RULES FOR CLASSIFICATION

Ships

Edition January 2017

Part 2 Materials and welding

Chapter 4 Fabrication and testing
FOREWORD

DNV GL rules for classification contain procedural and technical requirements related to obtaining and retaining a class certificate. The rules represent all requirements adopted by the Society as basis for classification.

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

If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of DNV GL, then DNV GL shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 2 million.

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CHANGES – CURRENT

This document supersedes the July 2016 edition.
Changes in this document are highlighted in red colour. However, if the changes involve a whole chapter, section or sub-section, normally only the title will be in red colour.

Main changes January 2017, entering into force 1 January 2017

- **Sec.1 General**
  - Sec.1 [1.3.1]: Reference to assignment of class has been deleted
  - Sec.1 [1.3.2]: Paragraph deleted
  - Sec.1 [1.3.3]: Applicable structures/components or WWA included
  - Sec.1 Table 2: Added reference for ISO 17662
  - Sec.1 Table 3: Reference to EN 1011-1 regarding thermal efficiency
  - Sec.1 Table 3: Heat input for multi-wire welding included
  - Sec.1 Table 3: Essential welding parameters included
  - Sec.1 Table 4: Clarification of applicability of WWA
  - Sec.1 Table 6: Additional description revised for welding
  - Sec.1 Table 7: Document type revised
  - Sec.1 Table 7: Additional description revised

- **Sec.3 Qualification of welders**
  - Sec.3 [2.1.1]: Reference to EN 287 deleted

- **Sec.4 Welding consumables**
  - Sec.4 [1.5.1]: Added steel groups
  - Sec.4 [1.5.4]: Added paragraph and reference for welding consumables for the repair of copper alloys
  - Sec.4 [1.5.5]: Added paragraph for welding consumables for other non-ferritic materials
  - Sec.4 [1.5.6]: Welding consumables for steel grades with minimum specified yield strength 890 and 960 MPa included
  - Sec.4 Table 6: Comment for welding consumables Y42
  - Sec.4 Table 7: Reference revised

- **Sec.5 Welding procedures**
  - Sec.5 [1.1.1]: BCA and COD grades included
  - Sec.5 [1.4.1]: Requirement for weldability of the base metal using high heat input welding deleted
  - Sec.5 [1.5.1]: Maximum thickness set for wide gap welding
  - Sec.5 [2.1.3]: Added Guidance Note for Calibration and validation
  - Sec.5 [2.1.6]: Weld bead included to weld parameters to be recorded
  - Sec.5 [2.1.7]: Added WPQR and corresponding
  - Sec.5 [3.1.1]: Guidance note revised
  - Sec.5 [3.1.2]: Paragraph transferred into guidance note
  - Sec.5 [3.2.5]: Mandrel diameter for SMYS > 690 MPa included
  - Sec.5 [3.6.1]: Added text for vertical-down fillet welds on structural steel grades A to F40
  - Sec.5 [5.3.2]: Maximum hardness limit for VL 890 and VL 960 included
  - Sec.5 [5.6.1]: Added text and guidance note / example for the qualification range of steels
— Sec.5 [6.2.2]: Deleted under d) first bullet point; new qualification only for TM steels not pre-qualified requested
— Sec.5 [6.2.6]: Information on consumable classification added
— Sec.5 [6.2.9]: Added exemption for SMAW in welding current change from A.C. to D.C.
— Sec.5 [8.2.3]: Added text in guidance note for essential parameters
— Sec.5 [8.3.2]: Added definition for t
— Sec.5 [9.2.2]: Adjusted text for Charpy V-notch locations acc. to the IGC code and added test temperature for austenitic stainless steels
— Sec.5 [11.2.1]: Added minimum
— Sec.5 [12.2.5]: Added paragraph for the macrosection
— Sec.5 Table 15: Filler grade 5556 included

• Sec.6 Fabrication and tolerances
— Sec.6 [5.2.3]: Added text and guidance note for representatively cold formed material
— Sec.6 [5.3.10]: Added text for tack welding - when integrated in production weld
— Sec.6 [6.1.2]: Added or and followed by

• Sec.7 Non destructive testing of welds
— Sec.7 [1.1.3]: Adjusted text for the inspection body to a guidance note

**Editorial corrections**

In addition to the above stated changes, editorial corrections may have been made.
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   8.3 Further limitations to the range of qualification

9 Additional requirements for welding procedure qualification test for liquefied gas systems
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   12.4 Branch connections
   12.5 Fillet welds
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SECTION 1 GENERAL

1 Introduction

1.1 Objective

1.1.1 This chapter provides requirements for fabrication and testing of welded structures and components.

1.2 Scope

1.2.1 This chapter contains requirements for:
— builders, manufacturers and subcontractors
— qualification of welders
— welding consumables
— welding procedures
— fabrication and tolerances
— non-destructive testing of welds
— structural and tightness testing
— goal-based ship construction standards for bulk carriers and oil tankers.

1.3 Application

1.3.1 Fabrication shall be carried out by certified welders and qualified welding operators with approved welding procedures and approved welding consumables.

1.3.2 Fabrication of important structures and components shall be carried out by an approved welding workshop (WWA), if not covered by an AoM. This is applicable to fabrication of important structures like, but not limited to:
— hull, superstructure taking part in the overall strength including blocks
— hull equipment, see Table 1
— machinery and systems, see Table 1

1.3.3 Welding Workshop Approval WWA, as given in [1.3.2], is generally not required for repairs or alterations to fleet in service.

Table 1 Applicable items

<table>
<thead>
<tr>
<th>Item</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull equipment and appendages</td>
<td></td>
</tr>
<tr>
<td>— Anchors</td>
<td>Pt.3 Ch.11 Sec.1</td>
</tr>
<tr>
<td>— Windlass and chain stoppers</td>
<td>Pt.3 Ch.11 Sec.1</td>
</tr>
<tr>
<td>— Propeller nozzles</td>
<td>Pt.3 Ch.11 Sec.4</td>
</tr>
<tr>
<td>— Propeller shaft brackets</td>
<td>Pt.3 Ch.13 Sec.1</td>
</tr>
<tr>
<td>Item</td>
<td>References</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>— Rudders, rudder horns and rudder trunks</td>
<td>Pt.3 Ch.13 Sec.1</td>
</tr>
<tr>
<td>— Container supporting fittings (e.g. raised ISO-foundations, flush/weld in foundations, lashing eye plates, D-rings, guide fittings)</td>
<td>Pt.5 Ch.2 Sec.1</td>
</tr>
<tr>
<td>— Container securing structure (e.g. lashing bridge, cell guide, container stanchions)</td>
<td>Pt.5 Ch.2 Sec.1</td>
</tr>
<tr>
<td>— Erected landing platform for helicopters</td>
<td>Pt.6 Ch.5 Sec.5</td>
</tr>
</tbody>
</table>

**Openings and closing appliance**

<table>
<thead>
<tr>
<th>Item</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>— Steel hatch covers and fittings</td>
<td>Pt.3 Ch.12 Sec.2</td>
</tr>
<tr>
<td>— Watertight doors and hatches</td>
<td>Pt.3 Ch.12 Sec.3</td>
</tr>
<tr>
<td>— Cargo hatch covers and fittings</td>
<td>Pt.3 Ch.12 Sec.4</td>
</tr>
<tr>
<td>— Side, stern and bow doors - ramps</td>
<td>Pt.3 Ch.12 Sec.5</td>
</tr>
<tr>
<td>— Windows, side scuttles and skylights</td>
<td>Pt.3 Ch.12 Sec.6</td>
</tr>
</tbody>
</table>

**Lifting appliance**

<table>
<thead>
<tr>
<th>Item</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>— Crane (safety related structure components like Crane jibs, crane houses, crane columns, foundations, hydraulic cylinders for lifting gear and luffing gear as well as for telescopic crane booms, derrick heel bearing and rotary bearing, screws for slew rings, load-bearing components of loose gear, axles, winch drums, winch frames and etc.)</td>
<td>DNVGL-ST-0377</td>
</tr>
<tr>
<td>— Crane (safe operation related components like hydraulic cylinders for slewing mechanisms, fittings, lateral wind bracings, rope-sheaves, hoisting eyes)</td>
<td>DNVGL-ST-0377</td>
</tr>
<tr>
<td>— Special lifting appliances</td>
<td>DNVGL-ST-0377</td>
</tr>
<tr>
<td>— Personnel lifts</td>
<td>DNVGL-ST-0377</td>
</tr>
<tr>
<td>— Assessories, such as: hooks, blocks, shackles, swivels, rings, chains, claws, clamps, pliers, load fastening ropes (slings/strops), lifting straps, etc.</td>
<td>DNVGL-ST-0377</td>
</tr>
<tr>
<td>— Launching appliances</td>
<td>LSA Code</td>
</tr>
<tr>
<td>— Accommodation ladder and gangway</td>
<td>MSC.1/Circ.1331</td>
</tr>
</tbody>
</table>

**Rotating machinery**

<table>
<thead>
<tr>
<th>Item</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>— Foundations for machinery</td>
<td>Pt.4 Ch.2 Sec.1</td>
</tr>
<tr>
<td>— Combustion engine, bed plate, thrust bearing</td>
<td>Pt.4 Ch.3 Sec.1</td>
</tr>
<tr>
<td>— Combustion engine, frame box</td>
<td>Pt.4 Ch.3 Sec.1</td>
</tr>
</tbody>
</table>
### 1.4 Relation to other Society documents

1.4.1 Where specific or additional requirements are provided in other parts of the rules, the specific or additional requirements are prevailing.

### 2 References

#### 2.1 External references

2.1.1 The external references given in Table 2 are referred in this chapter.

<table>
<thead>
<tr>
<th>Table 2 References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reference</strong></td>
</tr>
<tr>
<td>ANSI/AWS D1.1</td>
</tr>
<tr>
<td>ASME Section IX</td>
</tr>
<tr>
<td>ASTM E165</td>
</tr>
<tr>
<td>ASTM E562</td>
</tr>
<tr>
<td>Standard</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>ASTM G48</td>
</tr>
<tr>
<td>EN 1011-1</td>
</tr>
<tr>
<td>EN ISO 5817</td>
</tr>
<tr>
<td>EN ISO 6520-1</td>
</tr>
<tr>
<td>EN ISO 9712</td>
</tr>
<tr>
<td>EN ISO 10042</td>
</tr>
<tr>
<td>EN ISO 17635</td>
</tr>
<tr>
<td>IACS Rec. No.47</td>
</tr>
<tr>
<td>IACS UR S14</td>
</tr>
<tr>
<td>IACS UR W11</td>
</tr>
<tr>
<td>IACS UR W17</td>
</tr>
<tr>
<td>IACS UR Z23</td>
</tr>
<tr>
<td>ISO 148</td>
</tr>
<tr>
<td>ISO 3452</td>
</tr>
<tr>
<td>ISO 3834-2</td>
</tr>
<tr>
<td>ISO 4063</td>
</tr>
<tr>
<td>ISO 6507-1</td>
</tr>
<tr>
<td>ISO 9001</td>
</tr>
<tr>
<td>ISO 9015-1</td>
</tr>
<tr>
<td>ISO 9606</td>
</tr>
<tr>
<td>ISO 11666</td>
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<tr>
<td>ISO 10675</td>
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<td>ISO 14175</td>
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<tr>
<td>ISO 14341</td>
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<tr>
<td>ISO 14731</td>
</tr>
<tr>
<td>ISO 14732</td>
</tr>
<tr>
<td>ISO 15614-6</td>
</tr>
<tr>
<td>ISO 15614-7</td>
</tr>
</tbody>
</table>
2.2 Terminology and definitions

2.2.1 General terminology and definitions are given in Pt.1 Ch.1 Sec.1 [1.2]. Further definitions are given in Table 3.

Table 3 Definitions

<table>
<thead>
<tr>
<th>Automatic welding</th>
<th>Covers fully automatic processes, where all operations are mechanized and fully mechanized welding, where all main operations (excluding the handling of the work piece) are mechanized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential variables/parameters</td>
<td>Welding parameters essential for the range of validity of a welding procedure, see Sec.5 [6.2]</td>
</tr>
</tbody>
</table>
| Heat input | Energy introduced into the weld region during welding. Heat input is calculated as follows: 

\[
\text{Heat input (kJ/cm)} = \frac{\text{Volt} \times \text{Ampere} \times 6}{\text{Travel speed (cm/min)} \times 100}
\]

In case the heat input is corrected for thermal efficiency in accordance with EN 1011-1, the thermal efficiency coefficient shall be stated.

For multi-wire welding, the heat input is calculated as the sum of the heat inputs calculated separately for each wire. This do not apply if the interpass temperature between each wire is 250°C or lower |
| Inspection | An activity carried out by the builder or subcontractor to verify compliance with the applicable rules and specifications |
| Inspection body | An impartial body having the organisation, staffing, competence and integrity to perform to specified criteria functions such as assessing, recommending for acceptance and subsequent audit of manufacturers’ quality control operations, and selection and evaluation of products on site or in factories or elsewhere as directed, to specified criteria |
| Manual welding | Welding where the electrode holder, welding hand gun, torch or blowpipe is manipulated by hand |
New Building Survey Arrangement (NSA) | Agreement between the builder and the Society defining responsibility and authority of personnel and items to be controlled with acceptance criteria, quality control functions. The activities through this agreement are complementary to the Society’s own survey scheme

Semi-automatic welding | Same as partly mechanized welding: manual welding where the wire feed is mechanized

Quality management system | Quality management system worked out in accordance with a reputable quality standard, such as ISO 9001 or equivalent. The quality management system may be required to be certified by an accredited certification body

Supervisor | Responsible person who provides specific knowledge / expertise and who coordinates, monitors and regulates employees and their performance of assigned or delegated tasks, e.g. for welding and NDT

Subcontractor | Independent unit performing work under supervision by the builder

Welding, brazing, spraying | The term "welding", used in these rules also cover all other special thermal and/or mechanized joining processes such as brazing, spraying, etc. which require also pre-qualification for the personnel like brazer/sprayer tests or the procedures like brazing/spraying procedures. These rules shall be applied in an analogous manner to these special processes. Where no special provisions are made in these rules, the nature and scope of the pre-qualification tests and quality assurance measures required will be specified by the Society on a case-by-case basis

2.3 Abbreviations and symbols

2.3.1 Abbreviations and symbols are given in Ch.1 Sec.4.

3 Procedural requirements

3.1 Certification requirements

3.1.1 Organisations and personnel

General certification requirements are given in Ch.1 Sec.1 [3.1]. In addition, organisations and personnel shall be certified as required by Table 4.

Table 4 Certification requirements for organisations and personnel

<table>
<thead>
<tr>
<th>Object</th>
<th>Certificate type</th>
<th>Issued by</th>
<th>Certification standard*</th>
<th>Additional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding workshops</td>
<td>WWA</td>
<td>Society</td>
<td>*)</td>
<td>The welding workshop shall be approved for the relevant fields of application e.g. for welding of hull structures/equipment, machinery components, pressure equipment and piping systems. WWA certificate is not required if welding is carried out by an approved manufacturer qualified for welding.</td>
</tr>
<tr>
<td>Welders</td>
<td>Welders certificates</td>
<td>Society</td>
<td>See Sec.3</td>
<td>To be certified, see Sec.3</td>
</tr>
</tbody>
</table>
3.1.2 Materials
Welding related materials shall be certified as required by Table 5.

Table 5 Certification requirements for welding related materials

<table>
<thead>
<tr>
<th>Object</th>
<th>Certificate type</th>
<th>Issued by</th>
<th>Certification standard*</th>
<th>Additional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding consumables</td>
<td>TA</td>
<td>Society</td>
<td>See Sec.4</td>
<td>Welding consumables shall be type approved by the Society. See type approval programme DNVGL-CP-0069</td>
</tr>
<tr>
<td>Base materials for weld tests</td>
<td>MC</td>
<td>Society or Manufacturer</td>
<td>See Ch.1 and Ch.2</td>
<td>Base materials applied for WPQT</td>
</tr>
<tr>
<td>Shop primers</td>
<td>TA</td>
<td>Society</td>
<td>*)</td>
<td>See type approval programme DNVGL-CP-0109</td>
</tr>
</tbody>
</table>

*) Unless otherwise specified the certification standard is DNV GL rules

3.2 Documentation requirements

3.2.1 Documentation shall be submitted or available as required by Table 6 and Table 7.

Table 6 Documentation requirements – vessel

<table>
<thead>
<tr>
<th>Object</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>Info 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural fabrication</td>
<td>H130 - Fabrication specification</td>
<td>For builders unknown to the Society</td>
<td>FI, L, R</td>
</tr>
<tr>
<td></td>
<td>H131 - Non-destructive testing (NDT) plan</td>
<td></td>
<td>AP, L</td>
</tr>
<tr>
<td>Ship hull structure</td>
<td>H041 - Structural inspection plan</td>
<td></td>
<td>FI, L, R</td>
</tr>
<tr>
<td></td>
<td>H132 - Tank testing plan</td>
<td></td>
<td>AP, L</td>
</tr>
<tr>
<td></td>
<td>H133 - Erection and inspection plan</td>
<td></td>
<td>FI, L</td>
</tr>
<tr>
<td></td>
<td>H134 - Hole and penetration plan</td>
<td></td>
<td>FI, L, R</td>
</tr>
<tr>
<td></td>
<td>H140 - Welding tables</td>
<td></td>
<td>FI, L, R</td>
</tr>
<tr>
<td></td>
<td>H200 - Ship structure access manual</td>
<td></td>
<td>FI, L, R</td>
</tr>
<tr>
<td>Structural materials</td>
<td>M010 - Material specification, metals</td>
<td></td>
<td>FI, L, R</td>
</tr>
</tbody>
</table>
### M060 - Welding procedures (WPS)

Applicable for Vessel specific WPS not already approved

### M061 - Welding procedure qualification record (WPQR)

Applicable for Vessel specific WPQR not already approved. During qualification test welding, all welding parameters, see Sec. 5 [2.1.1], shall be recorded for each welding pass. The report summarizing the records from the welding and the test results, i.e. a welding procedure qualification record (WPQR), shall be prepared. The WPQR shall also give the material certificate of the base and filler materials applied in the WPQT

1) FI = For Information, AP = For Approval, L = by Local station, R = on Request. For full definition of abbreviations, see Pt. 1 Ch. 3 Sec. 2 Table 1

### Table 7 Qualification documentation for builder

<table>
<thead>
<tr>
<th>Item</th>
<th>Documentation type</th>
<th>Additional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull Survey for New Construction acc. to IACS UR Z23</td>
<td>Records</td>
<td>— The builder shall maintain the records acc. to IACS UR Z23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— the records shall be presented to the surveyor</td>
</tr>
<tr>
<td>Quality manual</td>
<td>Q010</td>
<td>To be submitted for information</td>
</tr>
<tr>
<td>Document control procedure</td>
<td>Q020</td>
<td>To be submitted for information</td>
</tr>
<tr>
<td>Welding workshop</td>
<td>WWA certificate</td>
<td>Evidence that all workshops (including subcontractors workshops), performing production welding according to [1.3] are qualified according to requirements given in Sec. 2</td>
</tr>
<tr>
<td>Welding operators</td>
<td>Records of proficiency</td>
<td>Evidence that the operators are receiving adequate regularly training in setting, programming and operating of the equipment (in accordance with an applicable WPS)</td>
</tr>
<tr>
<td>Welders’ list</td>
<td>Card index or register</td>
<td>Of all for the project relevant certified welders including information e.g. about welder approval range, date of initial test, validity, re-test/ prolongation, certification body</td>
</tr>
<tr>
<td>Welding consumables</td>
<td>Welding consumables list</td>
<td>List of all project relevant welding consumables and auxiliaries, e.g. wire-gas combination and wire-flux combinations, the DNV GL type approved grade and the base materials for which the consumable shall be applied</td>
</tr>
<tr>
<td></td>
<td>Procedure for storage and handling</td>
<td>The consumable manufacturer’s recommendations shall be observed and procedures giving details regarding conditions in storage rooms, temperature in storage ovens and quivers, length of exposure and conditions, as applicable shall be made available</td>
</tr>
</tbody>
</table>
3.2.2 For general requirements for documentation including definitions, see Pt.1 Ch.3.

3.3 Survey, inspection and testing requirements

3.3.1 General survey, inspection and testing requirements are given in Ch.1 Sec.1 [3.2] and in Table 8. Specific requirements are given in the following sections as relevant.

Table 8 Survey and testing requirements

<table>
<thead>
<tr>
<th>Survey, inspection and testing item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical composition</td>
<td>The chemical composition shall be analysed as specified in Ch.1 Sec.2 [3.2] and meet the requirements given herein</td>
</tr>
</tbody>
</table>
| Welding workshop approval          | — the welding workshop shall apply for the welding shop approval and provide an application together with the welding workshop description, as described in the relevant approval programme  
— the surveyor shall be given the opportunity to audit the workshop and survey all relevant processes and tests prior to start of fabrication |
| Mechanical properties including impact toughness, fracture mechanics, crack arrest properties, etc. | Mechanical properties shall be determined as specified in Ch.1 and meet the requirements given herein |
| Non-destructive testing            | — non-destructive tests shall be performed under the builder’s/manufacturer’s responsibility  
— the testing operators shall be certified in accordance with ISO 9712, ASNT ACCP or equal, as well as adequately qualified for this task  
— the surveyor shall be furnished with proof thereof if he so requests  
— when required, the surveyor shall be given the possibility to be present during non-destructive tests. See DNVGL-CG-0051 |
| Testing of welding consumables | — the appropriate type approval tests shall be carried out before the welding consumables are dispatched from the manufacturer  
|                               | — if the necessary facilities are not available at the manufacturer’s works, the testing shall be carried out at a recognized testing laboratory  
|                               | — where the Society’s certification is required, all the testing (except for chemical composition analysis) shall be witnessed by the surveyor, unless otherwise agreed  
|                               | — the surveyor may require further tests when deemed necessary  
|                               | — all tests shall be carried out by competent personnel on machines of accepted type. See DNVGL-CP-0069 |
| Testing of shop primer        | Where the Society’s certification is required, all testing shall be witnessed by the surveyor, unless otherwise agreed. See DNVGL-CP-0109 |
| Welder tests                 | Welding and testing of weld assemblies for welder certification by the Society shall be performed in the presence of the Society’s representative. Upon successful completion, and on client’s request, the Society will certify that the welder has passed the approval testing. |
| Welding procedure tests      | The welding procedure tests shall be arranged according to the requirements stated in Sec.5. Welding and testing of weld assemblies for welding procedure qualification shall be performed in the presence of the Society’s representative. |
SECTION 2 REQUIREMENTS FOR BUILDERS

1 General

1.1 Scope

1.1.1 This section specifies general requirements for builders, involved in building activities of structures and components intended for classification by the Society. This section shall also apply to subcontractors of builders, when performing fabrication under the Society's scope of classification.

