long products (sections, narrow flats, bulb flats, bars etc.)
- Mo or CrMo grades (ref. RU SHIP Pt.2 Ch.2 Sec.3 [2]).

Drop weight test shall be performed in accordance with ASTM E208 or similar standard, preferably using specimen type P1 or P2. Orientation of the specimens should be such that the crack starter weld is parallel to the direction of rolling:
- a set of two specimens tested at three temperature levels as described below:
  - hot rolled structural steels: at the impact test temperature prescribed in RU SHIP Pt.2 Ch.2 Sec.1 as well as 5°C above and 5°C below this temperature
  - steels for low temperature service: at the minimum design temperature prescribed in the DNV GL rules, as well as 5°C and 10°C below this temperature
- the ductile-brittle transition temperature shall be determined and photographs of the tested specimens shall be enclosed to the test report
- the drop weight energy used and the hardness of the weld deposit shall be recorded
- two valid tests (with a ‘break’ or ‘no-break’ result) are required at each test temperature
- to qualify the test, both test specimens shall display a ‘no-break’ result at the following temperatures:
  - hot rolled structural steels: at and above the impact test temperature prescribed in RU SHIP Pt.2 Ch.2 Sec.1
  - steels for low temperature service: at and 5°C below the minimum design temperature prescribed in the DNV GL rules
- test results corresponding to other test temperatures are for information.

2.8 Weldability testing

2.8.1 Scope of testing
Weldability testing is required for all flat products (plates, wide flats, sheets, etc.) of any grade that meet one of the following criteria:
- minimum specified yield stress 355 N/mm² or higher
- specified minimum impact toughness test temperature of –40°C or lower

Weldability test is not required for:
- long products (sections, narrow flats, bulb flats, bars etc.)

The material for the weldability evaluation shall be selected as follows:
- from products with carbon equivalent values within 0.03 per cent of the maximum permitted by the rules and/or manufacturers specification and
- products shall be in the specified condition of heat treatment
- test material for the weld test assemblies shall be taken from the top end of the products representing one heat of maximum thickness
- for special approval of steels intended for welding with high heat input, two test plates with different thickness shall be selected. The thicker plate (t) and thinner plate (less than or equal to t/2) shall be proposed by the manufacturer, and agreed with the Society

The following tests are required:
- for hull structural steels with thickness ≤ 50 mm:
  - two butt weld assemblies shall be tested in as-welded condition
  - if the products are intended to be suitable for post-weld heat treatment (PWHT) after welding, test weld sets shall be made and tested also after PWHT
— for hull structural steels with thickness ≥ 50 mm, and all grades of steels for low temperature service irrespective of product thickness:
— two butt weld assemblies shall be tested in both as-welded and in stress relieved condition. The stress relieving temperature shall be at least 580°C with holding time 1 hour per 25 mm thickness, unless otherwise justified.

2.8.2 Preparation and welding of the test assemblies
— Two butt weld assemblies with K-bevel or single-bevel groove shall be prepared with the weld seam orientation relative to the plate rolling direction as specified in RU SHIP Pt.2 Ch.4 Sec.5, and with following heat inputs:
— 1 butt weld with a low heat input approximately 15 kJ/cm ± 1 kJ/cm or lower
— 1 butt weld with a high heat input approximately 50 kJ/cm ± 2 kJ/cm
— for special approval of steel intended for high heat input welding, one butt weld shall be welded with the maximum heat input for which approval is requested
— welds shall be made in the flat position, preferably by SAW process, or by a fully automatic multi-run welding process
— one weld shall be made at the lowest pre-heat, interpass temperature, and heat input recommended for production welding, the other at the highest. Welding parameters shall be recorded and reported
— unless otherwise required for production welding, the applied preheating temperature shall be below 100°C, and the maximum interpass temperature shall be below 250°C
— a lower "high" heat input than 50 kJ/cm may be chosen for extra high strength steel grades subject to agreement with the Society. For this case the applied maximum heat input will be stated on the approval certificate

2.8.3 Extent of weldability testing
The weldability test shall comprise all requirements for welding procedure qualification as given by RU SHIP Pt.2 Ch.4 Sec.5 and shall also include the following tests for each assembly, unless otherwise agreed and where this is not required by the rules:

1) Visual examination:
   — overall welded surface shall be uniform and free from defects such as cracks, undercuts, overlaps, etc.

