CLASS PROGRAMME

Type approval

DNVGL-CP-0069 Edition March 2016

Welding consumables
FOREWORD

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

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This is a new document.
CONTENTS

Changes – current......................................................................................................................... 3

Section 1 Scope................................................................................................................................. 8
  1 General........................................................................................................................................ 8

Section 2 Type approval.................................................................................................................... 9
  1 Procedure..................................................................................................................................... 9
  2 Application for type approval........................................................................................................ 9
  3 The main elements of a DNV GL initial survey are:................................................................. 9
  4 Assessment of survey report and type test results................................................................. 9
  5 Issuance of type approval certificates....................................................................................... 9
  6 Certificate retention survey (annual testing)........................................................................... 9
  7 Application for renewal after five (5) years............................................................................. 10
  8 Documentation and information to be submitted................................................................... 10

Section 3 Approval testing................................................................................................................ 11
  1 General....................................................................................................................................... 11
  2 Changes...................................................................................................................................... 11
  3 Testing procedure....................................................................................................................... 11
  4 Test specimens........................................................................................................................... 11
  5 Fillet weld test............................................................................................................................ 14
  6 Welding consumables for corrosion resistant steel for oil cargo tanks.................................. 16
  7 Welding consumables with qualified CTOD properties....................................................... 16
  8 Re-testing.................................................................................................................................... 16

Section 4 Covered electrodes for shielded metal arc welding of normal and high strength steels................................................................................................................................. 18
  1 General....................................................................................................................................... 18
  2 All-weld-metal test...................................................................................................................... 18
  3 Butt-weld test............................................................................................................................ 19
  4 Covered electrodes for gravity or contact welding................................................................. 22
  5 Deep penetration electrodes...................................................................................................... 22
  6 Annual test................................................................................................................................ 24
  7 Upgrading and uprating............................................................................................................ 24

Section 5 Wire/flux combinations for submerged arc welding......................................................... 26
  1 General....................................................................................................................................... 26
2 Multi-run technique ........................................................................................................ 26
3 Two-run technique ......................................................................................................... 30
4 Annual tests .................................................................................................................. 31
5 Upgrading and uprating ............................................................................................... 31

Section 6 Combinations for use in one-side automatic welding processes .................. 33
1 General ........................................................................................................................ 33
2 One-run welding .......................................................................................................... 33
3 Multi-run welding ....................................................................................................... 33
4 One-and multi-run welding ........................................................................................ 34
5 Testing requirements ................................................................................................. 35
6 Annual tests ................................................................................................................. 36
7 Upgrading and uprating ............................................................................................... 36

Section 7 Wires and wire and gas combinations for gas metal arc welding ............ 37
1 General ........................................................................................................................ 37
2 Semi-automatic multi-run welding ............................................................................. 37
3 Automatic multi-run welding ..................................................................................... 39
4 Two-run welding ........................................................................................................ 41
5 Annual test ................................................................................................................ 42
6 Upgrading and uprating ............................................................................................... 43

Section 8 Combinations for use in electro-slag and electro-gas welding processes .... 44
1 General ........................................................................................................................ 44
2 Initial test ..................................................................................................................... 44
3 Annual test ................................................................................................................ 46
4 Upgrading and uprating ............................................................................................... 46

Section 9 Welding consumables for welding of steel grades VL 2-4, VL 2-4L, VL 4-4 and VL 4-4L for low-temperature .................................................. 47
1 General ........................................................................................................................ 47
2 Additional requirements ............................................................................................. 47
3 Annual test ................................................................................................................ 47

Section 10 Welding consumables for low-alloy, heat-resisting steels (VL 0.3Mo, VL 1Cr 0.5Mo and VL 2.25Cr 1Mo) .......................................................... 49
1 General ........................................................................................................................ 49
2 All weld metal test ...................................................................................................... 49
3 Butt weld test ............................................................................................................. 50
4 Chemical composition .............................................................................................. 51
Section 11 Welding consumables for welding of steel grades VL 1.5Ni; VL 3.5Ni; VL 5Ni and VL 9Ni

1 General.............................................................................................. 53
2 All-weld-metal test:........................................................................... 53
3 Butt-weld test:...................................................................................53
4 Annual test........................................................................................ 54
5 Other welding consumables...............................................................54

Section 12 Welding consumables for welding of extra high strength steels

1 General.............................................................................................. 55
2 Annual tests.......................................................................................57

Section 13 Welding consumables for welding of austenitic and non-magnetic stainless steels

1 General.............................................................................................. 58
2 All-weld-metal test............................................................................ 58
3 Butt weld test:...................................................................................59
4 Chemical composition........................................................................ 59
5 Corrosion Test................................................................................... 60
6 Austenitic welding consumables for welding of non-magnetic stainless steels................................................................................. 62
7 Annual test........................................................................................ 63