1.1.2 Prior to commencement, builders unknown to the Society shall demonstrate their capability to carry out fabrication in line with the overall requirements of this section. All builders and subcontractors shall comply with the criteria given in IACS UR Z23 Hull Survey for New Construction and provide the documentation stated. For bulk carriers and oil tankers further requirements according to Sec.9 are given.

1.2 Certification requirements

1.2.1 Certification requirements are given in Sec.1 [3.1].

1.2.2 All builders and subcontractors that carry out production welding shall be approved by the Society with respect to their ability to perform the welding operations in question. The approval shall be documented by a welding workshop approval certificate.

Guidance note:
Welding workshop approval certificates issued by either of the former companies DNV AS or GL SE will be accepted provided the validity is maintained. For welding workshops not already approved by either of the legacies, a reasonable grace period for establishing such approval will be given.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.3 Documentation requirements

1.3.1 Documentation requirements are given in Sec.1 [3.2].

1.4 Survey, inspection and testing requirements

1.4.1 Survey, inspection and testing requirements are given in Sec.1 [3.3]. Additional specific requirements are given in Table 1, as further detailed in this section.

Table 1 Additional survey and testing requirements

<table>
<thead>
<tr>
<th>Survey, inspection and testing item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull survey for new construction in accordance with IACS UR Z23</td>
<td>Survey and testing requirements are covered by the Society's rules, IACS UR Z23 and Sec.9</td>
</tr>
<tr>
<td>Welding workshop approval</td>
<td>Workshop audits are required as specified in the relevant approval program</td>
</tr>
</tbody>
</table>
2 Survey arrangement

2.1 Quality management system

2.1.1 Builders of hull structures shall possess a documented and implemented quality management system. If not, the Society will consider an extended survey scheme. The extent of the quality management system shall be dependent on the size and type of the organization, complexity and interaction of the processes and personnel competence.

3 Workmanship and supervision

3.1 General

3.1.1 Builders and subcontractors shall ensure that the work is executed in accordance with fabrication procedures and work instructions, inspection and test plans.

3.1.2 Builders shall ensure that the work is effectively and systematically controlled at all stages. Builders and subcontractors will have to prove and document their abilities to carry out the welding operations in question. Further:

— builders and subcontractors shall inspect welding operations by the use of necessary equipment in order to assure compliance with the welding procedures
— builders shall present the results of own and subcontractors inspections before surveys by the Society
— important welding operations shall be carried out under daily supervision of a nominated qualified and experienced welding supervisor/inspector. The work of each welder shall be regularly examined.

3.1.3 Builders shall be in control of work performed at the location of subcontractors and of subcontractors performing work at the builders.
SECTION 3 QUALIFICATION OF WELDERS

1 General

1.1 Scope

1.1.1 These requirements apply to the Society’s acceptance of welders and welding operators for fusion welding of steel and non-ferrous metals.

1.2 Certification requirements

1.2.1 Certification requirements are given in Sec.1 [3.1]. Additional requirements are given in [2.1.1], [2.1.3] and [2.2].

1.3 Documentation requirements

1.3.1 Documentation requirements are given in Sec.1 [3.2].

1.4 Survey, inspection and testing requirements

1.4.1 General survey, inspection and testing requirements are given in Sec.1 [3.3]. Additional specific requirements are given in Table 1, as further detailed in this section.

Table 1 Additional survey and testing requirements

<table>
<thead>
<tr>
<th>Survey, inspection and testing item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welders’ list</td>
<td>The surveyor shall be allowed to examine the register at any time</td>
</tr>
</tbody>
</table>

1.5 Requirements for welding operators

1.5.1 Welding operators using fully mechanized or fully automatic processes shall have records of proficiency, which give evidence for that they are receiving adequate regularly training in setting, programming and operation of the equipment (in accordance with an applicable WPS).

1.5.2 The training of welding operators shall include training in evaluation of:
— groove dimensions according to WPS
— groove cleanliness requirements
— weather and wind requirements
— handling of welding consumables.

Appropriate records of training shall be maintained.

Guidance note:
Alternatively to training records, welding operators certificates according to a recognized standard may be accepted, e.g. ISO 14732, ASME Section IX or ANSI/AWS D1.1.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
2 Qualification testing and certification process of welders

2.1 General

2.1.1 Welders shall be certified to a standard recognised by the Society, e.g. ISO 9606, ASME Section IX, ANSI/AWS D1.1.

2.1.2 Recognition of other standards is subject to acceptance by the Society.

2.1.3 Builders and subcontractors shall keep a card index or register of all certified welders. The register shall give information on welders training, and date and results of qualification tests. Information about the base metal, type of welding consumable, joint design and welding positions shall be stated in the event of re-qualification tests.

2.1.4 A welder's certificate shall be validated every 6 months in line with the referred standard. Records thereof are required. The surveyor shall be allowed to examine the register at any time and the records/evidence shall be provided according to the relevant standards.

2.1.5 Separate fillet welder certification is required for the following, in which case tests on separate fillet weld test pieces are required:
   — vertical down fillet welding
   — where fillet welding is mostly used in the shop or structure
   — where fillet joint is deemed critical with regard to the structure.

2.2 Certification process

2.2.1 Welding and testing of weld assemblies for welder certification by the Society shall be performed in the presence of the Society’s representative. Upon successful completion, and on client’s request, the Society will certify that the welder has passed the approval test.

2.2.2 Where certification is performed by another recognized classification Society or independent organisations, recognition of such certification will be evaluated on a case by case basis. The Society reserves the right to require verification of welders qualifications when deemed necessary. Such verification may include testing prior to production, extra NDT and/or welding production tests (WPT).

Guidance note:
An independent organisation may be an accredited or nationally approved certification body.
SECTION 4 WELDING CONSUMABLES

1 General

1.1 Scope

1.1.1 This section specifies basic groups and grades for type approved welding consumables, application of the various grades, and grouping of the shielding gases.

1.2 Certification requirements

1.2.1 Certification requirements are given in Sec.1 [3.1].

1.3 Documentation requirements

1.3.1 Documentation requirements are given in Sec.1 [3.2].

1.4 Survey, inspection and testing requirements

1.4.1 General survey, inspection and testing requirements are given in Sec.1 [3.3].

1.5 Basic groups and grades

1.5.1 Welding consumables are divided into groups, depending on the strength of the filler metal, corresponding to the strength of the steel grade to be welded. The applicable groups are:

— normal strength steels
— high strength steels
— extra high strength steels
— boiler and pressure vessel steels
— steels for low temperature service
— stainless steels
— aluminium alloys.

The groups are further divided into grades depending on the impact test temperature and the chemical composition of the filler metal. The grades of welding consumables are specified in Table 1.
Table 1 Correlation of welding consumables to hull structural steels

<table>
<thead>
<tr>
<th>Grade of welding consumables</th>
<th>Normal strength steels</th>
<th>High strength steels</th>
<th>Extra high strength steels</th>
<th>Austenitic stainless steels</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2 Y</td>
<td>3/4/5 Y42</td>
<td></td>
<td>308/308Mo/308L</td>
</tr>
<tr>
<td>II</td>
<td>3 Y</td>
<td>III/IV/V Y42</td>
<td></td>
<td>309/309L/309Nb/309Mo</td>
</tr>
<tr>
<td>III</td>
<td>4 Y</td>
<td>3/4/5 Y46</td>
<td></td>
<td>310/310Nb/310Mo</td>
</tr>
<tr>
<td>I</td>
<td>5 Y</td>
<td>III/IV/V Y46</td>
<td></td>
<td>312</td>
</tr>
<tr>
<td>II</td>
<td>2/3/4/5 Y40</td>
<td></td>
<td></td>
<td>316/316L</td>
</tr>
<tr>
<td>III</td>
<td>I Y</td>
<td>III/IV/V Y50</td>
<td></td>
<td>317/317L</td>
</tr>
<tr>
<td></td>
<td>II Y</td>
<td></td>
<td></td>
<td>318</td>
</tr>
<tr>
<td></td>
<td>III Y</td>
<td>III/IV/V Y55</td>
<td></td>
<td>330</td>
</tr>
<tr>
<td></td>
<td>IV Y</td>
<td>III/IV/V Y55</td>
<td></td>
<td>347</td>
</tr>
<tr>
<td></td>
<td>V Y</td>
<td>III/IV/V Y62</td>
<td></td>
<td>349</td>
</tr>
<tr>
<td></td>
<td>II/III/IV/V Y40</td>
<td>III/IV/V Y62</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3/4/5 Y62</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>III/IV/V Y69</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3/4/5 Y69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) grades 1, 2, 3, 4 and 5 are referring to covered electrodes; grades I, II, III, IV and V are referring to other consumables
2) increasing number means increasing impact toughness test requirements (test temperature grade 1/I: 20°C, grade 5/V: -60°C)
3) Y means high strength steels
4) Y followed by a number means extra high strength steels of corresponding strength (×10)

1.5.2 Type approved welding consumables for austenitic stainless steels and ferritic-austenitic (duplex) steels shall be selected in accordance with manufacturers recommendations for the applicable grade of steel, taking the corrosion resistance, strength requirements and the welding metallurgy (including resistance to hot cracking) into account.

1.5.3 Welding consumables which have satisfied the requirements for a higher toughness grade are considered to comply with the requirements for a lower toughness grade of the same group.

1.5.4 Recommendations for welding consumables for the repair of copper alloys are given in Sec.5 Table 19.

1.5.5 Welding consumables for other non-ferritic materials shall be selected in accordance with manufacturer’s recommendations for the applicable materials, taking the corrosion resistance, strength requirements and the welding metallurgy (including resistance to hot cracking) into account.
1.5.6 The following tables (Table 2 to Table 7) show which welding consumables that can be applied for various steel grades.

For steel grades with minimum specified yield stress 890 and 960 MPa the welding consumables shall, unless otherwise agreed, give weld deposit with strength and impact toughness properties not below that of the material to be welded. The consumables shall have hydrogen mark H5 or better (e.g. H2.5).

When two different steel grades shall be joined, the welding consumable shall have yield strength not below that of the lower strength steel.

Guidance note:
When welding high strength steels of grade E, it is recommended that the applied welding consumables have been tested at –40°C (grade 4 or IV).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.5.7 Where applicable, the composition of the shielding gas shall be reported.
The approval of a wire/gas combination with any particular gas can be applied to or transferred to, any combination of the same wire and any gas in the same numbered group as defined in Table 8.

Table 2 Correlation of welding consumables (covered electrodes) to hull structural steels

<table>
<thead>
<tr>
<th>Hull structural steel grade</th>
<th>Grade of welding consumables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 (DP)</td>
</tr>
<tr>
<td>VL A</td>
<td>X</td>
</tr>
<tr>
<td>VL B</td>
<td>X</td>
</tr>
<tr>
<td>VL D</td>
<td>X</td>
</tr>
<tr>
<td>VL E</td>
<td>X</td>
</tr>
<tr>
<td>VL A275</td>
<td>X</td>
</tr>
<tr>
<td>VL D275</td>
<td>X</td>
</tr>
<tr>
<td>VL E275</td>
<td>X</td>
</tr>
<tr>
<td>VL A32/36</td>
<td>X</td>
</tr>
<tr>
<td>VL D32/36</td>
<td>X</td>
</tr>
<tr>
<td>VL E32/36</td>
<td>X</td>
</tr>
<tr>
<td>VL F32/36</td>
<td>X</td>
</tr>
<tr>
<td>VL A40</td>
<td>X</td>
</tr>
<tr>
<td>VL D40</td>
<td>X</td>
</tr>
<tr>
<td>VL E40</td>
<td>X</td>
</tr>
<tr>
<td>VL F40</td>
<td>X</td>
</tr>
</tbody>
</table>

1) to have hydrogen mark H15, H10 or H5
2) the welding consumables approved for VL A40 to VL F40 can be used for welding of normal strength steel subject to special agreement with Society
3) for plates with thickness over 50 mm, welding consumables with at least one toughness grade higher shall be used (e.g. for VL E36: 4Y instead of 3Y)
Table 3 Correlation of welding consumables (other than covered electrodes) to hull structural steels

<table>
<thead>
<tr>
<th>Hull structural steel grade</th>
<th>Grade of welding consumables</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></td>
<td>I</td>
<td>Y</td>
<td>II</td>
<td>Y</td>
<td>II Y40</td>
<td>III</td>
<td>Y</td>
<td>III Y40</td>
<td>IV Y</td>
<td>Y</td>
<td>IV Y40</td>
</tr>
<tr>
<td>VL A</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
</tr>
<tr>
<td>VL B</td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
<td>X</td>
<td>X 1)</td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
</tr>
<tr>
<td>VL D</td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
<td>X</td>
<td>X 1)</td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
</tr>
<tr>
<td>VL E</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
<td>X</td>
<td>X</td>
<td>X 1)</td>
</tr>
<tr>
<td>VL A27S</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VL D27S</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VL E27S</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VL A32/36</td>
<td>X 2)</td>
<td>X 2)</td>
<td>X 2)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VL D32/36</td>
<td>X 2)</td>
<td>X 2)</td>
<td>X 2)</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VL E32/36</td>
<td>X 2)</td>
<td>X 2)</td>
<td>X 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VL F32/36</td>
<td></td>
<td></td>
<td></td>
<td>X 2)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VL A40</td>
<td></td>
<td></td>
<td></td>
<td>X 2)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VL D40</td>
<td></td>
<td></td>
<td></td>
<td>X 2)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VL E40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X 2)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>VL F40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X 2)</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

1) the welding consumables approved as Y40 may be used for welding of normal strength steel subject to special agreement with the Society
2) for plates with thickness over 50 mm, welding consumables with at least one toughness grade higher shall be used (e.g. for VL E36: IV Y instead of III Y)

Table 4 Correlation of welding consumables (covered electrodes) to boilers and pressure vessel steels and steels for low temperature service

| For welding of steel grade | Grade of welding consumables |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|                           | 1(DP) | 2   | 2Y 1) | 2Y 40 1) | 3   | 3Y 1) | 3Y40 1) | 4Y 1) | 4Y40 1) | 5   | 5Y 1) | 5Y40 1) |
| VL 360-0N                 | X     | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   |
| VL 360-1FN                | X     | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   |
| VL 360-2FN                | X     | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   |
| VL 410-0N                 | X     | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   |
| VL 410-1FN                | X     | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   |
| VL 460-0N                 | X     | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   |
| VL 460-1FN                | X     | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   | X   |

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Fabrication and testing

DNV GL AS
Fabrication and testing

Table 5 Correlation of welding consumables (other than covered electrodes) to boilers and pressure vessel steels and steels for low temperature service

<table>
<thead>
<tr>
<th>For welding of steel grade</th>
<th>Grade of welding consumables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
</tr>
<tr>
<td>VL 360-0N</td>
<td>X</td>
</tr>
<tr>
<td>VL 360-1FN</td>
<td>X</td>
</tr>
<tr>
<td>VL 360-2FN</td>
<td></td>
</tr>
<tr>
<td>VL 410-0N</td>
<td>X</td>
</tr>
<tr>
<td>VL 410-1FN</td>
<td></td>
</tr>
<tr>
<td>VL 460-0N</td>
<td>X</td>
</tr>
<tr>
<td>VL 460-1FN</td>
<td></td>
</tr>
<tr>
<td>VL 490-0N</td>
<td>X</td>
</tr>
<tr>
<td>VL 490-1FN</td>
<td></td>
</tr>
<tr>
<td>VL 510-1FN</td>
<td>X</td>
</tr>
<tr>
<td>VL 2-2</td>
<td></td>
</tr>
<tr>
<td>VL 2-3</td>
<td></td>
</tr>
<tr>
<td>VL 2-4 (L)</td>
<td></td>
</tr>
<tr>
<td>VL 4-2</td>
<td></td>
</tr>
<tr>
<td>VL 4-3</td>
<td></td>
</tr>
<tr>
<td>VL 4-4 (L)</td>
<td></td>
</tr>
</tbody>
</table>

1) shall have hydrogen mark H15, H10 or H5
### Table 6 Correlation of welding consumables to hull structural steels

<table>
<thead>
<tr>
<th>For welding of steel grade</th>
<th>Grade of welding consumable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Y42H10 1) 2)</td>
</tr>
<tr>
<td></td>
<td>Y46H10 1)</td>
</tr>
<tr>
<td></td>
<td>Y50H10 1)</td>
</tr>
<tr>
<td></td>
<td>Y55H5</td>
</tr>
<tr>
<td></td>
<td>Y62H5</td>
</tr>
<tr>
<td></td>
<td>Y69H5</td>
</tr>
<tr>
<td>VL D420</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL E420</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL F420</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>5/V</td>
</tr>
<tr>
<td>VL D460</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL E460</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL F460</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL D47 2)</td>
<td>t ≤ 50 mm</td>
</tr>
<tr>
<td></td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>t &gt; 50 mm</td>
</tr>
<tr>
<td></td>
<td>4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>4/IV, 5/V</td>
</tr>
<tr>
<td>VL E47 2)</td>
<td>t ≤ 50 mm</td>
</tr>
<tr>
<td></td>
<td>4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>t &gt; 50 mm</td>
</tr>
<tr>
<td></td>
<td>5/V</td>
</tr>
<tr>
<td></td>
<td>5/V</td>
</tr>
<tr>
<td>VL D500</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL E500</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL F500</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>5/V</td>
</tr>
<tr>
<td>VL D550</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL E550</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL F550</td>
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</tr>
<tr>
<td></td>
<td>4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>5/V</td>
</tr>
<tr>
<td>VL D620</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL E620</td>
<td>3/III, 4/IV, 5/V</td>
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<tr>
<td>VL F620</td>
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</tr>
<tr>
<td></td>
<td>4/IV, 5/V</td>
</tr>
<tr>
<td></td>
<td>5/V</td>
</tr>
<tr>
<td>VL D690</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL E690</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
<tr>
<td>VL F690</td>
<td>3/III, 4/IV, 5/V</td>
</tr>
</tbody>
</table>

1) may have hydrogen mark H5
2) shall have hydrogen mark H5
3) the welding consumables approved as Y42 may be used for welding of high strength steel subject to special agreement with the Society

### Table 7 Selection of suitable consumables for combinations of aluminium alloys

<table>
<thead>
<tr>
<th>Base metal alloy</th>
<th>VL 5052, VL 5754</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VL 5154, VL 5454</td>
</tr>
<tr>
<td></td>
<td>VL 5086</td>
</tr>
<tr>
<td></td>
<td>VL 5052, VL 5754</td>
</tr>
<tr>
<td></td>
<td>VL 5154, VL 5454</td>
</tr>
<tr>
<td></td>
<td>VL 5086</td>
</tr>
<tr>
<td></td>
<td>VL 5083</td>
</tr>
<tr>
<td></td>
<td>VL 5383</td>
</tr>
<tr>
<td></td>
<td>VL 5059</td>
</tr>
<tr>
<td></td>
<td>VL 6060, VL 6061</td>
</tr>
<tr>
<td></td>
<td>VL 6063, VL 6005A</td>
</tr>
<tr>
<td></td>
<td>VL 6082</td>
</tr>
</tbody>
</table>
### Table 8 Grouping of shielding gases

<table>
<thead>
<tr>
<th>Group</th>
<th>CO₂</th>
<th>O₂</th>
<th>H₂</th>
<th>He</th>
<th>Ar²</th>
</tr>
</thead>
<tbody>
<tr>
<td>I 1</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>I 2</td>
<td></td>
<td></td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>I 3</td>
<td>0 to 5</td>
<td>-</td>
<td>0 to 5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>M 11</td>
<td></td>
<td></td>
<td>-</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>M 12</td>
<td>0 to 5</td>
<td>-</td>
<td>-</td>
<td>0 to 95</td>
<td>-</td>
</tr>
<tr>
<td>M 13</td>
<td>-</td>
<td>0 to 3</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M 14</td>
<td>0 to 5</td>
<td>0 to 3</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M 21</td>
<td>5 to 25</td>
<td>-</td>
<td>-</td>
<td>Rest</td>
<td>Rest</td>
</tr>
<tr>
<td>M 22</td>
<td>-</td>
<td>3 to 10</td>
<td>-</td>
<td>Rest</td>
<td>Rest</td>
</tr>
<tr>
<td>M 23</td>
<td>5 to 25</td>
<td>0 to 8</td>
<td>-</td>
<td>Rest</td>
<td>Rest</td>
</tr>
<tr>
<td>M 31</td>
<td>25 to 50</td>
<td>-</td>
<td>-</td>
<td>Rest</td>
<td>Rest</td>
</tr>
<tr>
<td>M 32</td>
<td>-</td>
<td>10 to 15</td>
<td>-</td>
<td>Rest</td>
<td>Rest</td>
</tr>
<tr>
<td>M 33</td>
<td>5 to 50</td>
<td>8 to 15</td>
<td>-</td>
<td>Rest</td>
<td>Rest</td>
</tr>
<tr>
<td>C 1</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C 2</td>
<td>Rest</td>
<td>0 to 30</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) the compositions of shielding gases in group I are in accordance with ISO 14175, while group M and C gases are in accordance with IACS UR W17

2) argon may be partly substituted by helium up to 95% of the argon content

Note: All consumables are covered by the AWS specification. The prefix “ER” is omitted.

1) other consumables may be used if allowable stresses are reduced, see Sec.5 Table 14
SECTION 5 WELDING PROCEDURES

1 General

1.1 Scope

1.1.1 This section specifies requirements for welding procedure specifications (WPS) and welding procedure qualification tests (WPQT) for:

— carbon-manganese steels (C-Mn) and low alloy steels
— austenitic stainless steel
— ferritic-austenitic (duplex) stainless steels
— aluminium alloys
— copper alloys.

Additional requirements for BCA and COD grade steels, materials for liquefied gas systems and repair welding of steel castings are also given.

1.1.2 WPS for overlay/clad welding shall be qualified according to ISO 15614-7, ASME IX or another recognized standard.

1.1.3 WPS for materials not covered by this section shall be qualified in accordance with a recognized standard or a recognized practice accepted by the Society.

1.1.4 Method and general requirements for mechanical testing shall follow Ch.1.

1.1.5 This version of the Society’s rules do not invalidate welding procedure qualifications tests made and accepted by either of the former companies DNV AS or GL SE before 1st of January 2016 provided the welding procedures are made and accepted according to the DNV or GL classification rules if the validity is maintained.

In case of doubt the Society shall decide whether the already accepted welding procedures can be further applied or not.

1.2 Certification requirements

1.2.1 Certification requirements are given in Sec.1 [3.1].

1.3 Documentation requirements

1.3.1 Documentation requirements are given in Sec.1 [3.2]. Additional specific documentation requirements are given in Table 1.