2) Macroscopic test:
   — one macroscopic photograph shall be representative of transverse section of the welded joint and shall show absence of cracks, lack of penetration, lack of fusion and other injurious defects.

3) Microscopic test:
   — along mid-thickness line across transverse section of the weld, one micrograph with x100 magnification shall be taken at each position of the weld metal centerline, fusion line and at a distance 2, 5, 10 and minimum 20 mm from the fusion line. The test result is provided for information purpose only.

4) Hardness test:
   — the hardness testing shall be in accordance with ISO 6507/1 or equivalent. Normally, the Vickers method (HV10) is used. Indentations shall be made along two lines across traverses in weld metal centerline, fusion line and each 0.7 mm position from fusion line to unaffected base metal (minimum 6 to 7 measurements for each heat affected zone) approximately 1 mm beneath the plate surface on both the face side and the root side of the weld. For each traverse a minimum of 3 indentations shall be made in the weld, HAZ (both sides) and parent metal (both sides).

5) Transverse tensile test:
— two transverse (cross weld) tensile specimens shall be taken from the test assembly. Test specimens and testing procedures shall comply with the requirements given in the DNV GL rules (or where agreed, a relevant international standard such as ISO 4136)
— the obtained tensile strength shall be not less than the minimum required value for the grade of base metal.

6) Bend test:
— two root and two face bend specimens shall be tested. For thickness 12 mm and above, four side bend specimens may alternatively be tested. The test specimens shall be bent on a mandrel with diameter 4xt, where t is the thickness of the specimen, except for extra high strength steels grades 550, 620, and 690 where the diameter shall be 5xt. The bending angle shall be at least 180°
— for special approval of steels intended for welding with high heat input two transverse (cross weld) test specimens shall be taken from the test assembly and bent on a mandrel with diameter of quadruple specimen thickness. Bending angle shall be at least 120°. Test specimens shall comply with the requirements given in the DNV GL rules. For plate thickness up to 20 mm, one face-bend and one root-bend specimens or two side-bend specimens shall be taken. For plate thickness over 20 mm, two side-bend specimens shall be taken
— after bending, the test specimens shall not reveal any open defects in any direction greater than 3 mm. Defects appearing at the corners of a test specimen during testing shall be investigated case by case.

7) Impact test. Charpy V-notch impact tests shall be carried out on samples taken at locations as described below:
— one set of specimens (contain three test pieces) shall be taken within 2 mm below plate surface of the parent material on face side of the weld with the notch perpendicular to the plate surface
— one set each of the specimens transverse to the weld shall be taken with the notch located at the weld metal centreline, fusion line and at a distance 2, 5 and minimum 20 mm from the fusion line. An additional set of 3 Charpy test specimens at root is required for each aforementioned position for plate thickness t ≥ 50mm. The fusion boundary shall be identified by etching the specimens with a suitable reagent. The test temperature shall be the one prescribed for the testing of the steel grade in question
— for steel plate with thickness greater than 50 mm or one side welding for plate thickness greater than 20 mm, one additional set of the specimens shall be taken from the root side of the weld with the notch located at each the same position as for the face side
— additional tests at the different testing temperatures may be required for evaluating the transition temperature curve of absorbed energy and percentage crystallinity.

8) Other tests:
— additional tests such as wide-width tensile test, HAZ tensile test, cold cracking tests (CTS, Cruciform, Implant, Tekken, and Bead-on plate), CTOD or other tests may be required by the Society.

2.8.4 Acceptance criteria and reporting
A welding procedure qualification test report (WPQR) in accordance with RU SHIP Pt.2 Ch.4 Sec.5 shall be included in the report, and shall unless otherwise agreed or where this is not required by the rules, also include the following for each assembly:
— a sketch of the weld joint depicting groove dimensions number of passes
— the welding parameters including consumables designation and diameter, pre-heating temperatures, interpass temperatures, heat input, number of passes, etc.
— the tensile strength shall not be below the specified minimum tensile strength for the steel grade in question. The location of fracture shall be reported
— the Charpy V-notch test temperature and energy values, except for the weld metal, shall comply with the requirements specified for the base material
— macro-photo of the weld cross section showing also the hardness indentations should be included in the test report
the maximum hardness value in as-welded condition should not be higher than 350 HV10 for steels with specified minimum yield stress ≤ 500 N/mm². For steels with specified minimum yield stress > 500 N/mm², hardness up to 400 HV10 is generally acceptable. When higher hardness values are recorded, the HAZ cracking susceptibility such as Y-groove cracking test (JIS Z3158) or gapped bead-on-plate (G-BOP) test may be required by the Society.