Section 14 Welding consumables for welding of ferritic-austenitic stainless steels (duplex steels)

1 General.............................................................................................. 64
2 All weld metal test............................................................................ 64
3 Butt weld test....................................................................................64
4 Chemical composition........................................................................ 65
5 Microstructural examination............................................................ 65
6 Corrosion test.................................................................................... 65
7 Annual tests.......................................................................................65

Section 15 Welding consumables for welding of aluminium alloys for general and low-temperature service

1 General.............................................................................................. 66
2 Deposited weld metal test................................................................. 66
3 Butt weld test....................................................................................66
4 Annual tests.......................................................................................68
Section 16 Welding consumables for copper and copper alloys

1 General
2 All weld metal test
3 Butt weld test
4 Chemical composition
5 The chemical composition shall not exceed the limits specified by the manufacturer. Annual tests

Section 17 Welding consumables for nickel and nickel alloys

1 General
2 All weld metal test
3 Butt weld test
4 Chemical composition
5 Annual test

Section 18 Standards referred to in this document

1 Referred standards

Changes – historic
SECTION 1 SCOPE

1 General

This type approval programme specifies the requirements to be complied with for obtaining, maintaining and renewing the Society’s type approval of welding consumables for welding of normal, high and extra high strength steels, boiler and pressure vessel steels, steels for low temperature service, austenitic stainless steels, duplex steels, aluminium alloys, copper and copper alloys, and nickel and nickel alloys. This programme covers IACS UR W17, W23, W26 and W31.

Class programme DNVGL CP 0338 DNV GL type approval scheme, describes the type approval in general. Type approved products will be listed in the Society’s register of type approved products available on the DNV GL internet site.
SECTION 2 TYPE APPROVAL

1 Procedure
The type approval procedure normally consists of the following steps:
— application for type approval
— quotation
— assessment of type approval documentation
— initial survey of product and production facilities including witnessing of welding and type tests
— assessment of survey report and type test results
— issuance of type approval certificates
— annual certificate retention surveys
— application for renewal after five (5) years.

2 Application for type approval
The type approval shall be applied for in writing to Society's local office. The application shall include type approval documentation as specified in [8].

3 The main elements of a DNV GL initial survey are:
An initial survey will be carried out with the intention to confirm that:
— manufacturer has established a production line and quality control for consistent production
— documentation that is the basis for the TA is representative for the manufacturing of the product
— use of subcontractors is handled in a controlled manner
— manufacturer or the holder of certificate takes the responsibility for the complete product delivered.
All test assemblies shall be prepared under the supervision of the surveyor, and all tests shall be carried out in his presence.
When welding consumables are manufactured in several factories of the same company, the complete series of approval tests shall at least be carried out in one of the works. In the other factories, a reduced test programme, at least equivalent to annual tests and including hydrogen testing for low hydrogen type consumables, may be permitted if the manufacturer can verify that the materials used and the fabrication process are identical with those used at the main works. This requirement is applicable to all manufacturers of filler products under licence (sister firms). However, the Society may require complete test-series when found necessary.
The manufacturers documentation and reports relevant for the type approval shall be signed by staff in charge at the manufacturer.

4 Assessment of survey report and type test results
The initial survey report and type test results will be assessed in order to verify compliance with the requirements.

5 Issuance of type approval certificates
When the assessment of type approval documentation, type testing and survey of production and quality control arrangement is successfully completed, a type approval certificate will be issued to the manufacturer of the product. The certificate is normally given a validity period of five (5) years, with annual certificate retention surveys.
6 Certificate retention survey (annual testing)

The main objective of the annual certificate retention survey is to verify that the production process of welding consumables and the product marking are not altered since issuance of the type approval certificate, and shall ensure that the type approval documentation is available.

All approved welding consumables shall be subjected to a retention survey, which is usually performed by the local DNV GL office. The retention survey shall be carried out not later than 3 months from anniversary date. On these occasions, samples of the approved consumables shall be selected by the surveyor and subjected to the tests detailed in subsequent sections of this document. Testing of welding consumables shall be witnessed by the surveyor.

Use of a manufacturer’s quality assurance system as an alternative to retention survey may be accepted after agreement with the Society.

The certificate retention survey report shall conclude that either:

a) the type approval certificate shall be retained, or
b) the type approval certificate shall be modified or recalled due to the changes in the basis for the approval.

7 Application for renewal after five (5) years

Application for renewal shall be submitted to the Society’s local office no later than three (3) months before expiry date of the type approval certificate.

The application shall include updated type approval documentation where changes have been implemented since last issuance of the type approval.

Upon receipt of the application, the Society will perform a renewal survey with main objective to verify that the production process and the product marking are not altered since issuance of the type approval certificate. The renewal survey comprises of a works inspection and testing. The scope of testing will be as for a normal annual certificate retention survey.

Certificate renewal survey shall be carried out no later than five (5) years after issuance of the type approval certificate.