Table 1 Qualification documentation for builder

<table>
<thead>
<tr>
<th>Item</th>
<th>Documentation type</th>
<th>Additional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pWPS</td>
<td>Preliminary welding procedure specification</td>
<td>The builder or subcontractor shall submit to the Society a preliminary welding procedure specification (pWPS) for review prior to the WPQT. The pWPS shall give all relevant parameters as required in [2.1.1]</td>
</tr>
</tbody>
</table>
### 1.4 Survey, inspection and testing requirements

1.4.1 General survey, inspection and testing requirements are given in Sec.1 [3.3]. Additional specific requirements are given in Table 2, as further detailed in this section.

#### Table 2 Additional survey and testing requirements

<table>
<thead>
<tr>
<th>Survey, inspection and testing item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base material used for welding procedures</td>
<td>The base materials shall be identified by means of material marking and certificates</td>
</tr>
<tr>
<td>Consumables used for welding procedures</td>
<td>The consumables shall be approved by the Society. Non-approved consumables may be accepted for qualification of a WPS</td>
</tr>
<tr>
<td>Non-destructive testing</td>
<td>Test pieces for the welding procedure qualification shall be subject to non-destructive testing as specified herein. Waiting time for performance of NDT shall be observed. NDT shall be carried out before the test piece is dispatched.</td>
</tr>
<tr>
<td>WPS</td>
<td>WPS shall be approved by the Society prior to production welding</td>
</tr>
</tbody>
</table>
| WPQR | — welding of weld assemblies for welding procedure qualification shall be performed in the presence of the Society’s representative  
— where the Society’s certification is required, all the testing (except for chemical composition analysis) shall be witnessed by the surveyor, unless otherwise agreed |
| WPQT for fully mechanized or automatic welding process | If the test coupon is not welded in the comparable environment as the production condition or if the manufacturer has no or limited experience with the process and equipment, the first fabrication welds shall be included as part of the welding procedure tests and, as a minimum requirement, shall be subjected to non-destructive testing |
| WPT - additional requirements for liquefied gas systems | Welding production test is required in accordance with [9.4] |
| Corrosion test – stainless steels | Corrosion tests are required as described in [10] and [11] |
| Metallographic examination – ferritic-austenitic steels | Microstructural examination is required as described in [10] |
1.5 Wide gap welding

1.5.1 Wide gap welding for butt joint shall be qualified by a separate WPQT when the gap is more than 16 mm and up to maximum 1.5t×t (max. 25 mm), where t is the plate thickness. The largest gap in production (for remedial welding) shall be used.

Buttering of the weld groove shall be qualified by a separate WPQT for the following cases:

— the buttering process essential variables are different from the essential variables of the process used for subsequent completion of the joint
— the thickness of the buttering exceeds 8 mm.

For the WPQT to be qualified the buttered area shall be 100% tested with MT (ferromagnetic materials) or PT (non-magnetic materials) before the filling of the groove starts. No surface linear indications are accepted.

**Guidance note:**
For typical butt- and fillet weld plate edge preparation repairs, guidance is given to IACS Rec. No.47 Shipbuilding and Repair Quality Standard, Part A.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.6 Welding processes

1.6.1 Welding shall be performed with the following processes unless otherwise approved (methods numbering system in accordance with ISO 4063):

— 111 Manual metal arc welding (metal arc welding with covered electrode, SMAW)
— 114 Self-shielded tubular-cored arc welding (FCAW-S)
— 121 Submerged arc welding (SAW) with solid wire electrode
— 122 Submerged arc welding (SAW) with strip electrode
— 124 Submerged arc welding (SAW) with metal powder addition
— 125 Submerged arc welding (SAW) with tubular cored electrode
— 131 Metal inert gas welding (MIG, GMAW) welding with solid wire electrode
— 132 Metal inert gas welding (MIG, FCAW-G) with flux cored electrode
— 135 Metal active gas welding (MAG, GMAW) with solid wire electrode
— 136 Metal active gas welding (MAG, FCAW-G) with flux cored electrode
— 138 Metal active gas welding (MAG) with metal cored electrode
— 141 Gas tungsten arc welding (TIG, GTAW) with solid filler material (wire/rod)
— 15 Plasma arc welding.

1.6.2 Other processes and high heat input welding (> 50 kJ/cm) shall be specially approved.
2 Welding procedure specification

2.1 General

2.1.1 A WPS shall as a minimum contain the following information as relevant for the welding operation:

- identification of builder or subcontractor (name, address)
- identification of the WPS and reference to the WPQR
- welding process(es), including the order of processes if more than one process is used
- number and configuration of electrodes for multi-wire welding
- welding position(s) and direction of progression
- joint type
- backing and backing material
- preheat and interpass temperatures
- post-weld heat treatment details (temperature, time, etc.)
- method of preparation including cleaning process
- material: standard, grade and modification, delivery conditions (AR, N, NR, TM, QT), carbon equivalent (when relevant)
- nominal thickness or diameter range (dimensions)
- welding consumables: trade name, electrode or wire diameter, shielding gas type, purity and flow rate, flux and recognised classification
- joint or groove design with tolerances of angles, root face and root gap. Throat thickness range for fillet welds
- welding sequence: number and order of passes or layers
- electrical parameters: voltage range, current range, polarity, pulse welding details (machine settings and/ or program selection)
- travel speed ranges
- heat input ranges at least for root, fill and cap passes
- details on cleaning processes employed and restrictions if any
- minimum length of tack welds, when relevant
- type and coating thickness of overweldable shop primer for fillet welding if automatic welding is applied.

2.1.2 The builder or subcontractor shall submit to the Society a preliminary welding procedure specification (pWPS) for review prior to the WPQT. The pWPS shall give all relevant parameters as required in [2.1.1]. The pWPS may be modified and amended during the procedure welding as deemed necessary. In case that the test pieces welded according to the pWPS show unacceptable results, the pWPS shall be adjusted by the builder or subcontractor. The new pWPS shall be prepared and the test pieces shall be welded in accordance with the new pWPS.

2.1.3 All relevant instruments for checking of welding parameters (e.g. temperature, ampere, volt) applied for the WPQT shall have valid calibration certificates and the adequacy of any control software shall be documented.

Guidance note:
Calibration and validation in accordance with ISO 17662 is recommended.

---end of guidance note---

2.1.4 Qualification welding shall be performed under general conditions representative of the actual working environment for the work shop site where the production welding will be performed.

2.1.5 The test results shall meet the specified minimum requirements given in this standard in order to be valid for qualification of a WPS.
2.1.6 During qualification test welding, all welding parameters, (see [2.1.1]) and the weld bead width shall be recorded for each welding pass. A report summarizing the records from the welding and the test results, i.e. a welding procedure qualification record (WPQR), shall be prepared. The WPQR shall give the material certificate of the base and filler materials applied in the WPQT.

2.1.7 Upon satisfactory completion of the required tests, the Society may approve the WPQR and the corresponding WPS. The approval range shall be in compliance with the requirements given in [6].

2.2 Approval of welding procedure specification

2.2.1 WPS shall be approved by the Society prior to welding.

2.2.2 A WPS will be approved based on one of the following alternatives:

a) review of a WPQR corresponding to the WPS in question. The WPQT on which the WPQR is based shall be witnessed by the Society or by a party recognized by the Society
b) review and verification of documentation showing successful application of the WPS over a prolonged period of time
c) the WPS is compiled on basis of other approved WPS.

2.2.3 For the following applications the approval of WPS shall be based on alternative [2.2.2] a):

— all welds in aluminium
— butt welds and essential fillet welds used in cargo tanks, hull structure and process pressure vessel and piping systems for liquified gases
— piping systems in ferritic-austenitic stainless steels
— butt welds in plate thickness above 50 mm
— butt welds for heat input more than 50 kJ/cm
— butt welds of material grade E and F
— single run butt welds
— all welds in the vertical down positions
— welded connections between castings/forgings and rolled material, such as e.g. stern frames, rudder, rudder horns and struts
— welding of highly stressed butt welds and cruciform joints located at large hatch openings
— all welds on grades VL D/E 47 steels for container vessels.

2.2.4 One or more WPS(s) may be prepared based on the data of one or more accepted WPQR(s) provided the essential variables are kept within the acceptable limits. All limits and ranges for the applicable essential variables for the welding to be performed shall be stated in the WPS.

Guidance note:
The number of WPQRs (alternative a) used for the preparation of a new WPS should not exceed 6. The number of WPSs (alternative c) used for the preparation of a new WPS should not exceed 3 where each of these 3 WPSs are approved by the Society. When a new WPS is based on several WPQRs or WPSs the builder should prepare an overview indicating the overlap of each essential variable as specified in the Society's rules.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.2.5 For multi-process procedures the WPS approval shall be carried out by:

— separate WPQTs for each welding process, or
— a multi-process procedure test. The approval of a multi-process procedure test is only valid for the process sequence carried out for the qualification test.
3 Welding procedure qualification test assembly and sampling of test pieces

3.1 General

3.1.1 The base materials used for welding procedures shall be identified by means of material marking and certificates. The material shall be certified with a VL or works (W) certificate. For definition of certificate types, see Pt.1 Ch.1 Sec.4 [2.1.1].

Guidance note:
Requirements for impact toughness testing of base materials are given in Ch.2. Some welding procedures require impact testing at different material thicknesses, e.g. centre of plate. Certification of the base materials according to Ch.2 do not necessarily require impact toughness testing of all material thickness positions relevant for welding. Where relevant, the purchaser is recommended to order steel with adequate impact toughness at relevant plate thickness positions.

Guidance note:
For qualification of procedures for high heat input welding, the hull structural steels should be qualified accordingly for the maximum heat input.

3.1.2 For welding procedure qualification tests of partial penetration welds, including partial penetration T-butt welds, the test conditions including all essential variables, test specimens and acceptance criteria shall be agreed on a case by case basis with the Society.

3.2 Butt welds in plates

3.2.1 The test assembly shall consist of two plates welded together. For rolled plates, impact tested in the longitudinal direction (KV\textsubscript{L}-tested, see Figure 1), the butt weld of the test assembly is perpendicular to the rolling direction of the two plates. For extra high strength steel grades, impact tested in the transverse direction (KV\textsubscript{T}-tested, see Figure 1), the butt weld of the assembly is parallel to the rolling direction of the two plates.

As far as possible the plates shall have a size which can simulate the heat transfer during the production welding. For manual or semiautomatic welding, a test assembly according to Figure 1 shall be carried out with:

\[
\begin{align*}
l_{\text{min}} &= 300 \text{ mm} \\
L_{\text{min}} &= 350 \text{ mm}
\end{align*}
\]

For automatic welding, the dimensions shall be:

\[
\begin{align*}
l_{\text{min}} &= 400 \text{ mm} \\
L_{\text{min}} &= 1000 \text{ mm}
\end{align*}
\]

Guidance note:
An increase of the minimum test piece length \(l_{\text{min}}\) may be needed if additional specimens like the round tensile test from the weld metal are included.

Edge preparation and fit-up shall be as detailed in the pWPS. The plates shall be joined and held by tack welds to provide the correct gap for the edge preparation used. 50 mm of each end of the test piece shall be discarded.
**Figure 1 Test assembly for butt welds in plates**

**3.2.2** The first fabrication welds shall be included as part of the welding procedure tests if:
- the test coupon for approval of WPS for fully mechanized or automatic welding process is not welded in the comparable environment as the production condition or
- if the manufacturer has no or limited experience with the process and equipment.

For both cases the first fabrication welds shall be included as part of the welding procedure tests and be subjected to non-destructive testing.

**3.2.3** The following mechanical tests are required from each assembly, see Figure 2:
- 2 tensile tests (flat specimen transverse to the weld)
- 2 root and 2 face bend specimens shall be tested. For thickness 12 mm and over, 4 side bend specimens may alternatively be tested
- at least 9 Charpy V-notch specimens with the notch location as given in [3.2.8]. Depending on the type of joint (one side or both side), the heat input and the plate thickness, more than 9 specimens are required
- 1 macrosection test (metallographic examination + hardness measurements)
- 1 extra tensile test (round specimen from the weld metal) when the welding consumable is not type approved (valid for one year, unless the welding consumable is type approved, see guidance note)
- Specimens for transverse tensile testing shall be in accordance with Ch.1 Sec.3 [3.1.14]. Location of fracture (WM or BM), and tensile strength shall be reported.

**Guidance note:**
Non-approved consumables may be accepted for qualification of a WPS. Consumables for production welding shall be approved by the Society as required in Sec.1 [1.3].
3.2.4 When round tensile test specimen is required, the specimen shall be machined to the dimensions given in Ch.1 Sec.3 [3.1.14]. Care shall be taken so that the longitudinal axis coincides with the intersection between the mid-plane of the weld, and the mid-plane of the plates. If the section area of the weld metal is too small to allow sampling of the round specimen, an all-weld-metal tensile test shall be carried out.

3.2.5 Transverse side bend, root bend and face bend specimens shall be machined to the dimensions shown in Ch.1 Sec.3 [3.3]. For a mixed or heterogeneous butt joint, longitudinal bend test specimens may be replaced by transverse bend test specimens. For normal and high strength steels, the test specimens shall be bent on a mandrel with diameter $4 \times t$ where $t$ is the thickness of the specimen. For extra high strength steels with SMYS 420, 460, 500 the mandrel diameter shall be $5 \times t$ and for steels levels 550, 620 and
690 the mandrel diameter shall be 6 × t. For SMYS > 690 MPa, the mandrel diameter shall be agreed. The bending angle shall be minimum 180°.

3.2.6 The macrosection shall include about 10 mm of unaffected base material and shall be prepared and etched on one side to clearly reveal the fusion line and the HAZ.

3.2.7 The hardness testing shall be in accordance with ISO 6507-1 and ISO 9015-1 or equivalent. This is only required for grades with specified minimum yield strength 265 MPa and higher. Unless otherwise agreed, the Vickers method (HV10) is used. Indentations shall be made along traverses in the weld, HAZ and the parent metal; maximum 2 mm below the surface, see Figure 3. For each traverse, a minimum of 3 indentations shall be made in the weld, HAZ (both sides) and parent metal (both sides), see Figure 4. For HAZ the first indentation shall be placed as close to the fusion line as possible. For double sided welds, for fillet and T-butt welds, one additional row of indentations shall be made through the root area. For material grade VL D/E 47, one additional row of indentations shall be made from the mid-thickness of the plate.

Figure 3 Examples of hardness test with rows of indentations in butt welds
**Figure 4 Example of hardness indentations in butt welds**

3.2.8 The Charpy V-notch specimens shall be machined in accordance with the requirements given in Ch.1 Sec.3 [3.2]. Three sets of three specimens each shall be sampled 1 - 2 mm below the surface of the parent material and transverse to the weld. The V-notch shall be perpendicular to the plate surface.

At least 9 Charpy V-notch specimens shall be localized in the welded joint as follows:

- 3 specimens with the notch along the weld metal centerline (WM)
- 3 specimens with the notch in the fusion line (FL)
- 3 specimens with the notch in the HAZ, 2 mm from the fusion line (FL+2)
- Additional Charpy V-notch specimens with notch location(s) shall be tested as indicated in Figure 5, Figure 6 and Table 3.

For a single- or double bevel groove preparation the location of the impact test specimens shall be taken from the vertical side of the groove (without the bevel).
Figure 5 Locations of V-notch for butt weld of normal heat input (heat input ≤ 50 kJ/cm)
Figure 6 Locations of V-notch for butt weld of high heat input (heat input > 50 kJ/cm)

Table 3 Notch location of Charpy V-notch impact test

<table>
<thead>
<tr>
<th>Type of butt weld joint</th>
<th>Heat input (kJ/cm)</th>
<th>Plate thickness, t (mm)</th>
<th></th>
<th>Notch location</th>
</tr>
</thead>
<tbody>
<tr>
<td>One side</td>
<td></td>
<td></td>
<td></td>
<td>Cap</td>
</tr>
<tr>
<td></td>
<td>≤ 50</td>
<td>≤ 20</td>
<td>WM, FL, FL+2</td>
<td>WM, FL, FL+2</td>
</tr>
<tr>
<td></td>
<td>20 &lt; t ≤ 50</td>
<td>≤ 20</td>
<td>WM, FL, FL+2</td>
<td>WM, FL, FL+2</td>
</tr>
<tr>
<td></td>
<td>&gt; 50</td>
<td>≤ 20</td>
<td>WM, FL, FL+2</td>
<td>WM, FL, FL+2</td>
</tr>
<tr>
<td></td>
<td>50 &lt; E ≤ 200</td>
<td>≤ 20</td>
<td>WM, FL, FL+2, FL+5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>&gt; 20</td>
<td>≤ 20</td>
<td>WM, FL, FL+2, FL+5</td>
<td>WM, FL, FL+2</td>
</tr>
<tr>
<td></td>
<td>&gt; 200</td>
<td>≤ 20</td>
<td>WM, FL, FL+2, FL+5, FL+10</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes:
1. For one side welding with thickness over 20 mm notch locations "a", "b" and "c" are to be added on root side.
3.2.9 For austenitic stainless steels with service temperature above –105°C, HAZ impact test specimens are not required unless otherwise specified. For material thicknesses below 6 mm impact testing is not required unless specifically required by the Society.

Where multiple welding processes are qualified in a single test piece, impact test specimens shall be taken from the weld metal and HAZ that include each process. This does not apply to the process and consumables used to make the first weld run or root deposit of a multipass weld.

For dissimilar material grade and joints between cast or forged and rolled materials, impact tests shall be carried out on test specimens with notch in fusion line and 2 mm from fusion line in each parent material.

3.2.10 Where fracture mechanics testing (e.g. CTOD test) is required by the relevant rules, it shall be carried out in accordance with Ch.1 Sec.3 [3.9]. Acceptance criteria are given in [5.7] and [8.2.3].

Fracture mechanics testing of the base material, weld deposit or HAZ may be omitted based on a case-by-case approval. In this case, tests with satisfactory results shall have been carried out previously, by either the steel manufacturer or the welding consumable manufacturer. This provided that the tested base material, weld deposit or HAZ is representative.

3.3 Butt welds in pipes

3.3.1 The test assembly shall be in accordance with Figure 7.

![Figure 7 Test assembly for butt welds in pipes](image)

Figure 7 Test assembly for butt welds in pipes

\[ a = \text{minimum value 150 mm} \]
\[ D = \text{outside diameter.} \]

3.3.2 The following mechanical tests are required from each assembly, see Figure 8:
— 2 tensile test (flat specimen transverse to the weld)
— 2 root and 2 face bend tests when \( t < 12 \text{ mm} \) and 4 side bend tests when \( t \geq 12 \text{ mm} \)
— 3 sets of 3 Charpy V-notch specimens with the notch location as given in [3.2.8]
— for pipe thickness > 20 mm with one side welding, one additional set of specimens shall be taken from the root area as given in [3.2.8]
— 1 macrosection test (metallographic examination + hardness measurements).

![Figure 8 Sampling of test specimens in pipes](image)

3.4 Full penetration TKY joints for plates

3.4.1 WPQT’s for full penetration groove welds between plates at right angles or inclined, i.e. T- or K- or Y-configurations, shall cover a weld length of minimum 350 mm, see Figure 9. The test assembly shall consider the rolling direction, as for the butt welds, see [3.2.1].
3.4.2 The following mechanical tests are required from each assembly, see Figure 10:
- 3 sets of Charpy V-notch tests with the notch location as given in [3.2.8], see guidance note
- for web plate thickness > 20 mm with one side welding, one additional set of specimens shall be taken from the root area as given in [3.2.8], see guidance note
- 1 macrosection test (metallographic examination + hardness measurements).

Guidance note:
If the flange thickness is < 30 mm and therefore Charpy V-notch specimens can’t be machined, qualification tests on butt welds may be performed as an alternative. In this case, with comparable welding parameters as for the full penetration T-joint.

3.4.3 Tests as detailed do not provide information on the tensile strength of the joint. Where the tensile strength properties are relevant for the application an additional butt weld qualification shall be performed using the same welding parameters.
3.5 Branch connection

3.5.1 The following mechanical tests are required from each assembly, see Figure 11:
- 3 sets of Charpy V-notch tests sampled at 9 o'clock in the branch pipe and with the notch location as given in [3.2.8]
- for plate thickness > 20 mm with one side welding, one additional set of specimens shall be taken from the root area as given in [3.2.8]
- two (2) macrosection tests (metallographic examination + hardness measurements), one at 12 and one at 6 o'clock.

3.5.2 For joint configuration involving acute angles (less than 15°), restrictions and testing should be specified and accepted by the Society prior to qualification.
Figure 11 Test assembly for branch connections

- $a$ = minimum value 150 mm
- $D_1$ = outside diameter of the main pipe
- $t_1$ = wall thickness of the main pipe
- $D_2$ = outside diameter of the branch pipe
- $t_2$ = wall thickness of the branch pipe
- $\alpha$ = branch connection angle.

3.6 Fillet welds

3.6.1 For fillet welds, the two plates are assembled and positioned edgewise so as to constitute a tee-assembly with no clearance. For plate fillet welds, the test assembly shall be as defined in Figure 12, except for vertical-down fillet welds on structural steel grades A to F40. For vertical-down fillet welds the test assembly shall be as defined in Figure 13 or Figure 14. For pipe fillet welds the test assembly shall be as defined in Figure 15.
For manual and semi-automatic welding the length of the test piece shall be:

\[ L_{\text{min}} = 350 \text{ mm} \]

For automatic welding the length shall be:

\[ L_{\text{min}} = 1000 \text{ mm} \]

**Figure 12 Test assembly for plate fillet welds**

**Figure 13 Double T- joint (cruciform) plate test piece for manual and semi-automatic welding procedures**
Weld and fit-up shall be as detailed in the pWPS. The test assembly shall be welded on one side only. However, for automatic two side fillet welding (tandem technique), welding from two sides is acceptable. For manual and semi-automatic welding, the stop/restart position shall be included in the test length unless otherwise agreed, and shall be clearly marked for subsequent examination. The ends of the specimen are exempted from examination over a length of 50 mm.

When the automatic fillet welding procedure is intended for plates and sections coated with overweldable shop primer, similarly coated plates shall be used for the qualification. The type of the shop primer and the dry film thickness shall be recorded in the WPQR.
3.6.2 The following destructive tests shall be performed:

— two macrosection tests (metallographic examination, hardness measurements). One of the macrosections shall be taken at the marked position of the stop/restart, for more details see [3.2.6]. For hardness testing, see Figure 16, Figure 17 and [3.2.7].

— one fracture test. Shall be performed by folding the upright plate onto the through plate. Evaluation shall be concentrated on cracks, porosity and pores, inclusions, lack of fusion and incomplete penetration. Imperfections that are detected shall be assessed in accordance with EN ISO 5817 quality level B

— tests as detailed do not provide information on the mechanical properties of the joint. Where these properties are relevant for the application, an additional butt weld qualification shall be performed using the same welding parameters.