2.9 Through thickness testing (if applicable)

The following is required:

— through thickness testing is required when approval is requested for additional through thickness quality classes (Z25 or Z35) for hot rolled structural steels
— it is applicable for steel plates and wide flats with thickness ≥ 15 mm
— the following additional tests shall be performed for each grade for which approval requested:
  — three through thickness tensile tests shall be carried out in accordance with recognised standards, e.g. EN 10164 and ASTM A770
  — test material shall be taken close to the longitudinal centerline from one end of each product representing the test grade.
— Ultrasonic testing:
  — the plates shall be subjected to ultrasonic testing in the condition of supply with a probe frequency of 3-5 MHz
  — testing shall be performed in accordance with EN 10160 Level S1/E1 or ASTM A578 Level C.
— Reporting:
  — through thickness tensile testing report shall include complete testing details, standards and test methods used, test results and specimen photographs
  — the percentage reduction of area shall be reported for each through thickness tensile test sample and meet the rule requirements
  — the average reduction of area value of three test pieces shall be determined and meet the specified minimum average value given in the rules
  — ultrasonic inspection report confirming compliance with requirements given in EN 10160 Level S1/E1 or ASTM A578 Level C.

2.10 Residual stresses in strip/coil (if applicable)

The following is required:

— an assessment of the residual stress in the de-coiled plate shall be made: this should be done by flame cutting a 500 x 500 mm section from the mid width of a de-coiled plate, at least 500 mm from the edge of the plate. Alternatively an actual production cut section may be used of similar size and location
— the cut section shall be assessed and show no distortion.

2.11 Visual examination

Visual examination shall be conducted and recorded according to the relevant rule, standard and specification on the products submitted for approval purposes.

— the surfaces shall be adequately prepared for inspection
— the surfaces shall not be hammered, peened or treated in any way which may obscure discontinuities
— examination shall be done for all applicable sides and areas, i.e. manufacturer shall ensure that lifting devices for handling and turning of the products are available
— when relevant, visual examination shall include internal surfaces
— measurements shall be made on all applicable dimensions
— records of inspections including NDT shall be prepared
— manufacturer shall present representative products used for approval purpose and preferably several
other products from the current production to the surveyor, including record for visual inspection of the
products and surface condition.

2.12 Other tests (if applicable)
Other applicable tests which are carried out by the manufacturer, e.g. to customer purchase specification
requirements shall be reported.
## APPENDIX A APPROVAL RANGE BASED ON TESTED GRADE