If there, since last issuance of the type approval certificate, have been any relevant changes in the applicable rules and standards, a corresponding new assessment of products and type tests will be required.

8 Documentation and information to be submitted

The information relevant to the manufacturing of the welding consumables to be covered by the type approval certificate shall be submitted with the application for type approval.

The language of the submitted documentation shall be English.

8.1 General manufacturer information

The following general manufacturer information shall be submitted:

— an outline of the organisation structure including quality control responsibilities
— manufacturing process description, visualized in flow chart(s) indicating all process steps
— a list of the manufacturers written procedures for testing and inspection. The procedures need not to be submitted, but shall be available for review at the manufacturer’s works upon request
— procedure for product identification and traceability (including test samples).
SECTION 3 APPROVAL TESTING

1 General
All the weld tests may either be performed by the manufacturer or by anyone appointed by him.
The welding conditions used such as amperage, voltage, travel speed, etc. shall be within the range
recommended by the manufacturer for normal, good welding practice. When a filler metal is stated to be
suitable for both alternating current (A.C.) and direct current (D.C.), A.C. shall be used for the preparation of
the test assemblies.
The tests prescribed shall be carried out for each type of welding consumable for which approval is
requested.
The Society may request, in particular cases, additional tests or requirements as considered necessary.

2 Changes
Any alteration proposed by the maker to the approved consumable which may result in a change in the
chemical composition and the mechanical properties of the deposited metal, must be immediately notified to
the Society. Additional tests may be necessary.
Upgrading or up-rating of welding consumables will be considered only at the manufacturer’s request,
preferably at the time of annual testing. Generally, for this purpose, tests from butt weld assemblies will be
required in addition to the normal annual approval tests.

3 Testing procedure
The test welds shall normally be made on the materials listed in the rules RU SHIP Pt.2 Ch.2 for which
approval of the welding consumable is desired. Any grade of structural steel (ref. RU SHIP Pt.2 Ch.2 Sec.2)
may be used for the preparation of the all-weld-metal test assemblies.
The test specimens shall be made under controlled conditions, on metal deposited from the filler metal in
question.
When a test weld is performed, the edges of the plates shall be bevelled either by mechanical machining or
by oxygen cutting, in the latter case, a descaling of the edges is necessary.
After being welded, the test assemblies shall not be subjected to any heat treatment.
If manufacturer request approval for the heat-treated condition, additional test pieces shall be prepared and
heat-treated accordingly.
It is recommended that the welded assembly is subjected to radiographic examination to ascertain whether
there are any defects in the weld prior to testing.

4 Test specimens

4.1 General
The test specimens referred to in this section are described in the rules RU SHIP Pt.2 Ch.1 Sec.3.

4.2 Tensile test
Round tensile test specimens for deposited metal tensile test shall be machined to the dimensions shown
in the rules RU SHIP Pt.2 Ch.1 Sec.3. 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.
Flat specimens for butt weld tensile test shall be prepared in accordance to RU SHIP Pt.2 Ch.1 Sec.3. The
upper and lower surfaces of the weld shall be machined flush with the surface of the plate.
Prior to testing, the tensile test specimens may be subjected to a temperature not exceeding 250°C for a period not exceeding 16 hours, for hydrogen removal.

4.3 Charpy V-notch impact test

Standard Charpy V-notch test specimens shall be prepared and tested as specified in RU SHIP Pt.2 Ch.1 Sec.3.

The test specimens shall be cut with their longitudinal axis transverse to the weld length, with the notch perpendicular to the surface of the plate and positioned as follows:

— for deposited metal and butt weld test assemblies with multi-run technique, the test specimens shall be cut at mid thickness of the weld
— for two-run welded test assemblies the specimens shall be cut on the 2nd run side, 2 mm below the surface
— for electroslag or electrogas welded test assemblies all specimens shall be cut 2 mm below the surface
— for one-side automatic welding processes, the test specimens shall be cut 2 mm below the face side and 2 mm below the root side of the test assembly.

The average absorbed energy value shall comply with the requirements of subsequent sections. One individual value may be less than the required average value provided that it is not less than 70% of this value.

4.4 Bend test

Flat bend test specimens, as shown in RU SHIP Pt.2 Ch.1 Sec. 3 shall be used. The upper and lower surfaces of the weld shall be filed, ground or machined flush with the surface of the specimens and the edges of the specimens shall be rounded to a radius not exceeding 2 mm.

The test specimens shall, unless otherwise agreed or specified in the rules or in the following, be capable of withstanding bending through an angle of 180° over a former having a diameter four times the thickness of the specimen.