When the shop primer is not approved, see Sec.6 [3], extra testing according to DNVGL-CP-0109 is required.

[Image: Examples of hardness test with row indentation (R) in fillet welds and in T-joint welds]

Figure 16 Examples of hardness test with row indentation (R) in fillet welds and in T-joint welds

[Image: Example showing the position of the indentations for hardness test in the weld metal, the heat affected zone and the base metal of a fillet weld (dimensions in mm)]

Figure 17 Example showing the position of the indentations for hardness test in the weld metal, the heat affected zone and the base metal of a fillet weld (dimensions in mm)

3.6.3 Qualification of cruciform joints is required for vertical-down fillet welding on hull structure steel grades A to F40. For the test assembly see Figure 13 and Figure 14.
The throat thickness of the fillet for the cruciform test piece shall correspond to those used in production, but
shall not exceed 0.5 times the plate thickness of the test piece.
For the set of double-T (cruciform) test specimens see Figure 18 and for the calculation of the shear tensile
strength see Figure 19.
The cruciform tensile test specimens shall be evaluated in order to determine the tensile-shear strength
of the weld metal according to Figure 19. Before the performance of cruciform tensile tests, the fillet weld
throat thicknesses and the width of the specimens shall be measured. The width of the specimen should be
about 35 mm.
For the tensile-shear strength requirements see Table 6.
The following destructive tests shall be performed in addition to [3.6.2]:
— three cruciform tensile test specimens (Z)

\[ M = \text{macro section} \]
\[ Z = \text{cruciform tensile test specimen} \]

*Figure 18 Set of double-T (cruciform) test specimens*
3.6.4 WPQTs of pipe fillet welds and corresponding WPS shall be in accordance with an international recognized standard. Test assembly is shown in Figure 15.

4 Non-destructive testing of test assemblies

4.1 Butt welds in plates and pipes and full penetration T-, K-, and Y-joints

4.1.1 The extent of the testing shall be as follows:
— 100% visual testing (VT)
— 100% radiographic testing (RT) or ultrasonic testing (UT)
— 100% surface crack detection (magnetic particle testing (MT) for ferromagnetic materials or penetrant testing (PT) for non-ferromagnetic materials).

Acceptance criteria: The soundness of the weld shall comply, unless otherwise specified, with EN ISO 5817 quality level B. Regarding use of EN ISO 5817 and EN ISO 10042 for RT, UT, MT and PT, EN ISO 17635 shall be followed.

Guidance note: For ultrasonic testing, Level 2 of ISO 11666 is considered equal to Level B of EN ISO 5817.

4.2 Fillet welds and partial penetration welds

4.2.1 The extent of testing shall be as follows:
— 100% VT
— 100% surface crack detection (MT for ferromagnetic materials or PT for non-ferromagnetic materials).

Acceptance criteria: The soundness of the weld shall comply, unless otherwise specified, with EN ISO 5817 quality level B. If the stop/restart spot is included in the test length, special attention shall be paid to this position with respect to profile, proper fusion and absence of crater defects. Regarding use of EN ISO 5817 and EN ISO 10042 for MT and PT, EN ISO 17635 shall be followed.
5 Acceptance criteria of mechanical testing

5.1 Transverse tensile test

5.1.1 The tensile strength shall not be below the specified minimum tensile strength for the material grade in question. Location of fracture (WM or BM), and tensile strength shall be reported.

5.2 Bend test

5.2.1 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.

5.3 Macrosection and hardness testing

5.3.1 Macrosection
Cracks and lack of fusion are not accepted. Other defects shall follow Level B of EN ISO 5817. The welded joints shall have a regular profile with smooth transitions to the base materials and without significant or excessive reinforcement. Acceptance criteria for weld profile according to IACS Rec. No. 47.

5.3.2 Hardness test
— for material grades up to and including VL 420 a maximum hardness limit of 350 HV10 shall be met, except for single run fillet welds where the maximum hardness limit shall be 380 HV10
— for VL460 VL 500, VL 550, VL 620 and VL 690 grades the maximum hardness limit shall be 420 HV10
— for VL 890 and VL 960, the maximum hardness limit shall be 450 HV10.

5.4 Impact testing

5.4.1 Hull construction
The test temperature and absorbed energy shall be in accordance with the following requirements:

Table 4 Impact test temperature

<table>
<thead>
<tr>
<th>Impact test temperatures:</th>
<th>For grades:</th>
</tr>
</thead>
<tbody>
<tr>
<td>+20°C</td>
<td>A, A27S, A32, A36 and A40</td>
</tr>
<tr>
<td>0°C</td>
<td>B, D, D27S, D32, D36 and D40</td>
</tr>
<tr>
<td>-20°C</td>
<td>E, E27S, E32, E36 and E40</td>
</tr>
<tr>
<td>-40°C</td>
<td>F27S, F32, F36 and F40</td>
</tr>
</tbody>
</table>

The average value for absorbed energy in WM, FL and HAZ shall not be less than:
— for grades VL A and VL B, all welding methods and positions: 27 J
For all other grades given above:
— for manual and semi-automatic welding in all welding positions except vertical: 47 J
— for automatic welding and fully mechanised welding: 34 J (for VL 40 grades: 39 J)
For extra high strength structural steels (except D/E 47, see [7.1.4]), boiler and pressure vessel steels, and weldable C- and C-Mn hull steel castings and forgings, the Charpy V-notch test temperature and the average value for absorbed energy in weld metal, fusion line and HAZ shall be the same as required for the base material. For steels for low temperature services, including nickel alloy steels, see [9.2]. For stainless steels, see [10.1] and [11.2].

5.4.2 The average impact requirements shall be satisfied for each notch location. One single value of the three values from each notch location may be below the average requirement, but not below 70% of minimum average.

5.4.3 In the case of reduced Charpy V-notch test specimens (10 x 7.5 mm and 10 x 5 mm); the impact energy values to be obtained shall satisfy Table 5:

Table 5 Impact energy requirement for subsize specimens

<table>
<thead>
<tr>
<th>Dimensions of Charpy V-notch test specimen</th>
<th>Impact energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 x 10 mm</td>
<td>KV</td>
</tr>
<tr>
<td>10 x 7.5 mm</td>
<td>5/6 KV</td>
</tr>
<tr>
<td>10 x 5 mm</td>
<td>2/3 KV</td>
</tr>
</tbody>
</table>

5.4.4 Where the results from a set of three impact test specimens do not comply with the requirements, an additional set of three impact test specimens may be taken. The results obtained shall be combined with the original results to form a new average which, for acceptance, shall be not less than the required value. Additionally, for these combined results not more than two individual values shall be less than the required average value. Of these, not more than one shall be less than 70% of the required average value.

5.5 Cruciform joint tensile-shear strength

5.5.1 For the tensile-shear strength requirements applicable to cruciform tensile specimens, see Table 6.

Table 6 Requirements applicable to cruciform tensile specimens

<table>
<thead>
<tr>
<th>Grades</th>
<th>Tensile-shear strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - E, A27S - F27S</td>
<td>350</td>
</tr>
<tr>
<td>A32 – F36</td>
<td>430</td>
</tr>
<tr>
<td>A40 – F40</td>
<td>450</td>
</tr>
</tbody>
</table>

5.6 Welds between different material grades

5.6.1 When a butt weld is made between two steels of different grade, the test temperature and achieved impact energy shall comply with the minimum specified requirements for the lower grade, see [5.4.1] and [5.4.2]. The tensile strength shall meet the requirements of the steel having the lower strength. The validity of the corresponding WPS shall be limited to the range qualified by the lower steel grade welded to a steel limited by the range qualified by the higher grade.
Guidance note:
As an example the test temperature, impact energy and tensile strength for the butt welded joints given in Figure 20 are those required for the plate of grade D in the left assembly and for the plate of grade E in the right assembly.

As an example for the qualified range of steels, the left assembly qualifies welding of steel grades A - D welded to steel grades A - E. Welding of grade E to E is not covered. For the right assembly welding of steel grades A - E welded to steel grades A - EH is covered. Welding of AH - EH welded to AH - EH is not covered.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Figure 20 Butt welded plate joints of different grades

5.7 Fracture mechanics test

5.7.1 The critical CTOD for all of the specimens shall be equal to or larger than 0.15 mm unless otherwise specified by the relevant rules. For D/E 47 grades and COD grades, see [8.2.3].

5.7.2 If, for HAZ or weld deposit, one or more of the three specimens have a critical CTOD lower than 0.15 mm additional tests may be carried out. In such a case the characteristic value, as defined in Table 7, shall be equal to or larger than 0.15 mm.

Table 7 Characteristic value of CTOD

<table>
<thead>
<tr>
<th>Number of valid tests</th>
<th>Characteristic value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 to 5</td>
<td>Lowest result</td>
</tr>
<tr>
<td>6 to 10</td>
<td>Second lowest result</td>
</tr>
<tr>
<td>11 to 15</td>
<td>Third lowest result</td>
</tr>
</tbody>
</table>

1) All valid tests that have been carried out shall be included in the evaluation. It is not permissible to discard any valid test result.
5.7.3 If the characteristic value as specified in Table 7 is lower than 0.15 mm an ECA (engineering critical assessment) may be carried out with the purpose of demonstrating that extra capacity is available in the structure. Acceptance based on ECA shall be approved.

5.8 Retesting

5.8.1 If the WPQT fails to comply with any of the requirements for NDT one extra WPQT may be welded and subjected to the same testing. If this additional test does not meet the relevant requirements, the actual pWPS shall be considered as not qualified and a re-specification of the pWPS shall be made prior to a new qualification test.

If the result of any destructive test fails to meet the requirements, two further tests may be made from the same welded joint if there is sufficient material available. If not, a new assembly may be welded using the same WPS. If either of these additional test specimens does not comply with the relevant requirements, the WPS shall be regarded as not capable to comply with the requirements without modification.

6 Validity of approved welding procedures

6.1 General

6.1.1 The validity of an approved WPS is restricted to the builder/subcontractor receiving the approval. This includes yards/subcontractors under the same technical management and working in accordance with the same QA system and procedures. Builder’s WPS may be transferred to and used by a subcontractor, provided the welding workshop is approved by the Society and the principles of ISO 3834-2 and ISO 14731 are implemented. This shall be documented by the yard/subcontractor and accepted by the Society. For this case WPT or extended NDT may be required by the Society.

6.1.2 Qualification of a WPS remains valid provided the specified welding parameters are kept within the qualified ranges during production welding. The qualified ranges are given in [6.2]. If one or more of the WPS specified welding parameters are outside the qualified ranges during production, the WPS shall be re-specified and re-qualified.

6.2 Range of qualification

6.2.1 A qualified WPS shall be used within the ranges of the parameters of essential variables listed below.

6.2.2 Base material

The following changes and considerations shall lead to a new qualification:

a) significant change of material properties which obviously will affect the weldability and mechanical properties, such as:

   — change from wrought (rolled, forged) steel to cast steel or vice versa (applicable also for stainless steels)

   — change from delivery condition quenched and tempered (QT) to any other delivery condition or vice versa; applicable for forgings, castings, and steel plates of grade D40, E40, F32, F36, F40 and extra high strength steels

   — change from delivery condition thermo-mechanical rolling (TM) to any other delivery conditions, but not vice versa. Change from delivery condition TM to other delivery conditions will be accepted provided the carbon equivalent of the qualified TM-steel is same or higher than the steel to be covered

   — BCA steel grades with chemical composition outside the limitations of Ch.2 Sec.2 Table 8 and Ch.2 Sec.2 Table 14 shall follow the requirements of [8.3.1].
Guidance note:
For steels with C ≥ 0.22 or C_{eq} ≥ 0.45 the WPQT on which the WPS is based, should be qualified on a base material having a C_{eq} not less than 0.03 of the material to be welded. Example: A material with actual C_{eq}= 0.50 requires a WPQT qualified on a material with C_{eq} ≥ 0.47.

---end---of---guidance---note---

b) additional considerations for strength levels and toughness grades for rolled steel plates:
— for normal and high strength steels see Ch.2 Sec.2, WPQTs are considered applicable to the same and two lower strength levels as that tested (the special grade 27S is not counted, e.g. qualification of A36 may also qualify welding of grades A, A27S and A32)
— for extra high strength steels, WPQTs are considered applicable to the same and one lower strength level as that tested, e.g. qualification of A500 will qualify grade A460
— for high heat input welding processes (> 50 kJ/cm), the WPQT is applicable to the toughness grade tested and one strength level below, e.g. qualification of grade E40-W200 will qualify grades E40-W200 and E36-W200
— the qualification of steel grades of higher toughness requirements will qualify the grades of lower toughness but not vice versa, e.g. qualification of grade E will also qualify grades A, B and D

c) Additional considerations for strength levels and toughness grades for castings and forgings:
— change to a grade of higher specified strength
— change to higher specified toughness requirements. That is: lower impact toughness temperature requirements or higher impact toughness value requirements

d) Additional consideration for welding with heat input more than 50 kJ/cm:
— for TM steels not pre-qualified for high heat input welding: change of material manufacturer requires either new qualification, or special case by case approval. For case by case approval, the following information shall be submitted for the TM steels in question: grade, thickness range, deoxidation practice, fine grain practice, aim range of chemical composition, aim maximum C_{eq} and P/cm, welding production test results, etc.

6.2.3 Thickness
Thickness t is defined as follows:
a) for a butt weld:
  the base metal thickness, which for welds between dissimilar thicknesses is that of the thinner material
b) for a T-butt joint in plate:
  the thickness of the plate with bevelling (abutting member)
c) for a fillet weld:
  the thickness of both base materials
d) for a set-on branch connection:
  the thickness of the branch pipe
e) for a set-in or set-through branch connection:
  the thickness of the main pipe.

The requirements for qualified thickness range for butt welds shall be as given in Table 8. This table is also applicable to full penetration T, K, Y-joints.
Table 8 Qualified thickness range

<table>
<thead>
<tr>
<th>Thickness of test piece, ( t ) (mm)</th>
<th>Qualification range (^{1, 2, 3, 4)})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single run, or single run from both sides</td>
</tr>
<tr>
<td>t ≤ 3</td>
<td>(0.7 \times t ) to (1.3 \times t)</td>
</tr>
<tr>
<td>3 &lt; t ≤ 12</td>
<td>(0.7 \times t ) to (1.1 \times t)</td>
</tr>
<tr>
<td>12 &lt; t ≤ 100</td>
<td>(0.7 \times t ) to (1.1 \times t)</td>
</tr>
<tr>
<td>t &gt; 100</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

1) the maximum thickness qualified for vertical downward welding is \(1.0 \times t\)
2) for high heat input processes > 50 kJ/cm, the upper limit of range of approval is \(1.0 \times t\)
3) for multi process procedures, the recorded thickness contribution of each process shall be used as basis for the range of approval for the individual welding process
4) the approval of maximum thickness of base metal for any technique shall be restricted to the thickness of test assembly if three of the hardness values in the heat affected zone are found to be within 25 HV of the maximum permitted, as stated in [5.3.2]
5) where a fillet weld is qualified by a butt weld qualification, the throat thickness range qualified shall be the same as the qualified plate thickness range
6) for fillet welds between materials of dissimilar thickness, the qualified thickness range shall be applied to both parent materials independently. Example: Multi-run fillet weld. Thickness of abutting member is 15 mm, thickness of base plate is 25 mm and throat thickness is 15 mm by multi-run. Qualified range for abutting member is then 7.5 mm to 30 mm, qualified range for base plate is 12.5 mm to 50 mm. Qualified throat thickness “a” range is 7.5 mm to 30 mm

In addition to the requirements of Table 8, the range of approval of throat thickness “a” for fillet welds shall be as follows:
- single run: “0.75 × a” to “1.5 × a”
- multi-run: Same qualification range as for thickness (t) of multi-run butt welds, i.e. \(t = a\), see Table 8.

6.2.4 Diameter of pipes and branch connections
The qualification of a WPQT on diameter \(D\) shall include qualification for diameters in the following ranges as given in Table 9.

Table 9 Qualified range for pipe and branch connection diameters

<table>
<thead>
<tr>
<th>Diameter of the test piece, (D) (mm) (^{1, 2)})</th>
<th>Qualification range</th>
</tr>
</thead>
<tbody>
<tr>
<td>(D \leq 25)</td>
<td>(0.5 \times D ) to (2 \times D)</td>
</tr>
<tr>
<td>(D &gt; 25)</td>
<td>&gt; (0.5 \times D) and plates</td>
</tr>
</tbody>
</table>

1) \(D\) is the outside diameter of the pipe or outside diameter of the branch pipe
2) qualification given for plates also covers pipes when the outside diameter is greater than 500 mm

6.2.5 Angle of branch connections
A WPQT carried out on a branch connection with angle \(\alpha\) shall qualify all branch connection angles in the range of \(\alpha\) to 90°.
6.2.6 Welding consumables
The following changes shall lead to a new qualification:
— any change in consumable classifications: mechanical properties, type of covering core or flux (e.g. basic, rutile), nominal chemical composition and increase in hydrogen content
— change of consumable brand when impact testing for WPQT is required at temperatures below –20°C
— any significant change of mixture/composition, see Sec.4 Table 8, flow rate, filling time and filling volume for shielding and purging gases.

6.2.7 Welding positions
The following changes shall lead to a new qualification:
— change from one principal welding position to another, unless complying with Table 13. Welding positions are indicated in Figure 21, Figure 22 and Figure 23.

Figure 21 Plate test positions
6.2.8 Type of joint

The following changes shall lead to a new qualification:

a) change from fillet weld to butt weld
b) change from butt weld to fillet weld in case of automatic welding of fillet joint with shop primer
c) change from T-, K- or Y-joint to butt weld but not vice versa
d) change from butt joint in plates to butt joints in pipes with outside diameter less than 500 mm
e) changes outside the qualification ranges given in Table 10

Table 10 Qualified ranges for one and two-side butt welds with or without backing/gouging

<table>
<thead>
<tr>
<th>Type of welded joint for test assembly</th>
<th>Range of approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butt welding</td>
<td></td>
</tr>
<tr>
<td>One side</td>
<td>With backing</td>
</tr>
<tr>
<td></td>
<td>Without backing</td>
</tr>
<tr>
<td>Both Side</td>
<td>With gouging</td>
</tr>
<tr>
<td></td>
<td>Without gouging</td>
</tr>
</tbody>
</table>

f) any change of groove angle outside the limits given in Table 11

Table 11 Tolerances for groove angle of butt welds, based on groove angle qualified by WPQT

<table>
<thead>
<tr>
<th>Groove angle β (°) from WPQT</th>
<th>Qualified tolerances β (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>β &lt; 35</td>
<td>-0, +20</td>
</tr>
<tr>
<td>35≤ β &lt; 40</td>
<td>Min. 35, +20</td>
</tr>
<tr>
<td>β ≥ 40</td>
<td>-5, +20</td>
</tr>
</tbody>
</table>
g) any change of root gap outside the limits given in Table 12. Different gaps and tolerances may be approved based on adequate qualification.

**Table 12 Tolerances for root gap of butt welds, based on root gap qualified by WPQT**

<table>
<thead>
<tr>
<th>Backing</th>
<th>Welding method</th>
<th>Root gap (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Standard</td>
</tr>
<tr>
<td>With backing</td>
<td>All</td>
<td>3 - 10</td>
</tr>
<tr>
<td>Without backing</td>
<td>Manual, semi-automatic</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Automatic</td>
<td>0.8</td>
</tr>
</tbody>
</table>

1) Welding gap of more than 16 mm is for remedial welding. See also [1.5]

6.2.9 Welding condition

The following changes shall lead to a new qualification:

— any change of welding process
— any decrease in preheat temperature
— higher interpass temperature than that used in the qualification test
— change of post weld heat treatment parameters used in the qualification test. Holding time may be adjusted as a function of thickness
— change from multi-pass welding to one-pass welding
— change in welding current from A.C. to D.C. or vice versa, or change in polarity. If recommended by the welding consumable manufacturer a case by case exemption may be given for SMAW in change from A.C. to D.C.
— change in metal powder or wire addition beyond ±10%
— change from manual (or semi-automatic) to fully mechanized (or fully automatic welding processes), and vice versa, see [1.6.1]
— change in heat input beyond ±25% or 55 kJ/cm maximum heat input, whichever is smaller. For high heat input welding (> 50 kJ/cm) and/or for material with SMYS equal to or above 420 MPa the change shall not be more than ±10%. The heat input range shall be established at least for (1) root pass and (2) filling and cap passes.

**Guidance note:**

Average heat input for the relevant welding passes (root, fill, cap) is calculated based on the recorded values from the WPQT. The qualified range (±25% or ±10% as relevant) is based on the calculated average value.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---
**Figure 23** Positions of test plate for fillet welds

**Table 13** Qualified principal positions for butt welds and fillet welds, steel

<table>
<thead>
<tr>
<th>Test weld joint configuration&lt;sup&gt;1,2&lt;/sup&gt;</th>
<th>Principle positions</th>
<th>Qualified positions&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plates</td>
<td>Pipes</td>
</tr>
<tr>
<td>Butt welds in plates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2G + 3G</td>
<td>All</td>
<td>-</td>
</tr>
<tr>
<td>1G</td>
<td>All</td>
<td>-</td>
</tr>
<tr>
<td>2G</td>
<td>1G</td>
<td>-</td>
</tr>
<tr>
<td>3G</td>
<td>2G</td>
<td>-</td>
</tr>
<tr>
<td>4G</td>
<td>3G</td>
<td>-</td>
</tr>
<tr>
<td>Butt welds in pipes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2G + 5G = 6G</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td>1G</td>
<td>All</td>
<td>1G</td>
</tr>
<tr>
<td>2G</td>
<td>1G</td>
<td>1G</td>
</tr>
<tr>
<td>5G</td>
<td>2G</td>
<td>1G, 2G</td>
</tr>
<tr>
<td>Fillet welds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2F + 3F</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td>1F</td>
<td>All</td>
<td>-</td>
</tr>
<tr>
<td>2F</td>
<td>All</td>
<td>-</td>
</tr>
<tr>
<td>3F</td>
<td>All</td>
<td>-</td>
</tr>
<tr>
<td>4F</td>
<td>All</td>
<td>-</td>
</tr>
<tr>
<td>5F</td>
<td>All</td>
<td>-</td>
</tr>
</tbody>
</table>
7 Additional requirements for welding procedure qualification test of VL D/E47BCA, COD and BCACOD grades

7.1 Test requirements

7.1.1 These requirements shall be applied for all VL D/E47BCA, COD and BCACOD grades including those with additional suffixes, e.g. E47Z35BCACOD.