### Table 1 Principles for approval coverage of other grades based on any tested grade

<table>
<thead>
<tr>
<th>Product category</th>
<th>Steel group</th>
<th>Grades/Types</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot rolled</td>
<td>Normal strength</td>
<td>VL A - VL E</td>
<td>a) for normal strength steels approval testing of any higher toughness grade also covers approval for all lower toughness grades under the same approval conditions. Example: Approval of grade VL D may cover the grades VL B and VL A. See Table 2</td>
</tr>
<tr>
<td>Structural steels</td>
<td>High strength</td>
<td>VL A27S - VL F40</td>
<td>b) for high strength and extra high strength steels, approval testing of any higher toughness grade also covers approval for all lower toughness grades in the same strength level as well as similar toughness grade and all lower toughness grades in one strength level immediately below under the same approval conditions. Example: Approval of grade VL E36 may cover the grades VL D36, VL A36 as well as VL E32, VL D32 and VL A32. See Table 2</td>
</tr>
<tr>
<td></td>
<td>Extra high strength</td>
<td>VL A420 - VL F690</td>
<td>c) approval of Hot rolled Structural Steels grade VL B or higher may cover approval of &quot;Boiler and pressure vessel steels” and “Low temperature steels” of group carbon and carbon-manganese, of similar or lower grade, provided the relevant rule requirements for the grades in question are fulfilled; see App.B Table 1</td>
</tr>
<tr>
<td></td>
<td>Carbon and carbon-manganese</td>
<td>VL 360-0A to VL 510-1FN</td>
<td>d) approval testing of any given grade may also cover similar and lower grades in “Hot rolled structural steels” category under the same approval conditions</td>
</tr>
<tr>
<td></td>
<td>Alloy</td>
<td>VL 0.3Mo to VL 2.25Cr 1Mo</td>
<td>e) approval testing of any chosen grade in Mo and CrMo group may also cover all other grades with lower yield strength</td>
</tr>
<tr>
<td></td>
<td>Carbon and carbon-manganese</td>
<td>VL 360-2FN to VL 4-4L</td>
<td>f) approval testing of any given grade may also cover similar and lower grades in &quot;Hot rolled structural steels” and “Boiler and pressure vessels steels” categories under the same approval conditions</td>
</tr>
<tr>
<td></td>
<td>Alloy</td>
<td>VL 1.5Ni to VL 9Ni</td>
<td>g) approval testing of any chosen grade in may also cover all other grades with higher design temperature (i.e. VL 1.5Ni covers VL 0.5Ni).</td>
</tr>
</tbody>
</table>
Table 2 Guideline for approval coverage of other grades based on a tested grade—hot rolled structural steels

<table>
<thead>
<tr>
<th>Range</th>
<th>NS</th>
<th>High Strength</th>
<th>Extra High Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>A</td>
<td>√</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>E</td>
<td>√</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>A27S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D27S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E27S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F27S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A420</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D420</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E420</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F420</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### High Strength

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A460</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D460</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E460</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F460</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A500</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D500</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E500</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F500</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A550</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D550</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E550</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F550</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A620</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D620</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E620</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F620</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A690</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D690</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E690</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F690</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) Read the tested plate grade from the first column, then the coverage is found along the same row. Example: Tested plate grade is D32. Find D32 on the first column: from the same row you will see the coverage is: A27S, D27S, A32, D32

(2) Where considering coverage range for application, the steelmaking process, deoxidation and fine grain practice, casting method and condition of supply should be the same as for the similar approved structural steel plate grade

(3)*" denotes provided Ni less than 0.4%

(4)*+" denotes provided chemical composition are fulfilled.
## APPENDIX B APPROVAL OF BOILER AND PRESSURE VESSELS STEEL GRADES BASED ON APPROVAL OF HOT ROLLED STRUCTURAL STEEL GRADES

Table 1 Comparison between “Hot rolled structural steel grades” and “Boiler and pressure vessels steel grades” and 'Low temperature steels” for the purpose of approval coverage

<table>
<thead>
<tr>
<th>Approval for hot rolled structural steel grade</th>
<th>Boiler/pressure vessel and low temperature steel grade(s) that may be covered by the approval ¹, ²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL B</td>
<td>VL 360-0A, 360-0N, 360-1FN&lt;br&gt;VL 410-0A, 410-0N</td>
</tr>
<tr>
<td>VL A27S</td>
<td>VL 410-1FN</td>
</tr>
<tr>
<td>VL A32</td>
<td>VL 460-0A, 460-0N, 460-1FN</td>
</tr>
<tr>
<td>VL A36</td>
<td>VL 490-0N, 490-1FN</td>
</tr>
<tr>
<td>VL A40</td>
<td>VL 510-1FN</td>
</tr>
<tr>
<td>VL D</td>
<td>VL 360-2FN with thickness up to 25 mm</td>
</tr>
<tr>
<td>VL D27S</td>
<td>VL 2-2 with thickness up to 25 mm</td>
</tr>
<tr>
<td>VL D36</td>
<td>VL 4-2 with thickness up to 25 mm</td>
</tr>
</tbody>
</table>

¹) Applicable only when the steelmaking process, deoxidation and fine grain practice, casting method and condition of supply of tested hull structural grade and covered boiler/pressure vessel or low temperature steel grade are same and also fulfill rule requirements for the covered grade also

²) max. approved thickness shall be same as tested hull structural grade
## APPENDIX C EXAMPLES OF THE SCOPE OF TESTING FOR EXAMPLE GRADES IN DIFFERENT PRODUCT CATEGORIES