4.5 Hot cracking

Two plates shall for that purpose be welded together in the manner shown in Figure 1. The end face of the web plate must be cut straight and at right angles and must fit snugly against the flat upper surface of the bottom plate. Any unevenness is to be removed. The base plate shall be stiffened by three transverse web plates.
The first fillet weld shall be welded in a single pass in the downhand position. The current shall be at the upper limit of the range prescribed for the filler. The second fillet weld on the opposite side shall be welded immediately after the first, also in the downhand position and starting at the end of the test piece where the first fillet weld terminated. Both fillet welds shall be welded at a uniform speed without weaving of the electrode.

For the welding of the complete length of each fillet weld (120 mm), the electrode lengths indicated in Table 1 are to be molten off.

**Table 1 Molten-off lengths of electrodes**

<table>
<thead>
<tr>
<th>Electrode core wire diameter (mm)</th>
<th>Molten-off lengths</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; fillet weld (mm)</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; fillet weld (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
<td>200</td>
<td>150</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>100</td>
<td>75</td>
</tr>
</tbody>
</table>

After welding, the slag shall immediately be removed from the fillet welds.

When the test piece has cooled completely through its entire thickness, the fillet welds shall be examined for cracks.

The first fillet weld shall then be removed by machining and the second fillet weld shall be fractured by collapsing the plates (with the root in tension). The fractured seam shall then be examined for hot cracks.

When subjected to testing for hot cracks, the fillet welds may not reveal any superficial or internal cracks of any kind. Only end crater cracks may be tolerated.

**4.6 Hydrogen test**

Low hydrogen consumables shall be subjected to a hydrogen test. The test shall be carried out in accordance with the mercury method specified in ISO 3690, AWS A4.3 or other methods such as the gas chromatic which correlates with that method. The glycerine method may be admitted at the discretion of the Society. This method is described below.
Prior to welding, the consumables may undergo a normal drying process recommended by the manufacturer. Four test specimens shall be prepared measuring $12 \times 25$ mm in cross-section by about 125 mm in length. The parent metal may be any grade of structural steel. Before welding, the specimens shall be weighed to the nearest 0.1 gram. On the 25 mm surface of each test specimen, a single weld bead about 100 mm in length shall be deposited by a 4 mm diameter electrode, using about 150 mm of the electrode. The welding shall be carried out with an arc as short as possible and with a current of approximately 150 A. All four test specimens shall be welded within a period of 30 minutes. For iron powder electrodes, an electrode with a dimension giving approximately the same quantity of deposited metal as an ordinary 4 mm diameter electrode shall be used. For each test specimen, a new electrode shall be used.

Within 30 seconds of the completion of the welding of each specimen, the slag shall be removed and the specimen quenched in water at approximately 20°C. After 30 seconds in the water, the specimen shall be cleaned and dried and then placed in an apparatus suitable for the collection of hydrogen by displacement of glycerine. The last step shall be completed within 2 minutes after breaking the arc. The glycerine shall be kept at a temperature of 45°C during the test. All specimens shall be welded and treated identically.

The specimens shall be kept immersed in the glycerine for a period of 48 hours and, after removal, shall be cleaned in water and alcohol, dried and weighed to the nearest 0.1 gram to determine the amount of weld deposit.

The amount of gas given off shall be measured to the nearest 0.05 cm$^3$ and corrected for temperature and pressure to 20°C and 760 mm Hg.

Electrodes passing the hydrogen test as stipulated in [4.6] shall satisfy the requirements given in Table 2. Both the individual and the average diffusible hydrogen contents of the specimens shall be reported and the average value in cm$^3$ per 100 grams is not to exceed the following:

**Table 2 Hydrogen test requirements**

<table>
<thead>
<tr>
<th>Mark</th>
<th>Mercury method (ISO 3690) cm$^3$/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>H15</td>
<td>15 $^1$</td>
</tr>
<tr>
<td>H10</td>
<td>10 $^2$</td>
</tr>
<tr>
<td>H5</td>
<td>5 $^3$</td>
</tr>
</tbody>
</table>

1) 10 when Glycerine method is used  
2) 5 when Glycerine method is used  
3) Glycerine method is not allowed

**5 Fillet weld test**

Regardless if consumable is intended for fillet weld solely or for both butt and fillet welds the test scope shall include all-weld-metal tests and fillet weld tests described below.

Fillet weld test assemblies as shown in Figure 2 shall be prepared for each welding position (horizontal-vertical, vertical upwards, vertical downwards or overhead) for which the filler is recommended by the manufacturer.

The first side shall be welded using the maximum size of filler manufactured and the second side shall be welded using the minimum size of filler manufactured and recommended for fillet welding (only one run). The length of the test assemblies L shall be sufficient to allow at least the deposition of the entire length of the electrode being tested.

The fillet size will in general be determined by the filler's size and the welding current employed during testing.
Each test assembly shall be sectioned to form three macro-sections, each about 25 mm thick, as shown in Figure 3.

**Figure 2 Fillet weld test assembly**

Hardness readings shall be made in each section as indicated in Figure 3. The hardness of the weld shall be determined and shall meet the requirements in Table 3. The hardness of both heat affected zone (HAZ) and base metal shall be determined and reported (for information).