7.1.2 The butt weld tensile strength shall not be less than 570 N/mm². The position of fracture shall be reported.

7.1.3 The bending mandrel diameter shall be 5 × t and the bending angle shall be minimum 180°.

7.1.4 Charpy V-notch test results shall satisfy a minimum average requirement of 64J when tested at -20°C. Charpy V-notch impact toughness testing for plate thickness t > 50 mm; the following additional notch locations shall be tested:
   1) mid-thickness (t/2): WM, FL, FL+2, FL+5
   2) root, provided root is not at mid-thickness: WM, FL, FL+2, FL+5.

7.1.5 The maximum hardness limit shall be 380 HV10.

7.1.6 The COD grades shall additionally satisfy the requirements of [8].

8 Additional requirements for welding procedure qualification test of all COD grades

8.1 General

8.1.1 These additional requirements shall be applied for WPQT of the following steel grades:
   — all VL D36 and E36; grades with the suffix COD
   — all VL D40 and E40; grades with the suffix COD
   — all VL D47Z35COD and E47Z35COD, including those with additional suffixes, e.g. E47Z35BCACOD.

8.2 Welds in plates

8.2.1 Test assembly shall be as described in [3.2.1] and [3.2.2]. The WPQT plate thickness shall be the maximum production plate thickness, if not otherwise agreed.
8.2.2 Charpy V-notch test temperature and the average value for absorbed energy in weld metal, fusion line and HAZ shall be the same as required for the base material in transverse direction.

The following additional notch locations shall be tested:
1) mid-thickness (t/2): WM, FL, FL+2, FL+5
2) root, provided root is not at mid-thickness: WM, FL, FL+2, FL+5.

8.2.3 CTOD testing procedure and the specimens for CTOD testing shall be in accordance with Ch.1 Sec.3 [3.9].

One set of CTOD specimens is required for each of the notch locations given below for each test assembly:
— GCHAZ
— weld metal.

CTOD testing shall be carried out at −10°C or design temperature, whichever is lower.

Minimum single CTOD value of 0.18 mm and minimum average CTOD value of 0.20 mm for notch position in GCHAZ and weld metal shall be fulfilled. The average CTOD is calculated as average of three valid CTOD test results.

Provided the CTOD requirements are already qualified, e.g. during the approval of manufacturer test for the relevant essential welding parameters, then the applicable CTOD testing need not to be repeated. For this case, a new WPS may be prepared based on the WPQR established by manufacturer for qualification of the COD steel. In addition to the limitations to the validity given by [6], the limitations given by [8.3] do also apply.

Guidance note:
The required CTOD testing of the weld metal (i.e. for qualification of the welding consumables) is not commonly covered by the approval of manufacturer test of COD grade steel. Each welding consumable type and grade from each consumable manufacturer is to be qualified as relevant. A welding consumable qualified on one grade of COD steel may be used on COD steels from other steel manufacturer, provided the chemical composition range of the COD steel (as specified by the steel manufacturer) comply with the rule requirements for chemical composition of the corresponding steel grade without COD.

Essential parameters relevant for qualification of welding for COD steels may not be the same as the general essential parameters for WPS. Parameters affecting the CTOD properties should be considered as essential in this respect, e.g. heat input is an essential parameter for CTOD properties of HAZ, while welding method is not.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

8.3 Further limitations to the range of qualification

8.3.1 Limitations to the carbon equivalent (to be stated on the WPS):
— max. \( C_{\text{eq}} = C_{\text{eq(tested base material)}} + 0.03\% \)
— max. \( P_{\text{cm}} = P_{\text{cm(tested base material)}} + 0.02\% \).

8.3.2 The maximum thickness qualified is 1.0 x t, where t is the thickness of the tested plate, unless otherwise approved.

9 Additional requirements for welding procedure qualification test for liquefied gas systems

9.1 General

9.1.1 The general requirements are given in Pt.5 Ch.7 Sec.6. Other mandatory requirements, e.g. IGC code, are to be observed in addition, if more stringent.
9.2 Welds in plates and pipes

9.2.1 Test assembly shall be as described in [3.2.1] or [3.3.1]. For butt welds in plates the test assemblies shall be prepared so that the rolling direction is parallel to the direction of welding.

9.2.2 For carbon, carbon-manganese and low alloy steels:
From each test assembly for plates the Charpy-V-notch impact toughness test specimen locations shall be as follows (replacing those given in [3.2.1] and [3.3.1]):
One set of Charpy V-notch test specimens (each set consists of 3 specimens) with the notch location as follows:
— weld centerline
— fusion line
— 1 mm, 3 mm and 5 mm from the fusion line (HAZ).
Charpy V-notch testing shall be conducted at the temperature prescribed for the base material.
For austenitic stainless steels:
Only one set of Charpy V-notch test specimens with the notch in the centre of the weld is required, for design temperature below –105°C. Test is to be carried out at -196°C unless otherwise agreed.

9.3 Test requirements

9.3.1 The butt weld tensile test shall comply with the following requirements:
— generally, the tensile strength shall not be less than the specified minimum tensile strength for the parent material. In cases where the Society has approved the use of welding consumables which give lower tensile strength in the weld metal than that required for the parent material, the approved value for the welding consumable in question applies. The position of fracture shall be reported.

9.3.2 Charpy V-notch testing shall be conducted at the temperature prescribed for the base material. When specimens of 10 × 10 mm cross-section are used, the average value from 3 tests shall not be less than 27 J for weld metal. One single test may give a value below the required average but not lower than 19 J.
For fusion line and heat affected zone the requirement for minimum average value is the same as for the base material.

9.4 Weld production test (WPT) requirements

9.4.1 The test requirements shall comply with [9.1] and [9.2].

9.4.2 Impact testing for carbon-manganese steels, austenitic chromium-nickel steels and nickel steels shall be conducted at the temperature prescribed for the base material. For austenitic chromium-nickel steels, testing are only required for design temperature below –105°C. For welding of plates the following apply when pieces of 10 × 10 mm cross section are used:
  a) if the impact test pieces from plate materials are taken with their longitudinal axes transverse to the main direction of rolling, the average value from 3 tests shall not be less than 27 J for weld metal, fusion line, heat affected zone and parent material. One single test may give a value below the required average, but not lower than 19 J.
  b) if the impact test pieces from plate materials are taken with their longitudinal axes parallel with the main direction of rolling, the average value from 3 tests for the fusion line and the heat affected zone shall not to be less than 41 J, and for the weld metal not less than 27 J. One single test may give a value below the required average but not lower than 29 J and 19 J respectively. For testing of thin materials where it
is impossible to use a standard test piece 10 × 10 mm, the larger of the following pieces shall be used: 10 × 7.5 mm or 10 × 5 mm. The impact value requirements are then reduced to respectively 5/6 and 2/3 of the required values for the standard test pieces. For retesting, see Ch.1 Sec.2 [3.7].

10 Additional requirements for welding procedure qualification test of ferritic-austenitic stainless steel (duplex)

10.1 Test requirements

10.1.1 Impact testing shall be as described in [3.2.8] using an impact test temperature of −20°C, or −5°C below the design temperature whichever is lower. The average value for absorbed energy shall not be less than 27 J. Other test requirement can be agreed for individual cases.

10.1.2 When a butt weld is made between dissimilar material grades, both sides of the weld (HAZ) shall be impact tested.

10.1.3 The hardness of the HAZ after welding shall, unless otherwise agreed, not exceed the maximum hardness specified for the base material, and the hardness of the weld metal shall not exceed the maximum hardness specified for the weld deposit of the applied welding consumable.

10.1.4 Type 25Cr duplex shall be corrosion tested according to ASTM G48 Method A. The test specimen shall be in the as welded state after normal weld cleaning operation. The test specimens shall be exposed to the solution at a constant temperature of 40°C for 24 hours. The test specimens shall have a dimension of full wall thickness by 25 mm along the weld and 50 mm across the weld. The test shall expose the external and internal surface and a cross section surface including the weld zone in full wall thickness. Cut edges shall be prepared according to ASTM G48. The whole specimen shall be pickled before being weighed and tested. Pickling may be performed for 5 min. at 60°C in a solution of 20% HNO₃ + 5% HF. The following test requirements shall be fulfilled:
— there shall be no pitting at 20X magnification
— general weight loss shall be less than 4.0 g/m².

Guidance note:
Welds between ferritic-austenitic steels and other grades of stainless, C/Mn steels or for welds in “non-corrosive” area may not need to be corrosion tested.

10.1.5 Duplex stainless steel types shall be microstructurally examined and the test samples shall comprise the weld metal, heat affected zone and base metal. The microstructure shall be suitably etched and examined at 400X to 500X magnification and shall be free from grain boundary carbides and precipitates. The ferrite content in the weld metal root and un-reheated weld cap shall be determined in accordance with ASTM E562 and be in the range of 30-70%.

10.2 Validity of a qualified welding procedure

10.2.1 Reference is made to [6] and any change in the following additional essential variables which shall lead to a new qualification:
— variation in the heat input greater than ±15%.
11 Additional requirements for welding procedure qualification test of austenitic stainless steel

11.1 Welds in plates and pipes

11.1.1 When welding procedure qualification tests are required, the tests shall be performed in accordance with [3.2.1] or [3.3.1] and the supplementary requirements given below. The welding procedure qualification tests shall cover all relevant dimensions, positions and material combinations. Details regarding essential variables and validity of the procedure shall be as given in [6]. Mechanical testing acceptance requirements shall be as given in [5], if not otherwise specified below.

11.1.2 Impact testing is not required for design temperatures above –105°C.

11.1.3 Hardness testing is not required.

11.1.4 Depending on the field of application or if required for the base material, additional corrosion protection tests shall be performed within the scope of welding procedure tests, e.g. testing of resistance against intergranular corrosion.

11.2 Test requirements

11.2.1 If impact testing is required, the testing shall be conducted at –196°C meeting an average impact energy level of minimum 27 J.

11.3 Range of approval

11.3.1 The requirements of [6.2] apply. In addition; a change to a grade of higher specified strength or higher impact toughness requirements shall lead to a new qualification.

12 Welding procedures qualification for aluminium

12.1 General


12.1.2 Welding consumables shall be one of those recommended in Sec.4 Table 7.

12.2 Butt welds in plates

12.2.1 Test assembly shall be as described in [3.2.1].

12.2.2 The following mechanical tests are required from each assembly:

- 2 cross-weld tensile test specimen
- 2 root and 2 face or 4 side bend specimens
- 1 macro test specimen.

For the location of test specimens, see Figure 24.
12.2.3 Two cross-weld tensile specimens shall be taken from each of the welded assemblies. The test specimen dimensions are given in Ch.1 Sec.3 [3.1.9]. Side bend tests shall be carried out for thickness equal to and above 12 mm. Four bend specimens shall be taken from each of the welded assemblies. The bend test specimens shall be machined to the dimensions given in Ch.1 Sec.3 [3.3].

12.2.4 For thickness below 12 mm two face bend and two root bend test specimens shall be taken. The diameter of the bending mandrel shall be as given in [12.6.2].

12.2.5 One macrosection shall be prepared from the test assembly to reveal the weldment macro structure. The macrosection shall be visually inspected using a magnification of 5X to 10X.

12.3 Butt welds in pipes

12.3.1 Test assembly shall be as described in [3.3.1].

12.3.2 The following mechanical tests are required from each assembly:
— 2 cross-weld tensile test specimen
— 2 root and 2 face or 4 side bend specimens
— 1 macro test specimen.
Figure 25 Location of test specimens for a butt weld in pipe

12.3.3 Two cross-weld tensile specimens shall be taken from each of the welded assemblies. The test specimen dimensions are given in Ch.1 Sec.3 [3.1.9].

12.3.4 Side bend tests shall be carried out for thickness equal to and above 12 mm. Four bend specimens shall be taken from each of the welded assemblies. The bend test specimens shall be machined to the dimensions given in Ch.1 Sec.3 [3.3].

12.3.5 For thickness below 12 mm two face bend and two root bend test specimens shall be taken. The diameter of the bending mandrel shall be as given in [12.6.2].

12.3.6 One macrosection shall be prepared from the test assembly to reveal the weldment macro structure. The macrosection shall be visually inspected using a magnification of 5X to 10X.

12.4 Branch connections

The following mechanical tests are required from each assembly, see Figure 11:
— two macrosection tests at 12 and 6 o’clock.

12.5 Fillet welds

12.5.1 Test assembly shall be as described in Figure 12.

The following tests shall be performed:
— two macrosection tests. One of the macrosections shall be taken at the marked position of the stop/restart. The macrosection shall include about 10 mm of unaffected base material and shall be prepared and etched on one side to clearly reveal the fusion line and the HAZ
— one fracture test shall be performed by folding the upright plate onto the through plate. Evaluation shall concentrate on cracks, porosity and pores, inclusions, lack of fusion and incomplete penetration.
Non-destructive testing of test assemblies:
Non-destructive testing shall be according to [4.1] for butt welds and [4.2] for fillet welds and partial penetration welds.

### 12.6 Mechanical testing

**12.6.1** The tensile strength of the test specimens shall not be less than specified for the parent alloy in Table 14.

**Table 14 Mechanical properties in the welded condition**

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Temper</th>
<th>Filler</th>
<th>Tensile strength $R_{mu}$ minimum (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL 5052</td>
<td>0, H111, H32, H34</td>
<td>5356, 5556</td>
<td>170</td>
</tr>
<tr>
<td>VL 5754</td>
<td>0, H111, H24</td>
<td>5356, 5183, 5556</td>
<td>190</td>
</tr>
<tr>
<td>VL 5154A</td>
<td>0, H111, H32, H34</td>
<td>5356, 5183, 5556</td>
<td>215</td>
</tr>
<tr>
<td>VL 5454</td>
<td>0, H111, H32, H34</td>
<td>5356, 5183, 5556</td>
<td>215</td>
</tr>
<tr>
<td>VL 5086</td>
<td>0, H111, H112, H116, H321, H34</td>
<td>5356, 5183, 5556</td>
<td>240</td>
</tr>
<tr>
<td>VL 5083</td>
<td>0, H111, H112; t ≤ 6 mm</td>
<td>5356, 5183</td>
<td>270</td>
</tr>
<tr>
<td></td>
<td>0, H111, H112; t &gt; 6 mm</td>
<td>5356, 5183</td>
<td>270</td>
</tr>
<tr>
<td></td>
<td>H116, H321</td>
<td>5356, 5183</td>
<td>270</td>
</tr>
<tr>
<td>VL 5383</td>
<td>0, H111, H116, H321</td>
<td>5183, 5556</td>
<td>290</td>
</tr>
<tr>
<td>VL 5059</td>
<td>0, H111, H116, H321</td>
<td>5183</td>
<td>330</td>
</tr>
<tr>
<td>VL 6060</td>
<td>T4, T5, T6</td>
<td>5356, 5183, 5556</td>
<td>95</td>
</tr>
<tr>
<td>VL 6061</td>
<td>T4, T5, T6</td>
<td>5356, 5183, 5556</td>
<td>165</td>
</tr>
<tr>
<td>VL 6063</td>
<td>T4, T5, T6</td>
<td>5356, 5183, 5556</td>
<td>100</td>
</tr>
<tr>
<td>VL 6005A</td>
<td>T4, T5, T6</td>
<td>5356, 5183, 5556</td>
<td>165</td>
</tr>
<tr>
<td>VL 6082</td>
<td>T4, T5, T6</td>
<td>5356, 5183, 5556</td>
<td>170</td>
</tr>
</tbody>
</table>

**12.6.2** The bend test specimens shall be bent on a mandrel with maximum diameter as given in the formula below. The bending angle shall be minimum 180°. After bending, the test specimens shall not reveal any open defects greater than 3 mm in any direction. Smaller cracks developing from the edges of the specimens shall not normally be considered as significant, unless there is definite evidence that they result from inclusions or other defects. «Wrap around» bending as shown in Ch.1 is the preferred bending method.

\[
d = \frac{100t_s}{A} - t_s
\]

Where:

- $D$ = maximum former diameter
- $t_s$ = thickness of the bend test specimen (this includes side bends)
- $A$ = minimum tensile elongation required by the material specification (for combination between different alloys, the lowest individual value shall be used).
12.6.3 The macrosections shall show a regular weld profile with smooth transitions to the base materials and without significant or excessive reinforcement. Cracks and lack of fusion are not acceptable. The fillet weld fracture test as well as the macro examination shall satisfy the acceptance level in EN ISO 10042 quality level B except for excess weld metal or convexity, excess throat thickness and excess of penetration for which the level C applies.

12.6.4 When a butt weld is made between two plates of different alloys the tensile strength to be obtained on the welded assembly shall satisfy the requirements of the alloy with the lower strength.

12.6.5 If the WPQT fails to comply with any of the requirements for NDT, one extra WPQT shall be welded and subjected to the same testing. If this additional test does not meet the relevant requirements, the actual WPS shall be considered as not qualified and a re-specification of the WPS shall be made prior to a new WPQT.

12.7 Range of qualification

12.7.1 The validity of approved WPS shall be as given in [6.1].

12.7.2 A qualified WPS shall be used within the ranges of the welding parameters as given below.

**Base material**

The following changes shall lead to a new qualification:

a) in general, significant change of material properties which will obviously affect the weldability and mechanical properties

b) more specifically, aluminium alloys are grouped in the following categories:

   1) VL 5052, VL 5754A, VL 5154, VL 5454
   2) VL 5086, VL 5083, VL 5383, VL 5059
   3) VL 6060, VL 6061, VL 6063, VL 6005A, VL 6082.

For each group, the qualification made on one alloy qualifies the procedure also for the other alloys within the same group with equal or lower specified tensile strength after welding.

The qualification made on group 2) alloy, qualifies the procedure also for group 1) alloys.

A dissimilar metal joint shall be qualified by the same dissimilar combination.

**Thickness**

Thickness, t, is defined as follows:

a) for a butt weld: The base metal thickness, which for welds between dissimilar thicknesses is that of the thinner material

b) for a fillet weld: The base metal thickness, which for welds between dissimilar thicknesses is that of the thicker material. However, for each thickness range qualified, as given in Table 15 and Table 16 there is an associated range of qualified throat thickness

c) for a set-on branch connection: The thickness of the branch pipe

d) for a set-in or set-through branch connection: The thickness of the main pipe

e) for a T-butt joint in plate: The thickness of the prepared plate.

The requirements for qualified thickness range for butt welds shall be as given in Table 15.

**Table 15 Qualified thickness range**

<table>
<thead>
<tr>
<th>Thickness of test piece, t (mm)</th>
<th>Qualification range (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t &lt; 3</td>
<td>0.5 × t to 2 × t</td>
</tr>
<tr>
<td>3 ≤ t ≤ 20</td>
<td>3 to 2 × t</td>
</tr>
<tr>
<td>Thickness of test piece, t (mm)</td>
<td>Qualification range (mm)</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>t &gt; 20</td>
<td>≥ 0.8 × t</td>
</tr>
</tbody>
</table>

In addition to the requirements of Table 15, the range of qualification of the throat thickness “a” of fillet welds is given in Table 16.

**Table 16 Range of qualification for the throat thickness for plates and pipes**

<table>
<thead>
<tr>
<th>Throat thickness of the test piece, a (mm)</th>
<th>Range of qualification (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a &lt; 10</td>
<td>0.75 × a to 1.5 × a</td>
</tr>
<tr>
<td>a ≥ 10</td>
<td>≥ 7.5</td>
</tr>
</tbody>
</table>

Where a fillet weld is qualified by means of a butt weld test, the throat thickness range qualified shall be based on the thickness of the deposited weld metal.

**Diameter of pipes and branch connections**

The qualification of a welding procedure test on diameter D qualifies diameters in the ranges given in Table 17.

**Table 17 Qualified range for pipe and branch connection diameters**

<table>
<thead>
<tr>
<th>Diameter of the test piece, D (mm) ¹</th>
<th>Qualification range (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D ≤ 25</td>
<td>0.5 × D to 2 × D</td>
</tr>
<tr>
<td>D &gt; 25</td>
<td>≥ 0.5 × D and plates</td>
</tr>
</tbody>
</table>

¹ D is the outside diameter of the pipe or outside diameter of the branch pipe

**Angle of branch connections**

A WPQT carried out on a branch connection with angle α shall qualify all branch connection angles in the range of α to 90°.

**Welding consumables**

The following changes shall lead to a new qualification:

— any change in consumable classification
— any significant change of shielding gas mixture.

**Welding positions**

The following changes shall lead to a new qualification:

— change from one principal welding position to another, see Figures in [6.2], unless complying with Table 18.

**Type of joint**

The following changes shall lead to a new qualification:

— change from fillet weld to butt weld
— change from two sided welding to one side, but not vice versa
— deletion of back gouging
— deletion of backing
— change from butt joint in plates to butt joints in pipes with outside diameter less than 500 mm
— any change of groove dimensions specified in the WPS.

**Welding condition**
The following changes shall lead to a new qualification:
— any change of welding process
— change from spray arc to short arc or pulsed arc or vice versa
— change in heat input beyond ±25%
— any increase in preheat temperature for heat-treatable alloys when the specified preheat is above 50°C
— any decrease in preheat temperature
— higher interpass temperature than that used in the WPQT
— change of heat treatment used in the WPQT. Holding time may be adjusted as a function of thickness
— change from weaving to stringer bead technique or vice versa
— change from multi-pass welding to one-pass welding
— change in type of cleaning method (chemical or mechanical)
— change in welding current from A.C. to D.C. or vice versa, or change in polarity.

**Table 18** Qualified principal positions for butt welds and fillet welds, aluminium

<table>
<thead>
<tr>
<th>Test weld joint configuration 1, 2)</th>
<th>Principal positions</th>
<th>Qualified positions 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plates</td>
<td>Pipes</td>
</tr>
<tr>
<td></td>
<td>Butt welds</td>
<td></td>
</tr>
<tr>
<td>Butt welds in plates</td>
<td>1G</td>
<td>1G</td>
</tr>
<tr>
<td></td>
<td>2G</td>
<td>1G, 2G, 3G</td>
</tr>
<tr>
<td></td>
<td>3G</td>
<td>1G, 2G, 3G</td>
</tr>
<tr>
<td></td>
<td>4G</td>
<td>All</td>
</tr>
<tr>
<td>Butt welds in pipes</td>
<td>1G</td>
<td>1G</td>
</tr>
<tr>
<td></td>
<td>2G</td>
<td>1G, 2G, 3G</td>
</tr>
<tr>
<td></td>
<td>5G</td>
<td>All</td>
</tr>
<tr>
<td>Fillet welds</td>
<td>1F</td>
<td>1F</td>
</tr>
<tr>
<td></td>
<td>2F</td>
<td>1F, 2F, 3F</td>
</tr>
<tr>
<td></td>
<td>3F</td>
<td>1F, 2F, 3F</td>
</tr>
<tr>
<td></td>
<td>4F</td>
<td>1F, 2F, 3F</td>
</tr>
<tr>
<td></td>
<td>5F</td>
<td>All</td>
</tr>
</tbody>
</table>

1) Pipes with D > 500 mm are considered equivalent to plates (apply only to the main pipe in branch connections)
2) branch connections shall be qualified separately
3) the vertical downwards position shall be qualified separately.