### Table 1 Example cases. Test scope for each example case is given in Table 3

<table>
<thead>
<tr>
<th>Example</th>
<th>Initial approval of manufacturer of hot rolled structural steel Sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade or type:</td>
<td>Steelmaking 1) : Fine grain treatment: Delivery condition 2) : Max. thickness (mm): Z-quality:</td>
</tr>
<tr>
<td>VL A</td>
<td>EAF, IC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example</th>
<th>Initial approval of manufacturer of hot rolled structural steel Plates, normal strength steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade or type:</td>
<td>Steelmaking 1) : Fine grain treatment: Delivery condition 2) : Max. thickness (mm): Z-quality:</td>
</tr>
<tr>
<td>VL A, VL B, VL D</td>
<td>BOC, CC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example</th>
<th>Initial approval of manufacturer of hot rolled structural steel Strip /Plate made from coil.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade or type:</td>
<td>Steelmaking 1) : Fine grain treatment: Delivery condition 2) : Max. thickness (mm): Z-quality:</td>
</tr>
<tr>
<td>VL D, VL E</td>
<td>BOC, CC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example</th>
<th>Initial approval of manufacturer of hot rolled structural steel Plates, high strength steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade or type:</td>
<td>Steelmaking 1) : Fine grain treatment: Delivery condition 2) : Max. thickness (mm): Z-quality:</td>
</tr>
<tr>
<td>VL E32, VL F32, VL E36, VL F36</td>
<td>BOC, CC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example</th>
<th>Initial approval of manufacturer of steel Plates for low temperature service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade or type:</td>
<td>Steelmaking 1) : Fine grain treatment: Delivery condition 2) : Max. thickness (mm): Z-quality:</td>
</tr>
<tr>
<td>VL 4-4 L</td>
<td>BOC, CC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example</th>
<th>Initial approval of manufacturer of rolled round Bars intended to be machined into components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type:</td>
<td>Steelmaking 1) : Delivery condition 2) : Max. thickness/diameter (mm):</td>
</tr>
<tr>
<td>Carbon and carbon-manganese</td>
<td>BOC, CC</td>
</tr>
<tr>
<td>Alloy</td>
<td>BOC, CC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example</th>
<th>Initial approval of manufacturer of Round bars for Chain Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade:</td>
<td>Steelmaking 1) : Fine grain elements Delivery condition 2) : Max. Thickness (mm):</td>
</tr>
<tr>
<td>VL K3</td>
<td>BOC, VD, CC</td>
</tr>
</tbody>
</table>

1) **Steelmaking and casting process**: BOC: Basic Oxygen Converter, EAF: Electric Arc Furnace, CC: Continuous Casting, IC: Ingot Casting

2) **Delivery condition**: AR: As Rolled, NR: Normalising Rolling, N: Normalising, TM: Thermo-Mechanical rolling, QT: Quenched and Tempered
### Table 2 Impact test temperatures for the example cases given in Table 1

<table>
<thead>
<tr>
<th>Example cases:</th>
<th>Test temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example</strong></td>
<td>+20°C</td>
</tr>
<tr>
<td>A Impact</td>
<td>x</td>
</tr>
<tr>
<td>Strain aged</td>
<td>x</td>
</tr>
<tr>
<td>B Impact</td>
<td>x</td>
</tr>
<tr>
<td>Strain aged</td>
<td>x</td>
</tr>
<tr>
<td>C Impact</td>
<td>x</td>
</tr>
<tr>
<td>Strain aged</td>
<td>x</td>
</tr>
<tr>
<td>Drop weight</td>
<td>x</td>
</tr>
<tr>
<td>D Impact</td>
<td>x</td>
</tr>
<tr>
<td>Strain aged</td>
<td>x</td>
</tr>
<tr>
<td>Drop weight</td>
<td>x</td>
</tr>
<tr>
<td>E Impact</td>
<td>x</td>
</tr>
<tr>
<td>Strain aged</td>
<td>x</td>
</tr>
<tr>
<td>Drop weight</td>
<td>x</td>
</tr>
<tr>
<td>F Impact</td>
<td>x</td>
</tr>
</tbody>
</table>