**Table 3 Weld hardness requirements**

<table>
<thead>
<tr>
<th>Method</th>
<th>Grades 1, 2, 3</th>
<th>Grades 2 Y, 3 Y, 4 Y, 5 Y</th>
<th>Grades 2 Y40, 3 Y40, 4 Y40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vickers (50 or 100 N load)</td>
<td>To be reported for information</td>
<td>min. 150</td>
<td>min. 160</td>
</tr>
</tbody>
</table>

**Figure 3 Hardness readings**

*Breaking test:*

One of the remaining sections of the fillet weld shall have the weld on the first side gouged or machined to facilitate breaking the fillet weld on the second side by closing the two plates together, subjecting the root of the weld to tension. On the other remaining section, the weld on the second side shall be gouged or
machined and the section fractured using the same procedure. The fractured surfaces shall be examined and there shall be no evidence of incomplete penetration or internal cracking and they shall be reasonably free from porosities.

6 Welding consumables for corrosion resistant steel for oil cargo tanks

Requirements are supplementary and apply to welding consumables intended for welding of corrosion resistant steels for cargo oil tanks.

Approval will be considered subject to compliance with requirements of MSC.289(87) for corrosion testing and relevant requirements as specified in [4], (covered electrodes), [5], (wire/flux combinations) or [7], (wire/gas combinations). The corrosion testing shall be performed for butt weld test assembly. The base metal to be used shall be the same as that for which the welding consumable is intended.

Test plan shall be submitted for a review and verification prior to start of approval process.

The class may require other tests to be performed or stipulate other values for the required properties if they are more appropriate to the character of the welding consumables or are necessitated by the intended use of the material.

The approved welding consumable will be granted corresponding designation RCU, RCB or RCW to the grade, e.g. IV Y40(H5) RCU.

Approval may be given for application in one or more of the following areas of a cargo oil tank:

a) lower surface of strength deck and surrounding structures (RCU)
b) upper surface of inner bottom plating and surrounding structures (RCB)
c) for both strength deck and inner bottom plating (RCW).

7 Welding consumables with qualified CTOD properties

Requirements are supplementary and apply to welding consumables intended for the steel grades with specified CTOD properties, eg grades with the suffix COD. Test of the weld metal shall be carried out in accordance with RU SHIP Pt.2 Ch.1 Sec.3 and comply the acceptance criteria given in RU SHIP Pt.2 Ch.4 Sec.5 [5.7] and RU SHIP Pt.2 Ch.4 Sec.5 [8].

The base metal to be used shall be of the same strength and impact toughness grade and with similar chemical composition as that for which the welding consumable is intended. Two test assemblies shall be prepared in lowest and highest heat input and using plate of the greatest thickness for which approval is requested.

Approval will be granted for actual material grade, heat input and thickness ranges as per RU SHIP Pt.2 Ch.1 Sec.3.

The approved welding consumable will be granted designation COD to the grade, e.g. IV Y40MS(H5)COD.

8 Re-testing

Tensile and bend test:

Where the result of a tensile or bend test does not comply with the requirements, double quantity of specimens of the same type shall be tested and all new test results shall meet the requirements. Where insufficient original welded assembly is available, a new assembly shall be prepared using welding consumables from the same batch and with the same procedure as the original assembly. In this case only the failed test specimens’ needs to be prepared and tested. Otherwise, all test specimens should be prepared as for re-testing.

Charpy V-notch impact test

When the average value of a set of three impact test specimens fails to meet the stated requirements, or the value of more than one specimen is below the required average value, or when the value of only one specimen is below 70% of the specified average value, three additional specimens from the same piece may
be tested and the results added to those previously obtained to form a new average. If this new average complies with the requirements and if no more than two individual results are lower than the required average and no more than one of these two is below 70% of the specified average value, the tests may be accepted.
SECTION 4 COVERED ELECTRODES FOR SHIELDED METAL ARC WELDING OF NORMAL AND HIGH STRENGTH STEELS

1 General
Electrodes will be divided into the following grades:
— for normal strength steels: 1, 2 and 3
— for high strength steels with minimum yield strength up to 355 N/mm$^2$: 2 Y, 3 Y, 4 Y and 5 Y
— for high strength steels with minimum yield strength up to 390 N/mm$^2$: 2 Y40, 3 Y40, 4 Y40 and 5 Y40.

Approval will be considered subject to compliance with the specified tests and requirements. Electrodes complying with the requirements stipulated in Sec.3 [4.6] will be given the suffix H15, H10 or H5 added to the grade mark. Electrodes for high strength steels shall be hydrogen tested and shall satisfy the requirements for at least the suffix H15. Hydrogen test for the largest diameter should be performed.