### 12.8 Retesting

12.8.1 If the WPQT fails to comply with any of the requirements for NDT, one extra WPQT shall be welded and subjected to the same testing. If this additional test does not meet the relevant requirements, the actual WPS shall be considered as not qualified and a re-specification of the WPS shall be made prior to a new WPQT.

If the result of any destructive test fails to meet the requirements, two further tests may be made from the same welded joint if there is sufficient material available. If not, a new assembly shall be welded using the same pWPS. If either of these additional tests do not comply with the relevant requirements, the pWPS shall be regarded as not capable of complying with the requirements without modification.
13 Welding procedure qualification, copper alloys

13.1 Pipes, plates, castings and other product forms, not including propeller castings

13.1.1 WPS for pipes and plates shall be qualified in accordance with ISO 15614-6 unless otherwise agreed.

13.2 Copper alloy castings for propellers

13.2.1 General recommendations for filler metal and pre- and post-weld heat treatment of copper alloy propeller castings are given in Table 19.

Table 19 Recommendations for welding of copper alloy propeller castings

<table>
<thead>
<tr>
<th>Alloy type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn-bronze, Cu1</td>
<td>Use Al-bronze (^1) or Mn-bronze filler metal. Preheat to 150°C and interpass temperature not to exceed 300°C. Stress relief at 350°C to 500°C</td>
</tr>
<tr>
<td>Mn-Ni-bronze, Cu2</td>
<td>Use Al-bronze or Mn-Ni-bronze filler metal. Preheat to 150°C and interpass temperature not to exceed 300°C. Stress relief at 350°C to 550°C</td>
</tr>
<tr>
<td>Ni-Al-bronze, Cu3</td>
<td>Use Al-bronze, Ni-Al-bronze (^2) or Mn-Al-bronze filler metal. Preheat to 100°C and interpass temperature not to exceed 250°C. Stress relief at 450°C to 500°C</td>
</tr>
<tr>
<td>Mn-Al-Bronze, Cu4</td>
<td>Use Mn-Al-bronze filler metal. Preheat to 100°C and interpass temperature not to exceed 300°C. Stress relief at 450°C to 600°C</td>
</tr>
</tbody>
</table>

\(^1\) Ni-Al-Bronze and Mn-Al-Bronze acceptable
\(^2\) if Ni-Al-Bronze is used, stress relief is not required.

13.2.2 For qualification of WPS, a test assembly of minimum 30 mm thickness shall be welded. See Figure 26.
13.2.3 Prior to sectioning, the test assembly shall be visually inspected and liquid penetrant tested in accordance with a recognized standard, e.g. ISO 3452, ASTM E165. Imperfections shall be assessed in accordance with Table 20.

### Table 20 Allowable number and size of indications depending on severity zones

<table>
<thead>
<tr>
<th>Severity zone</th>
<th>Maximum total number of indications</th>
<th>Indication type</th>
<th>Maximum number for each type&lt;sup&gt;1, 2)&lt;/sup&gt;</th>
<th>Maximum dimension of indications (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>Non-linear</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear or aligned</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>14</td>
<td>Non-linear</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear or aligned</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>C</td>
<td>20</td>
<td>Non-linear</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear or aligned</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

<sup>1</sup> single non-linear indications less than 2 mm in zone A and less than 3 mm in other zones may be disregarded

<sup>2</sup> the total number of non-linear indications may be increased to the maximum total number, or part thereof, represented by the absence of linear or aligned indications.

13.2.4 Three macro-sections shall be prepared and etched on one side to clearly reveal the weld metal, the fusion line, and the heat affected zone. The sections shall be visually inspected for any imperfections...
present in the weld metal and HAZ. Inclusions or pores greater than 3 mm and cracks or lack of fusion are not permitted.

**Guidance note:**
An etching medium with the following constituents is suitable for this purpose:

- 5 g ferric (III) chloride
- 30 ml hydrochloric acid
- 100 mm distilled water.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

**13.2.5** Two tensile test pieces shall be prepared as shown in Figure 27. The tensile strength for copper alloy propeller castings shall meet the specified minimum values given in Table 21. The tensile strength for other copper alloy castings shall meet the requirements for the base material. The location of fracture shall be reported, i.e. weld metal, HAZ or base material.

**13.2.6** For welding procedures qualified according to this chapter, all thicknesses are qualified. Range of approval for other parameters shall follow ISO 15614-6 unless otherwise agreed.

---

**Figure 27** Tensile test specimen for weld test assembly

**Table 21** Tensile strength requirements for WPQT

<table>
<thead>
<tr>
<th>Alloy type</th>
<th>Tensile strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn-Bronze, Cu1 (brass)</td>
<td>370</td>
</tr>
<tr>
<td>Mn-Ni-Bronze, Cu2 (brass)</td>
<td>410</td>
</tr>
<tr>
<td>Ni-Al-Bronze, Cu3 (bronze)</td>
<td>500</td>
</tr>
<tr>
<td>Mn-Al-Bronze, Cu4 (bronze)</td>
<td>550</td>
</tr>
</tbody>
</table>

**14 Welding procedure qualification, repair welding of steel castings**

**14.1 General**

**14.1.1** These requirements are applicable to repair welding of steel castings, including stainless steel propeller castings.
14.2 Welding procedure qualification test

14.2.1 For qualification of procedures, a test assembly of minimum 30 mm thickness shall be welded.

14.2.2 Prior to sectioning, the test assembly shall be visually inspected and liquid penetrant tested. Imperfections shall be assessed in accordance with Ch.2 Sec.8 [4.6].

14.2.3 Two macro-sections shall be prepared and etched on one side to clearly reveal the weld metal, the fusion line, and the heat affected zone. The sections shall be examined by eye for any imperfections present in the weld metal and HAZ. Cracks or lack of fusion are not permitted. Inclusions or pores greater than 3 mm are not permitted.

14.2.4 Two flat transverse tensile test pieces shall be prepared. The tensile strength shall meet the specified minimum value of the base material. The location of fracture shall be reported, i.e. weld metal, HAZ or base material.

14.2.5 Two transverse side bend test pieces shall be prepared. The former diameter shall be 4 times the thickness except for austenitic steels, in which case the mandrel diameter shall be 3 times the thickness. The test piece, when visually inspected after bending, shall have no surface imperfections greater than 2 mm in length.

14.2.6 Where impact test is required for the base material, Charpy V-notch impact toughness test is required in accordance with [3.2.8]. For stainless steel propeller castings, two sets would suffice; one set with the notch positioned in the centre of the weld and one set with the notch positioned in the fusion line. The test temperature and absorbed energies shall comply with the requirements for the base material.

14.2.7 One of the macro-sections shall be used for HV5 hardness testing. Indentations shall traverse 2 mm below the surface. Minimum three individual indentations shall be made in the weld metal, the HAZ (both sides) and in the base material (both sides). The values shall be reported for information.

14.2.8 The chemical composition of the deposited metal shall be analysed and the result shall be within the same category as the parent metal.

14.3 Range of validity

14.3.1 The qualification is valid for repair welding on all thicknesses and bevel configurations. For limitations to range of approval for material grades, heat input and welding consumables, see [6].
SECTION 6 FABRICATION AND TOLERANCES

1 General

1.1 Scope

1.1.1 This section specifies general requirements for steel structure fabrication processes, including essential variables, which shall be maintained and controlled by the builders. The designing and dimensioning of welded joints in the various ranges of application is additionally governed by specific requirements stated in Pt.3 and Pt.4.

1.2 Certification requirements

1.2.1 General certification requirements are given in Sec.1 [3.1].

1.3 Documentation requirements

1.3.1 Documentation requirements are given in Sec.1 [3.2].

1.4 Survey, inspection and testing requirements

1.4.1 General survey, inspection and testing requirements are given in Sec.1 [3.3]. Additional specific requirements are given in Table 1, as further detailed in this section.

Table 1 Additional survey and testing requirements

<table>
<thead>
<tr>
<th>Survey, inspection and testing item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fit-up inspections</td>
<td>Fit-up shall be checked for dimensional accuracy before welding by the builder, in order to ensure compliance with the weld shapes and root openings (air gaps) according to the manufacturing documents and approved WPS. The surveyor may request to attend on a case by case basis</td>
</tr>
<tr>
<td>Weldability</td>
<td>In case of doubts, the weldability of the materials shall be verified before welding commences to the satisfaction of the surveyor</td>
</tr>
<tr>
<td>Welding production tests (WPT)</td>
<td>As verification of the quality of produced welds WPT may be required by the surveyor</td>
</tr>
<tr>
<td>Welding consumables</td>
<td>The welding shop’s supervisors shall ensure that only welding consumables which have been approved by the Society are being used and shall furnish proof thereof to the surveyor on request</td>
</tr>
</tbody>
</table>
2 Material, identification and weldability

2.1 General

2.1.1 A material identification system which ensures correct installation and traceability documentation of the material grades shall be established.

2.1.2 Welded structures shall be fabricated using base materials of proven weldability, see Ch.2 Sec.2. Special attention shall be paid regarding the approval of hull structural steels intended for welding with heat input more than 50 kJ/cm. In case of doubt, the weldability of the materials shall be verified before welding commences.

3 Shop primers

3.1 General

3.1.1 Shop primer applied over areas, which will subsequently be welded, shall be type approved in accordance with DNVGL-CP-0109. Fully mechanized fillet welding over shop primer shall be approved for each type of shop primer by a welding procedure qualification test (WPQT), see Sec.5.

Guidance note:
Type approved shop primers are listed in the Society register of approved products and manufacturers, available on the DNV GL internet site.

4 Welding environment

4.1 General

4.1.1 Welding work shall not be carried out in environmental conditions that have a detrimental effect such as wind, damp and low temperatures.

Guidance note:
If preheating at temperature above ambient is not already required or recommended, see [5.3.7], recommendations for preheating for welding at low temperatures are given in IACS Rec. No. 47, Table 6.12.

4.1.2 The grooves shall be clean and dry at all time of welding.

4.1.3 Preheating temperature, whenever required, shall in any case be within the limit of essential variables, see [5.3.7].

4.1.4 The welding interpass temperature shall not drop below the minimum required preheating temperature and shall not exceed the maximum qualified interpass temperature.

4.1.5 During the entire construction period, suitable measures shall be taken in transport, storage and fabrication to keep the surface of stainless steels free from impurities and extraneous metallic inclusions.
5 Cutting, forming, assembly and welding

5.1 Cutting

5.1.1 Cut edges shall be accurate and uniform in order to provide a shape compatible with the weld joint design.

5.1.2 Deviation of cut edges shall generally be within the standard specified by IACS Rec. No.47 Shipbuilding and Repair Quality Standard Part A.

5.1.3 Attention shall be paid to avoid excessive local hardening and carbon contaminations by thermal cutting.

5.1.4 The effect of work hardening and risk of cracked edges shall be considered if shearing is used for cutting of material.

5.1.5 Correction by welding as compensation for improper cutting shall be in accordance with procedures for repairs.

5.2 Forming

5.2.1 Forming and straightening of materials shall be performed according to procedures which outline the succession of the controlled steps.

5.2.2 Requirements for cold forming of hull structural steels, e.g. minimum steel grade toughness requirements (D/DH), and maximum theoretical deformation (5%, 10% and 20%, as specified), are given in Pt.3 Ch.3 Sec.1 [2.7].

5.2.3 Cold forming with theoretical deformation exceeding the limits given in Pt.3 Ch.3 Sec.1 [2.7] may be accepted subject to additional testing of representatively cold formed material, e.g. strain age testing. The strain age test method is described in Ch.1 Sec.3 [3.8], and acceptance criteria for the tests are given in Pt.3 Ch.3 Sec.1 [2.7]. Unless otherwise agreed, each heat represented shall be tested.

Cold forming to an inside bending radius of less than 2 times the plate thickness shall in no case be carried out, unless specially approved.

Guidance note:
In addition to representative cold forming, in this context "representative material" means at least same material grade, with similar chemical composition and mechanical properties, and from one steel manufacturer. For destructive testing, the following should be tested as a minimum; impact toughness tests of representatively strained material and strain aged material. Test temperature should be the same as required for the base material.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.2.4 Cold forming to a theoretical deformation exceeding the limits given in [5.2.3] may be pre-qualified by the manufacturer. The pre-qualification is subject to special consideration and with agreed additional process and testing requirements.

5.2.5 If welding is applied in cold formed areas, special consideration shall be taken with respect to material properties and subsequent cracking.
5.2.6 The theoretical plastic deformation $\varepsilon$ (%) shall be calculated by the following simplified formulas:

**Single-curvature deformation**

Cold rolling or pressing of plates to cylindrical forms:

$$\varepsilon = \frac{t}{2R_c + t} \times 100$$  \hspace{1cm} (1)

Cold bending of straight pipes to bends:

$$\varepsilon = \frac{D}{2R_c} \times 100$$  \hspace{1cm} (2)

**Double curvature deformation**

Forming of plates to spheres:

$$\varepsilon = \frac{t(1 + \nu)}{2R_c} \times 100$$  \hspace{1cm} (3)

$D$ = outside diameter of pipe of vessel, mm  
$\varepsilon$ = theoretical plastic deformation, %  
$R_c$ = forming radius (inner radius of bend), mm  
$t$ = material thickness, mm  
$\nu$ = Poisson's ratio (0.5 for plastic condition).

5.2.7 Forming of steels at high temperatures shall be effectuated with due regard to adverse effects of the material’s properties. Forming of steels above 650°C shall be subject to agreement with the Society, considering steel manufacturer’s recommendation.

5.3 Assembly and welding

5.3.1 Members to be welded shall be brought into correct alignment and held in position by clamps, tack welds, or other suitable devices. Structures or components shall not be subjected to any appreciable movements or vibration during welding.

5.3.2 Parts to be assembled while suspended from cranes or floating shall be clamped prior to tack-welding of the joints, in such a way that no relative movement of the parts is possible. Components which have not been fully welded and which shall be handled or turned shall have welded joints of adequate strength.

5.3.3 Fit-up shall be checked for dimensional accuracy before welding, in order to ensure compliance with the weld shapes and root openings (air gaps) according to the manufacturing documents and approved WPS. The root opening shall not exceed twice the specified gap as given in the approved WPS. If the permitted size of the gap is exceeded locally over a limited area, remedial work shall be carried out within the limitations specified in IACS Rec. No.47.

Special attention shall be paid to the alignment of structural members where visual inspection is not possible.

5.3.4 Surfaces to be welded shall be free from mill scale, slag, rust, paint or other contaminating substances.


**Guidance note:**

Internal defects, e.g. inclusions making the steel plate prone to lamination, may to some extent be considered consistent with method of manufacture, unless Z-grade steels are specified. Purchasers should specify additional requirements for the internal quality (e.g. ultrasonic testing) where this is critical for the intended application.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.3.5 Grooves produced by gouging shall be followed by grinding removing carbonized material.

5.3.6 All welding, including tack welding, seal welding, welding of lifting lugs and attachment welds as well as repair welding, shall be performed within the limits of essential variables of the qualified WPS.

5.3.7 The need and the degree of preheating necessary for welding are governed by a series of factors (see Guidance note). If preheating is necessary for welding it shall be applied in accordance with agreed preheating procedures. Special attention shall be paid to temperature control during the welding process such that the preheat temperature is kept uniformly in affected part of the welded object.

**Guidance note:**

Normal strength steels may require preheating depending on the plate thicknesses and the degree of joint restraint. Preheating is normally required for welding of high and extra high strength steels depending on:

— plate thickness
— the chemical composition of the parent material and weld metal
— the hydrogen content of the weld metal
— heat input during welding
— the temperature of the welded object
— the stress level (incl. the joint restraint condition)
— post heating may additionally be required for extra high strength steels.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.3.8 The welding sequence shall be such that the amount of shrinkage, distortions and residual stresses are minimised.

**Guidance note:**

Welding should be performed in the optimum welding position. Positional welding (e.g. in the overhead positions) should be limited to the indispensable minimum.

Vertical down fillet welding should not be used:

— for joining together continuous primary supporting members interrupted by transverse members (e.g. the longitudinal members of the upper and lower girder); the same applies where transverse loads predominate
— for mainly dynamically loaded welded joints (e.g. in the area of engine base plates, shaft, brackets and rudders)
— on crane components and other lifting gear including their substructures (e.g. crane pillars)
— at intersections of main girders and in the area of the supports or stoppers of hatchway covers.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

5.3.9 Welds shall be terminated in a manner such that all welds are sound and without end craters. Run-in and run-off plates shall be used, where practicable. They shall be removed upon completion and cooling of the weld. Cut welds shall be made smooth and flush with the edges of the abutting parts.

5.3.10 Tack welding shall, when integrated in production weld, be carried out in accordance with approved WPS specifying the applied minimum welding length.

5.3.11 Tack welds, if retained as part of the welding process, shall be free from defects and provide adequate conditions for pass welding. Cracked tack welds shall not be welded over.
5.3.12 Clamping plates, temporary ties and aligning pins shall be made from a material of similar composition and should not be used more than necessary. Any damage caused during removal shall be competently repaired.

5.3.13 The welding consumables (including flux, backing, welding gas, etc.) shall enable a welded joint to be made which is suited to the base material and the operating conditions.

5.3.14 Storage and handling of welding consumables shall be in accordance with the manufacturer’s recommendations, and in accordance with procedures giving details regarding conditions in storage rooms, temperature in storage ovens and quivers, length of exposure and conditions.

5.3.15 Consumables which have been contaminated by moisture, rust, oil, grease, dirt or other deleterious matters, shall be discarded unless properly reconditioned.

5.3.16 Recycling of fluxes for SAW shall be performed in a manner that ensures a mixture of new and used flux with continually homogenous properties.

5.3.17 The welding shop’s supervisors shall ensure that only welding consumables which have been approved by the Society are used. Proof thereof shall be furnished to the surveyor on request. Welding consumables specified in an approved welding procedure can only be replaced by equivalent consumables approved by the Society with an appropriate quality grade. Further details are given in Sec.5.

5.3.18 Additional requirements applicable for VL D/E47COD, BCA and BCACOD steels:

— wherever possible, multi-pass welding shall be applied
— tack welds shall have a length not less than 50 mm. For steel with $P_{cm} \leq 0.19$, tack welds with length not less than 25 mm may be accepted subject to qualification and approval
— preheating shall be 50°C or over when air temperature is 5°C or below. For steel with $P_{cm}$ less than or equal to 0.19 and subject to qualification and approval, air temperature below 5°C may be accepted. The pre-heating temperature shall be measured at a distance of 75 mm from the edges of the groove at the opposite side of the heating source, or as close as possible to this position. When preheating is required, the temperature shall be strictly controlled

Guidance note:
For the required preheating, electric heating elements are considered adequate in order to give sufficient temperature control. When preheating is not strictly required by the rules, and air temperature below 5°C is accepted without preheating, drying out using a properly designed gas torch should be considered. Cutting torch is considered not suitable for drying out. For repair welding, preheating temperature should be increased 50°C above minimum specified preheating temperature given by the WPS.

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— special care shall be paid to the final welding so that harmful defects do not remain. Jig mountings shall be completely removed. If there are defects present after JIG removal, means for correction shall be accepted by the Society
— welding procedures (WPS) shall be qualified through welding procedure qualification test (WPQT) as described in Sec.5, with the additional requirements for fracture mechanics testing (FM) as follows: CTOD testing is required for base material, heat affected zone and weld metal. Testing shall be carried out at minus 10°C or design temperature, whichever is lower. Test method and acceptance criteria are given in Sec.5. Provided that the relevant CTOD requirements are qualified during the approval of manufacturer test for relevant welding parameters, the applicable CTOD testing does not have to be repeated. (Note that CTOD testing of the weld metal is not commonly covered by the approval of manufacturer test)
— verification of the WPS during welding shall be carried out and recorded
— gouging shall be followed by grinding to remove any carburised layer. The surveyor may require proof of satisfactory performance of gouging and grinding
— arc strikes shall be repaired by mechanical removal of affected base material followed by magnetic particle testing (MT) in order to verify absence of cracks.
5.3.19 When deemed necessary by the Society, WPT shall be made during fabrication of welds to verify that the produced welds are of acceptable quality.

6 Remedial

6.1 General

6.1.1 Guidance to general welding repair work is given in IACS Rec. No.47 Shipbuilding and Repair Quality Standard Part A.

6.1.2 Defects in welds may be repaired by grinding or machining and/or followed by welding. In order to verify complete removal of defects, affected areas shall be examined with suitable NDT methods.

6.2 Repair welding

6.2.1 Repairs by welding shall be carried out in accordance with approved WPS. Mechanical properties shall satisfy the minimum specified properties of the material in question.

6.2.2 Repair welding in the same area shall not be carried out more than twice. Further repairs shall be subject to agreement with the Society.

6.2.3 Defects shall be completely removed before necessary repairs are carried out. Repairs with arc-air gouging shall be followed by grinding.

6.2.4 Repair welding of post-weld heat-treated joints shall unless otherwise agreed initiate a new heat treatment.

6.2.5 All weld repairs shall at least be re-inspected with the same NDT methods as originally applied, see also Sec.7 [5.2].

6.3 Flame straightening

6.3.1 Members distorted by welding may be straightened by mechanical means or by a limited amount of localized heat. Flame straightening shall be done in accordance with an agreed procedure.

6.3.2 Corrective measures relating to flame straightening shall be carried out with due regard to possible degradation of the material properties. Reference is made to IACS Rec. No.47 Shipbuilding and Repair Quality Standard Part A Table 6.5, regarding max. temperature on the surface.

7 Inspection, survey and tolerances

7.1 General

7.1.1 Inspection shall be carried out in accordance with inspection and test plans, to confirm that work is carried out in accordance with established project procedures and plans, such that all project requirements are complied with to the satisfaction of the Society. Reference is given to IACS UR Z23 regarding the survey of hull structure.
7.1.2 Due consideration shall be given to the access and time required for adequate inspection and survey during fabrication.

7.1.3 High non-conformance rates in execution of the work or in the product itself shall call for special considerations in agreement with the Society. Such special considerations may include increased inspection by the builder, increased surveys by the Society, re-qualification of personnel and other agreed remedial actions.

7.2 Alignment and straightness

7.2.1 Allowable acceptable alignment shall be established depending on the criticality of the design. Special requirements related to special type and service are given in Pt.5.

7.2.2 Unless otherwise agreed, fabrication tolerances shall be in compliance with IACS Rec. No.47 Shipbuilding and Repair Quality Standard, Part A.