### Table 3 Test scope examples, see description in Table 1

<table>
<thead>
<tr>
<th>Type of test</th>
<th>Details</th>
<th>Reporting</th>
<th>Example cases:</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3 Chemical composition</td>
<td>4.3 a) All steels: - All heats, one end</td>
<td>C, Si, Mn, P, S, Cu, Al, Cr, Ni, Mo, V, Nb, Ti, Sn, Sb, As, B and N</td>
<td>X X X X X X X</td>
</tr>
<tr>
<td>4.4 Tensile test</td>
<td>4.4 a) All steels: - All heats, both ends</td>
<td>YS, TS, El, RA</td>
<td>X X X X X X X</td>
</tr>
<tr>
<td></td>
<td>4.4 b) Stress relieved: - All heats, one end</td>
<td>YS, TS, El, RA</td>
<td>- X - X X - -</td>
</tr>
<tr>
<td></td>
<td>4.4 c) Made from coil: - All heats, centre lap</td>
<td>YS, TS, El, RA</td>
<td>- - X - - - -</td>
</tr>
<tr>
<td>4.5 Impact tests</td>
<td>4.5 a1) Longitudinal transverse specimens: - All heats, both ends</td>
<td>Single and average values, test temperature, transition curve plot</td>
<td>X X X X X X X</td>
</tr>
<tr>
<td></td>
<td>4.5 a2) Transverse specimens: - All heats, both ends</td>
<td>Single and average values, test temperature, transition curve plot</td>
<td>X X X X X X -</td>
</tr>
<tr>
<td>Type of test</td>
<td>Details</td>
<td>Reporting</td>
<td>Example cases:</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>4.5 b) Made from coil:</td>
<td>- All heats, centre lap</td>
<td>Single and average values, test temperature, transition curve plot</td>
<td>A  B  C  D  E  F  G</td>
</tr>
<tr>
<td>4.6 Strain age tests, 5% strained, 5% strained</td>
<td>- All heat, one end</td>
<td>Single and average values, test temperature, transition curve plot</td>
<td>X  X  X  X  X  -  -</td>
</tr>
<tr>
<td>4.7 Metallographic examination</td>
<td>- Microstructure photos at 100x and 500x</td>
<td></td>
<td>X  X  X  X  X  X  X</td>
</tr>
<tr>
<td>4.8 Drop Weight test</td>
<td>Reporting according to ASTM E208 A</td>
<td></td>
<td>-  X  X  X  -  -</td>
</tr>
<tr>
<td>4.9 a) Cross weld tensile test</td>
<td>Tensile Strength, location of fracture</td>
<td></td>
<td>-  -  X  X  X  -  -</td>
</tr>
<tr>
<td>4.9 b) Charpy V-notch test at WM, FL, FL+2 mm,</td>
<td>Specimens taken from 2 mm below parent material</td>
<td>Single and average values</td>
<td>-  -  X  X  X  -  -</td>
</tr>
<tr>
<td>4.9 c) Hardness test, HV-5</td>
<td>Hardness values</td>
<td></td>
<td>-  -  X  X  X  -  -</td>
</tr>
<tr>
<td>4.9 d) Cross weld tensile test</td>
<td>Tensile Strength, location of fracture</td>
<td></td>
<td>-  -  -  X  X  -  -</td>
</tr>
<tr>
<td>4.9 e) Charpy V-notch test at WM, FL, FL+2 mm,</td>
<td>Specimens taken from 2 mm below parent material</td>
<td>Single and average values</td>
<td>-  -  -  X  X  -  -</td>
</tr>
<tr>
<td>4.9 f) Hardness test, HV-5</td>
<td>Hardness values</td>
<td></td>
<td>-  -  -  X  X  -  -</td>
</tr>
<tr>
<td>4.10 Through thickness test</td>
<td>TS, RA, UT-report</td>
<td></td>
<td>-  -  -  X  X  -  -</td>
</tr>
</tbody>
</table>

Abbreviations: YS = Yield Stress, TS = Tensile Strength, El = Elongation, RA = Reduction of Area, WM = Weld Metal, FL = Fusion Line, UT = Ultrasonic Test, HAZ = Heat Affected Zone.
CHANGES – HISTORIC

There are currently no historical changes for this document.
Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16 000 professionals are dedicated to helping our customers make the world safer, smarter and greener.