2 All-weld-metal test
Two all-weld-metal test assemblies shall be welded in the downhand position as shown in Figure 1, one using 4 mm diameter electrodes and the other using the largest size manufactured. If 4 mm is the largest size, still two test assemblies are required. If an electrode is available in one diameter only, one test assembly is sufficient.

Figure 1 All-weld-metal test
The weld metal shall be deposited in single or multi-run layers according to normal practice, the direction of deposition being reversed between subsequent layers, each bead being no less than 2 mm and not more that 4 mm thick. Between each run, the assembly shall be left in still air until it has cooled below 250°C, the temperature being checked in the middle of the weld bead.
Test specimens:
One longitudinal tensile and three impact test specimens shall be taken from each test assembly as shown in Figure 1. The test specimens shall be prepared according to Sec. 3 [4].

Test requirements:
The test results shall comply with the requirements given in Table 1.

Chemical analysis:
The chemical analysis of the deposited weld metal in each test assembly shall be supplied by the manufacturer and shall include the content of all significant alloying elements.

Table 1 All-weld-metal test requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ (N/mm$^2$)</td>
<td>$R_{eH}$ min. (N/mm$^2$)</td>
</tr>
<tr>
<td>1</td>
<td>400 - 560</td>
<td>305</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>490 - 660</td>
<td>375</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>510 - 690</td>
<td>400</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Reduction of area to be reported for information.

3 Butt-weld test
Butt-weld test assemblies as shown in Figure 2 shall be prepared for each welding position (downhand, horizontal-vertical, vertical and overhead) for which the electrode is recommended, except that electrodes satisfying the requirements for downhand and vertical position will be considered as also complying with the requirements for the horizontal-vertical position.

When an electrode is intended for downhand position only, one additional test assembly shall be prepared in this position.

Welding procedure for test assemblies:
Butt-welds in accordance with Figure 2 shall be welded in the positions and with the electrode diameters as specified in Table 2.
### Table 2 Butt weld test pieces, welding positions and electrode diameters

<table>
<thead>
<tr>
<th>No.</th>
<th>Position</th>
<th>Root pass</th>
<th>Fill and cover passes</th>
<th>Back pass</th>
</tr>
</thead>
<tbody>
<tr>
<td>All positions incl. vertical-down (1)</td>
<td>1</td>
<td>PA (1G)</td>
<td>4</td>
<td>5 to 8&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PF (3G)</td>
<td>3</td>
<td>4 or 5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PE (4G)</td>
<td>3</td>
<td>4 or 5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PG (3G)</td>
<td>acc. to manufacturer's instructions</td>
<td></td>
</tr>
<tr>
<td>All positions except vertical-down (2)</td>
<td>1</td>
<td>PA (1G)</td>
<td>4</td>
<td>5 to 8&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PF (3G)</td>
<td>3</td>
<td>4 or 5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PE (4G)</td>
<td>3</td>
<td>4 or 5</td>
</tr>
<tr>
<td>Downhand positions and vertical-up (3)</td>
<td>1</td>
<td>PA (1G)</td>
<td>4</td>
<td>5 to 8&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PF (3G)</td>
<td>3</td>
<td>4 or 5</td>
</tr>
<tr>
<td>Downhand positions only (4)</td>
<td>1</td>
<td>PA (1G)</td>
<td>4</td>
<td>5 to 8&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>PA (1G)</td>
<td>4</td>
<td>5 to 8&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Horizontal-vertical PC (h-v) position only</td>
<td>1</td>
<td>PC (2G)</td>
<td>4 or 5</td>
<td>5</td>
</tr>
<tr>
<td>Other individual positions (x)</td>
<td>1</td>
<td>(x)</td>
<td>as specified above</td>
<td></td>
</tr>
</tbody>
</table>

1) Electrode diameters (mm)
2) Filler passes with 5 or 6 mm size; last two runs including the cover pass with the largest diameter electrodes produced, up to a maximum of 8 mm
3) Includes the horizontal-vertical PC (2G) position
4) Second pass with 5 or 6 mm size; all other filler and cover passes to be made with the largest diameter electrodes produced, up to a maximum of 8 mm

**Test specimens:**

One transverse tensile, two bend tests (face and root bend) and three impact test specimens shall be taken from each test assembly as shown in Figure 2.

The test specimens shall be prepared according to Sec.3 [4].