7.3 Weld production test requirements

7.3.1 The Society may require WPTs to be carried out. The extent and type of testing shall be agreed with the Society.

7.3.2 When WPTs are required the test assembly and test requirements shall comply with relevant requirements of Sec.5.

7.3.3 If the achieved test results do not comply with the requirements of Sec.5, the results shall be submitted for consideration. The WPT may be accepted subject to acceptable results from additional test prescribed by the Society.
SECTION 7 NON DESTRUCTIVE TESTING OF WELDS

1 General

1.1 Scope

1.1.1 This section provides requirements for the quality control of ship hull welds in the newbuilding phase. The section contains requirements for the application of non-destructive testing (NDT) - methods, extent of testing and acceptance criteria.

1.1.2 Additional requirements for extent of testing and acceptance criteria are given in Pt.5 for the relevant ship types.

1.1.3 For non-destructive testing the builder or its sub-supplier shall set up a qualified inspection body.

Guidance note:
The inspection body should be independent of the manufacturing departments. Furthermore, it is recommended that the inspection body is either approved according to DNVGL CP 0484, App. B, Sec. 4 or complies with ISO/IEC 17020 Type A or B or ISO/IEC 17025.

1.2 Certification requirements

1.2.1 General certification requirements are given in Sec.1 [3.1].

1.3 Documentation requirements

1.3.1 Documentation requirements are given in Sec.1 [3.2]. Additional documentation requirements are given in DNVGL-CG-0051.

1.4 Survey, inspection and testing requirements

1.4.1 General survey, inspection and testing requirements are given in Sec.1 [3.3]. Additional specific requirements are given in Table 1.

Table 1 Additional survey and testing requirements

<table>
<thead>
<tr>
<th>Survey, inspection and testing item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDT inspections</td>
<td>NDT reports shall be signed by the NDT operator performing the testing</td>
</tr>
<tr>
<td>NDT operators / supervisor(s)</td>
<td>The testing operators and the supervisor(s) shall be certified in accordance with ISO 9712, ASNT ACCP or equal. The surveyor shall be furnished with proof thereof if he so requests. The supervisor(s) / level III shall be available for scheduling and monitoring the performed NDT. The supervisor(s) / level III shall be responsible for developing, verifying and/or approving the NDT procedures in use and make sure these procedures are in compliance with the rules.</td>
</tr>
</tbody>
</table>
1.5 Basic requirements

1.5.1 The rules are based on the following conditions:

Weld joint types
The following main weld joints are covered, see the Figures in Sec.5:
— butt joints
— T-joints (with and without full penetration)
— fillet welds.

Types of imperfections
The main types of imperfections in fusion welding are given in EN ISO 6520-1 Welding and Allied Processes - Classification of Geometric Imperfections in Metallic materials, Part 1: Fusion Welding.

Testing methods
For detection of surface imperfections the following methods applies:
— visual testing (VT)
— magnetic particle testing (MT)
— penetrant testing (PT).
For detection of sub-surface imperfections the following methods applies:
— ultrasonic testing (UT)
— radiographic testing (RT).

For the choice of applicable test methods, reference is given to DNVGL-CG-0051.

1.5.2 The test method selected shall in a reliable way be capable of detecting external and/or internal defects present. Where necessary, this shall be achieved by using two or more test methods in combination. The particular test method(s) to be used shall be stated in the inspection plan.

1.5.3 For VL 420 grades and higher, final inspection and NDT shall not be carried out before 48 hours after completion, unless heat treatment has been carried out.

2 Non-destructive testing procedures and reports

2.1 General

2.1.1 NDT shall be performed in accordance with agreed written procedures. The procedures shall be in accordance with DNVGL-CG-0051. Other recognised standards may be accepted based on case by case approval.

2.1.2 Unless otherwise agreed, the surface to be tested shall be presented clean and smooth, i.e. free from dirt, scale, rust, welding spatter, etc., which may influence the results of the testing.

2.1.3 Unless otherwise agreed, NDT reports shall be signed by the NDT operator performing the testing.
2.2 Visual testing

2.2.1 Unless otherwise agreed, VT shall be completed before other NDT methods are applied.

2.3 Magnetic particle testing

2.3.1 Where possible, both sides of the welds shall be tested. Magnetic particle testing (MT) shall be applied for welds in ferro-magnetic materials if not otherwise agreed.

2.4 Radiographic testing

2.4.1 For radiographic testing, X-ray source shall be used whenever possible. Gamma-ray sources may be used when qualified through examination by the Society. Radiographic testing (RT) may be replaced by ultrasonic testing and vice versa, when justifiable and in agreement with the Society.

2.4.2 Processing and storage shall be such that the radiographs maintain their quality throughout the agreed storage time. The radiographs shall be free from imperfections due to processing.

2.4.3 Indications suspected to be planar and discovered by RT shall be type determined, located and sized by UT.

2.5 Ultrasonic testing

2.5.1 Ultrasonic testing (UT) shall not be carried out on welds with thickness < 10 mm unless qualified and accepted down to 8 mm.

2.6 Penetrant testing

2.6.1 Where possible, both sides of the welds shall be tested. Penetrant testing (PT) shall only be applied for welds in non-ferromagnetic materials if not otherwise agreed.

3 Personnel qualifications

3.1 General

3.1.1 All testing shall be carried out by qualified and certified personnel. The NDT operators shall be certified according to a 3rd party certification scheme based on ISO 9712 or ASNT Central Certification Program (ACCP). SNT-TC-1A may be accepted if the NDT company's written practice is reviewed and accepted by the Society. The certificate shall clearly state the qualifications as to which testing method, level and within which industrial sector the operator is certified.

NDT operators; shall be certified Level 2 in the testing method and industrial sector concerned.

3.1.2 The supervisor shall be available for scheduling and monitoring the performed NDT. The supervisor shall be available for developing, verifying and/or approving the NDT procedures in use and make sure these procedures are in compliance with the rules. NDT supervisors shall, unless otherwise agreed, be certified Level 3 in the testing method and industrial sector concerned.
Guidance note:
Welding supervisors with tasks and responsibilities for welding inspection according to ISO 14731 may be recognized in way of the DNV GL welding workshop approval also as supervisors for NDT based on additional NDT training and qualification. Personnel qualifications are to be verified by certification.

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4 Extent of non-destructive testing

4.1 General

4.1.1 The extent of testing will depend on the type of vessel and the location of the joints.

4.1.2 The basic requirements for all vessel types are that all welds are subject to 100% visual testing carried out by the builder’s qualified personnel before any other NDT is applied. In addition, welds shall be subjected to testing with other test methods as given in the Table 2 below.

The extent may be extended further depending on quality of welds and repair rate, see [5.2.1].

The Society reserves the right to alter the test positions and/or to extend the scope of NDT against the NDT plan in case of doubts about proper workmanship.

4.1.3 The locations and areas to be examined shall be incorporated into the NDT plan. The NDT plan shall clearly identify the critical areas as defined below.

Table 2 Minimum non-destructive testing extent (in % of weld seam length) for structural welds

<table>
<thead>
<tr>
<th>Area</th>
<th>Type of connection</th>
<th>Testing method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MT/PT 1)</td>
</tr>
<tr>
<td>General areas</td>
<td>Butt- and T-Joints, full penetration</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>T-Joints, partly penetration</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Fillet welds</td>
<td>-</td>
</tr>
<tr>
<td>Deck/bottom plating within</td>
<td>Butt- and T-Joints, full penetration</td>
<td>5%</td>
</tr>
<tr>
<td>0.4 L amidship</td>
<td>T-Joints, partly penetration</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>Fillet welds</td>
<td>-</td>
</tr>
<tr>
<td>Critical areas</td>
<td>Butt- and T-Joints, full penetration</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>T-Joints, partly penetration</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Fillet welds</td>
<td>20%</td>
</tr>
</tbody>
</table>

1) MT testing shall be applied for ferro-magnetic materials
2) RT shall not be applied for T-joints

4.1.4 The different areas in Table 2 are defined as follow:

Critical areas
Areas in way of critical load transfer points and large stress concentrations where a failure will endanger the safety of the vessel, such as:
— stress concentrations in rudders or intersection between rudder structure and hull
— for twin hull vessels stress concentrations in way of connections between hull and wet deck
— deck beams in open hatch container ships
— strength deck plating at outboard corners of cargo hatch openings in container carriers and other vessels with similar hatch opening configuration
— other areas where the likelihood of occurrence of detrimental defects is considered to be extra high.

**Guidance note:**
Areas to be considered for classification under this item are:
— welds produced by welding methods which the yard has little or no user experience
— welds produced by high heat input (> 50 kJ/cm) welding methods
— welds in large thickness (> 50 mm).

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**Deck and bottom plating within 0.4 L amidship:**
— sheer strake at strength deck
— stringer plate in strength deck
— deck strake at longitudinal bulkhead
— strength deck plating at corners of cargo hatch openings in bulk carriers, ore carriers, combination carriers and other vessels with similar hatch opening configuration
— bilge strake
— longitudinal hatch coamings of length greater than 0.15 L
— end brackets and deck house transition of longitudinal cargo hatch coamings
— all watertight bulkheads independent of location.

**Guidance note:**
For vessels with no clearly defined strength deck e.g. cruise ships, the above extents shall be applied to the decks contributing most to the hull strength.

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**General areas**
Areas not mentioned above.

4.1.5 NDT shall cover start and stop points of automatically welded seams, except for internal stiffeners where the extent of testing shall be agreed with the Society. Extent is as given in Table 2.

5 Acceptance criteria for non-destructive testing

5.1 General

5.1.1 All welds shall show evidence of good workmanship. For NDT acceptance criteria Table 3 applies:

**Table 3 Acceptance criteria for non-destructive testing**

<table>
<thead>
<tr>
<th>Testing method</th>
<th>Symbol</th>
<th>General areas</th>
<th>Critical areas, and deck and bottom plating within 0.4 L amidship</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Container vessels</td>
</tr>
<tr>
<td>Visual testing</td>
<td>VT</td>
<td>IACS Rec. 47 1)</td>
<td>IACS Rec. 47 1, 2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISO 5817 level C</td>
<td>ISO 5817 level B</td>
</tr>
<tr>
<td>Magnetic particle testing</td>
<td>MT 3)</td>
<td>ISO 23278 level 2x</td>
<td>ISO 23278 level 2x</td>
</tr>
<tr>
<td>Penetrant testing</td>
<td>PT 3)</td>
<td>ISO 23277 level 2x</td>
<td>ISO 23277 level 2x</td>
</tr>
<tr>
<td>Radiographic testing</td>
<td>RT 3)</td>
<td>ISO 10675 level 2</td>
<td>ISO 10675 level 1</td>
</tr>
</tbody>
</table>
Ultrasonic testing 4)  | UT 3)  | ISO 11666 level 3  | ISO 11666 level 2  | ISO 11666 level 3 2)  
--- | --- | --- | --- | ---  
1) IACS Rec. No.47 may be applied for imperfections in finished welds. Alternatively, and for all other imperfections not defined in IACS Rec. No.47, ISO 5817 level B or C applies  
2) the Society may require higher acceptance criteria e.g. ISO 5817 level B  
3) regarding use of ISO 5817 and quality level for RT, UT, MT and PT, correlation is given in EN ISO 17635  
4) all imperfections from which the reflected echo amplitude exceeds the evaluation level shall be characterized, and all that are characterized as planar e.g. cracks, lack of fusion, incomplete penetration shall be rejected

Welds tested and accepted by the builder/manufacturer shall be verified if deemed necessary by the Society. Welds in aluminium shall comply with ISO 10042 level B (in critical areas, and in deck and bottom plating within 0.4 L amidship) or level C (in general areas). Regarding use of ISO 10042 and quality level for RT, UT and PT, correlation is given in EN ISO 17635 (ISO 10675-2), the same way as described for ISO 5817 above.

5.2 Non-conforming weldments

5.2.1 If a non-conforming discontinuity is detected during testing at spot basis, the scope of testing shall be extended. Unless otherwise agreed, for each section of weld to be repaired two more of the same length shall be tested. If systematically repeated discontinuities are revealed, the extent of testing shall be increased for welds manufactured under same conditions and where similar defects may be expected.

5.2.2 If non-conforming discontinuities are found to occur regularly, the reason for the non-conforming discontinuities shall be investigated. The WPS shall be reassessed before continuation of the welding. Necessary actions shall be taken to bring the production to the required quality level.

5.2.3 Detected non-conforming discontinuities shall be repaired unless they are found acceptable by the Society. Removal of weld discontinuities and repair shall be performed in accordance with a procedure approved by the Society.

5.2.4 After repair welding has been performed, the complete weld, (i.e. the repaired area plus minimum 100 mm on each side) shall be subjected to at least the same NDT method(s) as specified for the original weld.
SECTION 8 STRUCTURAL AND TIGHTNESS TESTING

1 General

1.1 Scope

1.1.1 This section specifies general requirements for structural and tightness testing of tanks and holds of:
— new vessels prior to delivery
— structures involved in, or affected by, conversions or repairs.
For details see IACS UR No. S14.

1.1.2 For liquefied gas carriers additional requirements are given in the relevant part of the rules.

1.1.3 The requirements in this section are not applicable for high speed light crafts and naval vessels.

1.1.4 Additional requirements for vessels subject to IACS Common Structural Rules (CSR) are specified in the relevant CSR for Bulk Carriers and Double Hull Oil Tankers.

1.2 Certification requirements

1.2.1 General certification requirements are given in Sec.1.

1.3 Documentation requirements

1.3.1 Documentation requirements are given in Sec.1.

1.4 Survey, inspection and testing requirements

1.4.1 General survey, inspection and testing requirements are given in Sec.1. Additional specific requirements are given in Table 1, as further detailed in this section.

Table 1 Additional survey and testing requirements

<table>
<thead>
<tr>
<th>Survey, inspection and testing item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural and tightness testing</td>
<td>The particular test method(s) to be used shall meet the requirements given herein. Tests shall be carried out in the presence of the surveyor</td>
</tr>
</tbody>
</table>
2 Testing

2.1 Definitions

2.1.1 The following terms are used:

— **Structural testing** is a hydrostatic test, carried out in order to demonstrate the tightness of the tanks and the structural adequacy of the design. Where hydrostatic testing is not practically feasible, hydropneumatic testing may be carried out instead under provision that the test is simulating, as far as practicable, the actual loading of the tank.

— **leak testing** is an air or other medium test, carried out in order to demonstrate the tightness of the structure.

— **shop primer** is a thin coating applied after surface preparation and prior to fabrication as a protection against corrosion during fabrication.

— **protective coating** is a coating protecting the structure from corrosion.

— **watertight** means capable of preventing the passage of water through the structure under a head of water for which the surrounding structure is designed.

— **weathertight** means that in any sea conditions water will not penetrate into the vessel.

— **FRP** means fibre reinforced plastic.

2.1.2 Definition of test types

**Table 2 Test types**

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrostatic test: (Leak and structural)</td>
<td>A test by filling the space with a liquid to a specified head.</td>
</tr>
<tr>
<td>Hydropneumatic test: (Leak and structural)</td>
<td>A test wherein the space is partially filled with liquid and air pressure applied on top of the liquid surface.</td>
</tr>
<tr>
<td>Hose test: (Leak)</td>
<td>A test to verify the tightness of the joint by a jet of water. The hose pressure shall be minimum 200 kN/m² and applied at a maximum distance of 1.5 m. The nozzle inside diameter shall be minimum 12.0 mm.</td>
</tr>
<tr>
<td>Air tests: (Leak)</td>
<td>A test to verify the tightness by means of air pressure differential and leak detection solution. It includes tank air tests and joint air tests, such as a compressed air test and vacuum box test. An efficient indicating liquid shall be applied, when air is used as the test medium. The air pressure shall be kept at a maximum pressure of 20 kN/m² for 1 hr. and shall be reduced to 15 kN/m² before inspection. In addition to an effective means of reading the air pressure, a safety valve, or a reliable equivalent alternative, shall be connected to the compartment being tested.</td>
</tr>
<tr>
<td>Compressed air fillet weld test: (Leak)</td>
<td>An air test of a fillet welded T-joint with a leak indicating solution applied on the fillet welds. Pressure gauges shall be arranged so that an air pressure of minimum 15 kN/m² can be verified at each end of all passages within the portion being tested.</td>
</tr>
<tr>
<td>Vacuum box test: (Leak)</td>
<td>A box over a joint with leak indicating solution applied on the fillet or butt welds. A vacuum (20 to 26 kN/m²) is created inside the box to detect any leaks.</td>
</tr>
<tr>
<td>Ultrasonic test: (Leak)</td>
<td>A test to verify the tightness of a sealing by means of ultrasound.</td>
</tr>
<tr>
<td>Penetration test: (Leak)</td>
<td>A test to verify that no continuous leakages exist in the boundaries of a compartment by the application of low surface tension liquids.</td>
</tr>
</tbody>
</table>
Other test methods are subject to approval by the Society upon submission of full particulars.

2.2 General requirements

2.2.1 Tests shall be carried out for:
— hatches
— doors
— windows
— all penetrations including pipe connections fitted.

At a stage sufficiently close to work completion but before any ceiling and cement work is applied over the joints.

Structural testing may be carried out after a protective coating has been applied, provided a leak test is carried out before application of the protective coating.

All pipe connections to tanks shall be fitted before structural testing.

When structural testing at the building berth is undesirable or impossible, structural testing afloat may be accepted. The structural testing shall be carried out by filling each tank separately to the test head.

Examination of bottom and lower side structures shall be made in empty tanks at the maximum practical attainable draught.

2.2.2 Leak testing shall be carried out before protective coating being applied to the welds. Shop primer may be applied to welds prior to leak test.

Test pressure shall be verified by means of one master pressure gauge. The Society may accept alternative means which are considered to be equivalently reliable, see Table 2.

Guidance note:
Silicate based shop primer may be applied to welds before leak testing. The layer of the primer should be maximum 50 microns.
Other primers of uncertain chemical composition shall be maximum 30 microns.

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2.3 Specific requirements for extent and type of testing

2.3.1 The requirements in [2.3] provide conditions for testing of:
— gravity tanks
— watertight or weathertight structures.

Guidance note:
Gravity tank means a tank that is subject to vapour pressure not greater than 70 kPa.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.3.2 Leak testing shall be carried out on all weld connections of:
— tank boundaries,
— pipe penetrations and
— erection joints on tank boundaries.

Automatic full penetration T-joints and automatic butt welds of erection joints, see Table 4 are exempted.

For the leak test specified in Table 3, a tank air test, compressed air fillet weld test, vacuum box test, or their combination is acceptable.

A hydrostatic or hydropneumatic test may be accepted as a leak test.

A hose test will be acceptable for the locations as specified in Table 3 with note 3.
A joint air test may be carried out in the block stage, provided all work on the block that may affect the tightness of the joint is completed before testing. See also Table 3.

Selected locations of automatic erection welds and pre-erection automatic welds may be required to be similarly tested, upon consideration of the quality control procedures in use by the shipyard.

2.3.3 A structural test shall be carried out for at least one tank of the same construction (i.e. tanks of the same structural design and configuration and same general workmanship as determined by the attending surveyor) on each vessel, provided all subsequent tanks are tested for leaks by an air test. The relaxation to accept leak testing using an air test instead of a structural test does not apply to cargo space boundaries in tankers and combination carriers and tanks for segregated cargoes or pollutants.

Where structural adequacy of a tank was verified by structural testing as required in Table 1, subsequent vessels in a series (i.e. sister ships built in the same shipyard) may be exempted from such testing for other tanks which have the structural similarity to the tested tank. The water-tightness in all boundaries of exempted tanks shall be verified by leak tests and thorough inspection.

For sister ships keel laid two years or more after the last ship of the series, such exemption may be reconsidered. In any case, structural testing shall be carried out for at least one tank for each vessel in order to verify structural fabrication adequacy.

The relaxation to accept leak testing and thorough inspections instead of a structural test on subsequent vessels in the series, does not apply to cargo space boundaries in tankers and combination carriers and tanks for segregated cargoes or pollutants.

2.3.4 For watertight boundaries of spaces other than tanks (excluding chain lockers), structural testing may be exempted, provided that the water tightness in all boundaries of exempted spaces are verified by leak tests and thorough inspection.

2.3.5 Subsequent tanks may require structural testing if found necessary after the structural testing of the first tank.

2.3.6 Tanks for structural test shall be selected such that all representative structural members are tested for the expected tension and compression.

2.3.7 Test requirements for tanks and boundaries are given in Table 3. Testing of structures not listed in Table 3 shall be specially considered.

### Table 3 Test requirements for tanks and boundaries

<table>
<thead>
<tr>
<th>Item to be tested</th>
<th>Type of testing</th>
<th>Structural test pressure</th>
<th>Extent of structural testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>All ship/vessel types</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Double bottom tanks   | Structural and leak testing | The greater of the following:  
— head of water up to top of overflow  
— 2.4 m head of water above highest point of tank. For FRP tanks: 1.0 m above highest point of tank.  
— top of bulkhead deck | Tank boundary tested from at least one side 1, 2, 3)  
Including tanks arranged in accordance with the provisions of SOLAS regulation II-1/9.4 |
<table>
<thead>
<tr>
<th>Component</th>
<th>Test Type</th>
<th>Description</th>
<th>Boundary Tested From</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double side tanks</td>
<td>Structural and leak testing</td>
<td>The greater of the following:</td>
<td>1, 2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- head of water up to top of overflow</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- 2.4 m head of water above highest point of tank</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- top of bulkhead deck</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- pressure relief valve opening pressure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tank boundary tested from at least one side</td>
<td></td>
</tr>
<tr>
<td>Cargo oil tanks</td>
<td>Structural and leak testing</td>
<td>The greater of the following:</td>
<td>1, 2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- head of water up to top of overflow</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 2.4 m head of water above highest point of tank</td>
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<tr>
<td></td>
<td></td>
<td>- head of water up to top of overflow or,</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- 2.4 m head of water above highest point of tank</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Tank boundary tested from at least one side</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Test of aft peak tank to be carried out after the stern tube has been fitted</td>
<td></td>
</tr>
<tr>
<td>Peak tanks</td>
<td>Structural and leak testing</td>
<td>The greater of the following:</td>
<td>1, 2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- head of water up to top of overflow</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 2.4 m head of water above highest point of tank</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- pressure relief valve opening pressure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tank boundary tested from at least one side</td>
<td></td>
</tr>
<tr>
<td>Fore peak voids</td>
<td>Leak testing</td>
<td></td>
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</tr>
<tr>
<td>After peak voids</td>
<td>Leak testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double side and bottom voids</td>
<td>Leak testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep tanks other than those listed elsewhere in this table</td>
<td>Structural and leak testing</td>
<td>The greater of the following:</td>
<td>1, 2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- head of water up to top of overflow or,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- 2.4 m head of water above highest point of tank</td>
<td></td>
</tr>
<tr>
<td>Chain locker</td>
<td>Structural and leak testing</td>
<td>Head of water up to top of chain pipe</td>
<td></td>
</tr>
<tr>
<td>Double plate rudders</td>
<td>Leak testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watertight doors below freeboard or bulkhead deck and watertight hatch covers</td>
<td>Leak testing</td>
<td></td>
<td>Each door and hatch cover 3, 6)</td>
</tr>
<tr>
<td>Weather tight doors, shell doors, hatch covers, and closing appliances</td>
<td>Leak testing</td>
<td></td>
<td>3)</td>
</tr>
<tr>
<td>Watertight bulkheads and decks</td>
<td>Leak testing</td>
<td></td>
<td>3, 4, 5)</td>
</tr>
<tr>
<td>Component Description</td>
<td>Testing Method</td>
<td>Requirements</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------------------</td>
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</tr>
<tr>
<td>Superstructure end bulkhead</td>
<td>Leak testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ballast ducts</td>
<td>Structural and leak testing</td>
<td>— ballast pump maximum pressure, or — setting of any pressure relief valve</td>
<td>1, 2)</td>
</tr>
<tr>
<td>Trunks, tunnels and ventilators</td>
<td>Leak testing</td>
<td></td>
<td>5)</td>
</tr>
<tr>
<td>Cofferdams</td>
<td>Leak testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Independent tanks</td>
<td>Structural and leak testing</td>
<td>The greater of the following: — head of water up to top of overflow — 0.9 m head of water above highest point of tank — pressure relief valve opening pressure</td>
<td>1, 2)</td>
</tr>
<tr>
<td>Dual purpose tank/dry cargo hatch cover</td>
<td>Leak testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry bulk cargo carrier</td>
<td></td>
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</tr>
<tr>
<td>Ballast holds</td>
<td>Structural and leak testing</td>
<td>The greater of the following: — head of water up to top of overflow, or — top of cargo hatch coaming</td>
<td>1, 2)</td>
</tr>
<tr>
<td>Combination carriers (OBOs)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watertight hatch covers of cargo tanks</td>
<td>Structural and leak testing</td>
<td>The greater of the following: — head of water up to top of overflow — 2.4 m head of water above hatch coaming — pressure valve opening pressure</td>
<td>At least every second hatch cover, provided that leak testing is carried out for all hatch covers</td>
</tr>
<tr>
<td>Chemical carriers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integral and independent cargo tanks</td>
<td>Structural and leak testing</td>
<td>1) Integral and independent tanks with a design pressure of less than 70 kN/m²: the greater of the following: — 2.4 m head of water above the highest point of the tank — top of tank plus setting of any pressure relief valve. 2) independent tanks with a design pressure exceeding 70 kN/m² shall be tested to 1.5 times the pressure valve opening pressure</td>
<td>Tank boundary tested from at least one side 1, 2)</td>
</tr>
<tr>
<td>Edible independent liquid tanks</td>
<td>Structural and leak testing</td>
<td>The greater of: — top of the overflow, or; — to 0.9 m above top of tank</td>
<td>1, 2)</td>
</tr>
</tbody>
</table>
1) Structural test shall be carried out for at least one tank of the same construction (i.e., same design and same workmanship) on each vessel provided all subsequent tanks are leak tested. These relaxations do not apply to cargo space boundaries in tankers and combination carriers and tanks for segregated cargoes or pollutants

2) Where structural adequacy of a tank has been verified by structural testing, tanks of similar structure of subsequent vessels in the series, i.e., sister ships built in the same shipyard, may be exempted from such testing. It is a provision that the water-tightness in all boundaries of the exempted tanks are verified by leak tests, and inspected thoroughly.

3) In any case, structural testing shall be carried out for at least one tank for each vessel in order to verify structural fabrication adequacy.

4) These relaxations do not apply to cargo space boundaries in tankers and combination carriers and tanks for segregated cargoes or pollutants.

5) When a hose test cannot be performed without possible damage to already installed outfitting, i.e. machinery, cables, switchboards, insulation, etc., it may be replaced, at the Society’s discretion. In this case a careful visual inspection of all the crossings and welded joints is required. In addition, dye penetrant test, leak test or an ultrasonic leak test may be required, see SOLAS regulation II-1/11.1.

6) Testing main compartments (not tanks for liquids) by filling them with water is not compulsory. When such testing is not carried out, a hose test is compulsory. This test shall be carried out in the most advanced stage of the outfitting of the vessel. In any case, a thorough inspection of the watertight bulkheads shall be carried out, see SOLAS regulation II-1/11.1.

7) After completion, a hose or flooding test shall be applied to watertight decks and a hose test to watertight trunks, tunnels and ventilators, see SOLAS Ch. II-1/16-1.4.

8) Where water tightness of watertight door has not been confirmed by prototype test, testing by filling watertight spaces with water shall be carried out, see SOLAS regulation II-1/16.2 and MSC/Circ.1176.

2.3.8 Application of leak test, coating and provision of safe access for type of welded joints are given in Table 4.

Table 4 Application of leak test, coating and provision of safe access for type of welded joints

<table>
<thead>
<tr>
<th>Type of welded joints</th>
<th>Leak test</th>
<th>Coating 1)</th>
<th>Safe access 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before leak test and before structural test</td>
<td>After leak test and before structural test</td>
<td>Leak test</td>
</tr>
<tr>
<td>Butt and T-joints, full penetration 3)</td>
<td>Automatic</td>
<td>Not required</td>
<td>Allowed</td>
</tr>
<tr>
<td></td>
<td>Manual or semi-automatic 4)</td>
<td>Required</td>
<td>Not allowed</td>
</tr>
<tr>
<td>Fillet and T-joints partly penetration 3)</td>
<td>Automatic, semi-automatic or Manual</td>
<td>Required</td>
<td>Not allowed</td>
</tr>
</tbody>
</table>

1) Coating refers to internal (tank/hold coating), where applied, and external (shell/deck) painting. It does not refer to shop primer.

2) Temporary means of access for verification of the leak test.

3) Boundaries including penetrations.

4) Flux core arc welding (FCAW) semi-automatic butt welds need not be tested provided that careful visual inspections show continuous uniform weld profile shape, free from repairs, and the results of NDE testing show no significant defects.
SECTION 9 GOAL-BASED SHIP CONSTRUCTION STANDARDS FOR BULK CARRIERS AND OIL TANKERS

1 General

1.1 Application

1.1.1 This section provides requirements for tankers and bulk carriers subject to SOLAS Chapter II-1 Part A-1 Regulation 3-10, Goal-based ship construction standards for bulk carriers and oil tankers. Reference is made to IACS UR Z23, Hull Survey for New Construction, Appendix 2.

2 Examination and test plan for newbuilding activities

2.1 Requirements

2.1.1 The shipbuilder shall provide plans of the items which are intended to be examined and tested in accordance with the Society’s rules in the quality survey plan (QSP), taking into account the ship type and design. This QSP shall be reviewed at the time of the kick off meeting, and must include:

— types of surveys (visual, non-destructive examination, etc.) depending on location, materials, welding, casting, coatings, etc.
— establishment of a construction survey schedule for all assembly stages from the kick-off meeting, through all major construction phases, up to delivery
— quality survey plan, including provisions for critical areas identified during design approval
— criteria for acceptance
— interaction with shipyard, including notification and documentation of survey results
— correction procedures to remedy construction defects
— list of items that would require scheduling or formal surveys
— determination and documentation of areas that need special attention throughout ship's life, including criteria used in making the determination.

2.1.2 A set of requirements, including specifying the extent and scope of the construction survey(s) and identifying areas that need special attention during the survey(s), to ensure compliance of construction with mandatory ship construction standards including:

3 Design transparency

3.1 General

3.1.1 For ships subject to compliance with IMO Res. MSC.287(87), IMO Res. MSC.290(87), IMO Res. MSC.296(87) and IMO MSC.1/Circ.1343, readily available documentation is to include the main goal-based parameters and all relevant design parameters that may limit the operation of the ship.
4 Ship construction file

4.1 Content of ship construction file

4.1.1 A ship construction file (SCF) with specific information on how the functional requirements of the goal-based ship construction standards for bulk carriers and oil tankers have been applied in the ship design and construction is to be provided upon delivery of a new ship, and kept on board the ship and/or ashore and updated as appropriate throughout the ship's service. The contents of the SCF are to conform to the requirements below.

4.1.2 The following design specific information is to be included in SCF:

— areas requiring special attention throughout the ship's life (including critical structural areas)
— all design parameters limiting the operation of a ship
— any alternatives to the rules, including structural details and equivalency calculations
— "as built" drawings and information which are verified to incorporate all alterations approved by the recognized organization or flag State during the construction process including scantling details, material details, location of butts and seams, cross section details and locations of all partial and full penetration welds
— net (renewal) scantlings for all the structural constituent parts, as built scantlings and voluntary addition thicknesses
— minimum hull girder section modulus along the length of the ship which has to be maintained throughout the ship's life, including cross section details such as the value of the area of the deck zone and bottom zone, the renewal value for the neutral axis zone
— a listing of materials used for the construction of the hull structure, and provisions for documenting changes to any of the above during the ship's service life
— copies of certificates of forgings and castings welded into the hull (Ref. IACS UR W7 and UR W8)
— details of equipment forming part of the watertight and weather tight integrity of the ship
— tank testing plan including details of the test requirements (Ref. IACS UR S14)
— details for the bottom survey afloat, when applicable, information for divers, clearances measurements instructions etc., tank and compartment boundaries
— docking plan and details of all penetrations normally examined at dry docking
— coating Technical File, for ships subject to compliance with the IMO Performance Standard for Protective Coatings (PSPC).

4.1.3 See Table 1 for details of information to be further included. This information has to be kept on board the ship and/or ashore and updated as appropriate throughout the ship's life in order to facilitate safe operation, maintenance, survey, repair and emergency measures.

4.1.4 It is to be noted that parts of the content of the SCF may be subject to various degrees of restricted access and that such documentation may be appropriately kept ashore.

4.1.5 The SCF has to include the list of documents constituting the SCF and all information listed in Table D1, which is required for a ship's safe operation, maintenance, survey, repair and in emergency situations. Details of specific information that is not considered to be critical to safety might be included directly or by reference to other documents.

4.1.6 When developing an SCF, all of the columns in Table 1 have to be reviewed to ensure that all necessary information has been provided.

4.1.7 It may be possible to provide information listed in Table 1 under more than one Tier II functional requirement as a single item within the SCF, for example, the coating technical file required by the PSPC is relevant for both coating life and survey during construction.
**4.1.8** The SCF has to remain with the ship and, in addition, be available to its classification Society and flag state throughout the ship's life. Where information not considered necessary to be on board is stored ashore, procedures to access this information should be specified in the onboard SCF. The intellectual property provisions within the SCF should be duly complied with.

**4.1.9** The SCF should be updated throughout the ship's life at any major event, including, but not limited to, substantial repair and conversion, or any modification to the ship structure.

### Table 1 List of information to be included in the ship construction file

<table>
<thead>
<tr>
<th>Tier II items</th>
<th>Information to be included</th>
<th>Further explanation of the content</th>
<th>Example documents</th>
<th>Normal storage location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESIGN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Design life</td>
<td>assumed design life in years</td>
<td>SCF-specific</td>
<td>on board ship</td>
</tr>
<tr>
<td></td>
<td></td>
<td>statement or note on midship section</td>
<td></td>
<td>on board ship</td>
</tr>
<tr>
<td></td>
<td></td>
<td>midship section plan</td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>Environmental conditions</td>
<td>assumed environmental conditions</td>
<td>SCF-specific</td>
<td>on board ship</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— statement referencing data source or rule (specific rule and data) or</td>
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<tr>
<td></td>
<td></td>
<td>— in accordance with rule (date and revision)</td>
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<tr>
<td>3</td>
<td>Structural strength</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>3.1</td>
<td>General design</td>
<td>applied rule (date and revision)</td>
<td>SCF-specific</td>
<td>on board ship</td>
</tr>
<tr>
<td></td>
<td></td>
<td>applied alternative to rule</td>
<td></td>
<td>on board ship</td>
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<tr>
<td></td>
<td></td>
<td>capacity plan</td>
<td></td>
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<tr>
<td>3.2</td>
<td>Deformation and failure modes</td>
<td>calculating conditions and results</td>
<td>loading manual</td>
<td>on board ship</td>
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<td>allowable loading pattern</td>
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<td></td>
<td>assumed loading conditions</td>
<td>trim and stability booklet</td>
<td>on board ship</td>
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<tr>
<td></td>
<td></td>
<td>maximum allowable hull girder bending moment and shear force</td>
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</tr>
<tr>
<td>Section</td>
<td>Subsection</td>
<td>Description</td>
<td>Additional Information</td>
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<tr>
<td>3.3</td>
<td>Ultimate strength</td>
<td>Operational restrictions due to structural strength</td>
<td>Loading instrument instruction manual on board ship</td>
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<td>Maximum allowable cargo density or storage factor</td>
<td>Operation and maintenance manuals on board ship</td>
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<tr>
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<td></td>
<td>Strength calculation</td>
<td>Archive</td>
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<td>3.4</td>
<td>Safety margins</td>
<td>Strength calculation results</td>
<td>Bulky output of strength on board ship</td>
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<tr>
<td></td>
<td></td>
<td>Areas prone to yielding and/or buckling</td>
<td>General arrangement plan on board ship</td>
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<tr>
<td></td>
<td></td>
<td>Gross hull girder section modulus</td>
<td>Plan showing highly stressed areas on board ship</td>
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<tr>
<td></td>
<td></td>
<td>Plan showing highly stressed areas (e.g. critical structural areas) prone to yielding and/or buckling</td>
<td>General arrangement plan on board ship</td>
<td></td>
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<tr>
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<td></td>
<td>Minimum hull girder section modulus along the length of the ship to be maintained throughout the ship’s life, including cross section details such as the value of the area of the deck zone and bottom zone, the renewal value for the neutral axis zone</td>
<td>General arrangement plan on board ship</td>
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<tr>
<td></td>
<td></td>
<td>Gross scantlings of structural constituent parts</td>
<td>Structural drawings on board ship</td>
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<tr>
<td></td>
<td></td>
<td>Structural drawings</td>
<td>Key construction plans on board ship</td>
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<tr>
<td></td>
<td></td>
<td>Rudder and stern frame</td>
<td>Rudder and rudder stock plans on board ship</td>
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<tr>
<td></td>
<td></td>
<td>Net scantlings of structural constituent parts, as built scantlings and voluntary addition thicknesses</td>
<td>Structural details on board ship</td>
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<td></td>
<td></td>
<td>Structural details of typical members</td>
<td>Yard plans on shore archive</td>
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<td>Yard plans</td>
<td>Dangerous area plan on board ship</td>
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<tr>
<td></td>
<td></td>
<td>Dangerous area plans</td>
<td>Hull form information indicated in key construction plans on shore archive or equivalent</td>
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</tr>
<tr>
<td>4</td>
<td>Fatigue life</td>
<td>applied rule (date and revision)</td>
<td>applied design method alternative to rule and subject structures</td>
<td>SCF-specific</td>
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<tr>
<td></td>
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<td>applied alternative to rule</td>
<td>hull form data stored within an onboard computer necessary for trim and stability and longitudinal strength calculations</td>
<td>on board ship</td>
</tr>
<tr>
<td></td>
<td></td>
<td>calculating conditions and results; assumed loading conditions and rates</td>
<td>structural details</td>
<td>on board ship</td>
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<tr>
<td></td>
<td></td>
<td>fatigue life calculation results</td>
<td>bulky output of fatigue life calculation</td>
<td>on shore archive</td>
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<tr>
<td></td>
<td></td>
<td>plan showing areas (e.g. critical structural areas) prone to fatigue</td>
<td>areas prone to fatigue</td>
<td>on board ship</td>
</tr>
<tr>
<td>5</td>
<td>Residual strength</td>
<td>applied rule (date and revision)</td>
<td>SCF-specific</td>
<td>on board ship</td>
</tr>
<tr>
<td>6</td>
<td>Protection against corrosion</td>
<td>coated areas and target coating life and other measures for corrosion protection in holds, cargo and ballast tanks, other structure-integrated deep tanks and void spaces</td>
<td>plans showing areas (e.g. critical structural areas) prone to excessive corrosion</td>
<td>Coating technical file required by PSPC (Performance standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers, adopted by IMO Resolution MSC.215(82), as amended and Performance standard for protective coatings for cargo oil tanks of crude oil tankers, adopted by IMO Resolution MSC.288(87), as amended)</td>
</tr>
<tr>
<td></td>
<td>Fabrication and testing</td>
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<tr>
<td>6.2</td>
<td><strong>Corrosion addition</strong></td>
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<tr>
<td></td>
<td>specification for coating and other measures for corrosion protection in holds, cargo and ballast tanks, other structure-integrated deep tanks and void spaces</td>
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<tr>
<td></td>
<td>gross scantlings of structural constituent parts</td>
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<td>net scantlings of structural constituent parts, as built scantlings and voluntary addition thicknesses</td>
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<td>areas prone to excessive corrosion</td>
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<td>on board ship</td>
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<tr>
<td>7</td>
<td><strong>Structural redundancy</strong></td>
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<td>applied rule (date and revision)</td>
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<td><strong>Watertight and weathertight integrity</strong></td>
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<td>key factors for watertight and weathertight integrity</td>
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<td>details of equipment forming part of the watertight and weathertight integrity</td>
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<td>structural details of hatch covers, doors and other closings integral with the shell and bulkheads</td>
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<td><strong>Human element considerations</strong></td>
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<td>list of ergonomic design principles applied to ship structure design to enhance safety during operations, inspections and maintenance of ship</td>
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<td>reference to part of SCF information kept ashore</td>
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<td>CONSTRUCTION</td>
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<td><strong>Construction quality procedures</strong></td>
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<td>copies of certificates of forgings and castings welded into the hull</td>
<td>tank testing plan</td>
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**IN-SERVICE CONSIDERATIONS**

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<tr>
<th></th>
<th>Survey and maintenance</th>
<th>maintenance plans specific to the structure of the ship where higher attention is called for</th>
<th>plan showing highly stressed areas (e.g. critical structural areas) prone to yielding, buckling, fatigue and/or excessive corrosion</th>
<th>SCF-specific</th>
<th>on board ship</th>
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<tbody>
<tr>
<td>13</td>
<td></td>
<td>preparations for survey</td>
<td>arrangement and details of all penetrations normally examined at dry-docking</td>
<td>docking plan</td>
<td>on board ship</td>
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<td>gross hull girder section modulus</td>
<td>details for dry-docking</td>
<td>dangerous area plan</td>
<td>on board ship</td>
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<td>minimum hull girder section modulus along the length of the ship to be maintained throughout the ship’s life, including cross section details such as the value of the area of the deck zone and bottom zone, the renewal value for the neutral axis zone</td>
<td>details for in-water survey</td>
<td>Ship Structure Access Manual</td>
<td>on board ship</td>
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<td>Means of access to other structure-integrated deep tanks</td>
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<td>Coating Technical File required by PSPC</td>
<td>on board ship</td>
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<td>key construction plans</td>
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### Fabrication and testing

**Rules for classification:**

| Net scantlings of structural constituent parts, as built scantlings and voluntary addition thicknesses | rudder and rudder stock | on board ship |
| structural details | on board ship |
| yard plans | on shore archive |
| lines plan or equivalent | on shore archive |
| Hull form | Hull form information indicated in key construction plans | on board ship |

#### 14 Structural accessibility

| Means of access to holds, cargo and ballast tanks and other structure-integrated deep tanks | Plans showing arrangement and details of means of access | Ship structure access manual | on board ship |
| means of access to other structure-integrated deep tanks | | | on board ship |

#### RECYCLING CONSIDERATIONS

| Recycling | Identification of all materials that were used in construction and may need special handling due to environmental and safety concerns | List of materials used for the construction of the hull structure | SCF-specific | on board ship |
| | | | | |
Note:

1) **SCF-specific** means documents to be developed especially to meet the requirements of these GBS guidelines (MSC.1/Circ.1343)

2) **key construction plans** means plans such as midship section, main O.T. and W.T. transverse bulkheads, construction profiles/plans, shell expansions, forward and aft sections in cargo tank (or hold) region, engine-room construction, forward construction and stern construction drawings

3) **yard plans** means a full set of structural drawings, which include scantling information of all structural members

4) **hull form** means a graphical or numerical representation of the geometry of the hull. Examples would include the graphical description provided by a lines plan and the numerical description provided by the hull form data stored within an onboard computer

5) **Lines plan** means a special drawing which is dedicated to show the entire hull form of a ship

6) **equivalent (to Lines plan)** means a set of information of hull form to be indicated in key construction plans for SCF purposes. Sufficient information should be included in the drawings to provide the geometric definition to facilitate the repair of any part of the hull structure

7) **normal storage location** means a standard location where each SCF information item should be stored. However, those items listed as being on board in the table above should be on board as a minimum to ensure that they are transferred with the ship on a change of owner

8) **shore archive** is to be operated in accordance with applicable international standards.

---e-n-d---o-f---n-o-t-e---

5 Determination of number of surveyor(s)

5.1 General

5.1.1 The Society will assign adequate number of suitable qualified surveyor(s) for new building projects according to the construction progress of each ship to meet appropriate coverage of the examination and testing activities as agreed in the quality survey plan.
CHANGES – HISTORIC

July 2016 edition

Main changes July 2016, entering into force January 2017

• Sec.1 General
  — Sec.1 Table 5: Document type H133 shall always be submitted
  — Sec.1 Table 5: Document type H150 removed and replaced by H200
  — Sec.1 Table 5: Document type Q010 and Q020 removed
  — Sec.1 Table 5: Document type H140 added to table
  — Sec.1 Table 5: Explanation for WPS added
  — Sec.1 Table 6: Document type Q010 and Q020 added
  — Sec.1 Table 6: Requirements for NDT procedures already given in the text are now added to the overview table.

• Sec.5 Welding procedures
  — Sec.5 [7.1.4]: Charpy V-notch test requirements have been aligned with IACS UR W31
  — Sec.5 [9.1]: Wording updated
  — Sec.5 [14]: Figure 28 removed

• Sec.6 Fabrication and tolerances
  — Sec.6 [5.3.3]: Wording updated

• Sec.7 Non destructive testing of welds
  — Sec.7 [2.4.1]: Wording updated

October 2015 edition

This is a new document.
The rules enter into force 1 January 2016.

Amendments January 2016

• General
  — Only editorial corrections have been made.

Amendments October 2015

• Sec.5 Welding procedures
  — Table 8 has been corrected.
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.