**Test requirements:**

The test results shall comply with the requirements given in Table 3. The position of fracture in the transverse tensile test specimen shall be reported. The bend test specimens will be considered as complying with the requirements if, after bending, no crack or defect having any dimensions exceeding 3 mm are seen on the outer surface of the test specimen.
Figure 2 Butt weld test assembly

Table 3 Butt-weld test requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test, KV (J), minimum average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ min. (N/mm²)</td>
<td>Temperature (°C)</td>
</tr>
<tr>
<td>1</td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>-20</td>
</tr>
<tr>
<td>2 Y</td>
<td>490</td>
<td>0</td>
</tr>
<tr>
<td>3 Y</td>
<td></td>
<td>-20</td>
</tr>
<tr>
<td>4 Y</td>
<td></td>
<td>-40</td>
</tr>
<tr>
<td>5 Y</td>
<td></td>
<td>-60</td>
</tr>
</tbody>
</table>
### 4 Covered electrodes for gravity or contact welding

Where an electrode is submitted solely for approval for use in contact welding using automatic gravity or similar welding devices, deposited metal tests, fillet weld tests (see Sec.3 [5]) and, where appropriate, butt weld tests similar to those for normal manual electrodes shall be carried out using the process for which the electrode is recommended by the manufacturer.

Where an electrode is submitted for approval for use in contact welding using automatic gravity or similar welding devices in addition to normal manual welding, fillet weld and, where appropriate, butt weld tests, using the gravity or other contact device as recommended by the manufacturer, shall be carried out in addition to the normal approval tests.

**Preparation of test assembly:**

The fillet welding shall be carried out using the welding process recommended by the manufacturer, with the longest size of the electrode manufactured. The manufacturer’s recommended current range shall be reported for each electrode size.

### 5 Deep penetration electrodes

Deep penetration electrodes will be approved as grade 1 electrode only. The suffix DP will be added.

If an electrode approved as a normal penetration electrode is also desired approved as a deep penetration electrode for downhand butt welding and horizontal-vertical fillet welding, the additional tests given below shall be carried out.

The electrode will be tested as a normal penetration electrode and the full series of tests shall be carried out, together with the deep penetration tests given below.

#### 5.1 Butt weld test

Butt weld test assemblies in the downhand position:

Two plates of thickness equal to twice the diameter of the core of the electrode plus 2 mm shall be butt welded, with one downhand run of welding from each side, see Figure 3.

The joint edges shall be prepared square and smooth. The gap is not to exceed 0.25 mm after the tack welding.

The test assembly shall be welded with an 8 mm diameter electrode or the largest size manufactured if this is less than 8 mm.

**Test specimens:** Two transverse tensile, two bend (one face and one root bend) and three impact test specimens shall be taken as shown in Figure 3.

The test specimens shall be prepared according to [4].

---

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test, KV (J), minimum average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ min. (N/mm²)</td>
<td>Temperature (°C)</td>
</tr>
<tr>
<td>2 Y40</td>
<td>510</td>
<td>0</td>
</tr>
<tr>
<td>3 Y40</td>
<td></td>
<td>- 20</td>
</tr>
<tr>
<td>4 Y40</td>
<td></td>
<td>- 40</td>
</tr>
<tr>
<td>5 Y40</td>
<td></td>
<td>- 60</td>
</tr>
</tbody>
</table>
Figure 3 Deep penetration butt weld tests

Test requirements:
The transverse tensile strength shall not be less than 400 N/mm².
The bend test specimens can be considered as complying with the requirements if, after bending, no crack or defect having any dimensions exceeding 3 mm can be seen on the outer surface of the test specimen.
The average impact value for the three specimens taken from the centre of the weld shall not be less than 47 J at +20°C.

5.2 Fillet weld test

A fillet weld test assembly shall be prepared as shown in Figure 4. The welding shall be carried out in one run for each fillet weld, with plate A in the horizontal plane during welding. The length of the fillet weld shall be 160 mm and the gap between the plates is not to exceed 0.25 mm.

One side shall be welded with 4 mm diameter electrode and the second side shall be welded with the maximum size of electrode manufactured. The welding current used shall be within the range recommended by the manufacturer and the welding shall be carried out using normal welding practice.

The welded assembly shall be cut by sawing or machining about 35 mm from the ends of the fillet welds and the joints shall be ground, polished and etched.

Fillet weld test requirements:
The welding of the fillet made with a 4 mm diameter electrode shall show a penetration of 4 mm, see Figure 4, and the corresponding penetration of the fillet made with the maximum size electrode shall be reported.
6 Annual test

6.1 Covered electrodes for normal welding:
Two all-weld metal test assemblies shall be prepared in accordance with [2]. The extents of testing and mechanical requirements shall be as given in [2]. These requirements also apply to electrodes which are approved for fillet welding only. For covered electrodes with Mark H10 and Mark H5 one hydrogen test is required.

6.2 Covered electrodes for gravity or contact welding
One all-weld metal test assembly using the gravity or other contact device as recommended by the manufacturer shall be prepared. If this electrode is approved also for normal manual arc welding, the annual test shall be performed according to [6.1].

6.3 Covered electrodes for deep penetration
One butt weld test assembly shall be prepared as given in [5]. One transverse tensile test specimen, two bend (one face and one root) test and three impact test specimens shall be prepared. At each cut in the test assembly, the joints shall be examined to ensure that complete fusion has taken place. For those electrodes which are approved for both normal penetration welding and for deep penetration welding in the downhand position, deep penetration weld tests shall be carried out in addition to the all-weld metal tests for normal penetration.
Annual test requirements:
The tensile strength, yield stress, elongation and impact test results are all to comply with the requirements for initial approval tests.
Additional tests:
If any of the above tests fails, re-testing shall be carried out in accordance with Sec.3 [9].

7 Upgrading and uprating
Normal requirements for annual testing shall be fulfilled in addition to the tests specified below:
For upgrading of notch toughness, impact testing shall be carried out from the butt weld test assemblies welded in each respective position. Testing to be performed at the upgraded temperature.
If uprating is requested in order to cover the welding of higher strength steels all butt weld tests shall be performed again. A material of higher strength shall be used as parent plate.
Welding consumables which have not previously been subjected to a hydrogen test, shall be tested according to Sec.3 [4.5] when uprating to the grades 2, 3, 4, 5 Y H15/H10/H5 and 2, 3, 4, 5 Y40 H15/H10/H5.
SECTION 5 WIRE/FLUX COMBINATIONS FOR SUBMERGED ARC WELDING

1 General

Wire/flux combinations will be divided into the following grades:

— for normal strength steels: I, II and III
— for high strength steels with minimum yield strength up to 355 N/mm²: I Y, II Y, III Y, IV Y and V Y
— for high strength steels with minimum yield strength up to 390 N/mm²: II Y40, III Y40, IV Y40 and V Y40.

Approval will be considered subject to compliance with the specified tests and requirements in [2] and [3].

The tests are intended for automatic single or multiple electrode submerged arc welding and the combinations are divided into the following categories:

— for use with the multi-run technique
— for use with the two-run technique.

The suffixes T, M or TM will be added to the grade mark to indicate two-run technique, multi-run technique or both techniques, respectively.

When a manufacturer states that a particular wire/flux combination is suitable for welding with both techniques, both series of tests shall be carried out.

2 Multi-run technique

Where approval for use with multi-run technique is requested, all-weld-metal and butt-weld tests shall be carried out as specified in [2.1] and [2.2].

2.1 All-weld-metal test:

One all-weld-metal test assembly shall be welded in the downhand position as shown in Figure 1.

The direction of deposition of each run shall alternate from each end of the plate. After completion of each run, the flux and welding slag shall be removed. Between each run, the assembly shall be left in still air until it has cooled to 250°C, the temperature taken in the centre of the weld on the surface of the seam. The thickness of each layer shall not be less than the diameter of the wire, nor less than 4 mm.

Test specimens:

Two longitudinal tensile and three impact test specimens shall be taken from the test assembly as shown in Figure 1.

The test specimens shall be prepared according to Sec.3 [4].

Test requirements:

The test results shall comply with the requirements given in Table 1.
Figure 1 Multi-run weld. All-weld-metal test

Table 1 Submerged arc welding, all-weld-metal test requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ (N/mm²)</td>
<td>$R_{eH}$ min. (N/mm²)</td>
</tr>
<tr>
<td>I</td>
<td>400 - 560</td>
<td>305</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV Y</td>
<td>490 - 660</td>
<td>375</td>
</tr>
<tr>
<td>V Y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) For grades II, III, IV, V.
### Welding consumables

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ (N/mm$^2$)</td>
<td>$R_{eh}$ min. (N/mm$^2$)</td>
</tr>
<tr>
<td>II Y40</td>
<td>510 - 690</td>
<td>400</td>
</tr>
<tr>
<td>III Y40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV Y40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V Y40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Reduction of area to be reported for information

**Chemical analysis:**
The chemical analysis of the deposited weld metal shall be supplied by the manufacturer and shall include the content of all significant alloying elements.

**2.2 Butt weld test:**
One butt weld test assembly shall be welded in the downhand position as shown in Figure 2. The welding shall be carried out by the multi-run technique and the welding conditions shall be the same as those adopted for the all weld metal test assembly. The back sealing run shall be applied in the downhand position after cutting out the root run to clean metal.

**Test specimens:**
Two transverse tensile, four bend (two face and two root bend) and three impact test specimens shall be taken from the test assembly as shown in Figure 2. The test specimens shall be prepared according to Sec.3 [4].
### Table 2 Submerged arc welding, butt-weld-test requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ min. (N/mm$^2$)</td>
<td>Temperature (°C)</td>
</tr>
<tr>
<td>I</td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>II</td>
<td>400</td>
<td>0</td>
</tr>
<tr>
<td>III</td>
<td>400</td>
<td>-20</td>
</tr>
<tr>
<td>IY</td>
<td>490</td>
<td>20</td>
</tr>
<tr>
<td>IIY</td>
<td>490</td>
<td>0</td>
</tr>
<tr>
<td>IIIY</td>
<td>490</td>
<td>-20</td>
</tr>
<tr>
<td>IVY</td>
<td>490</td>
<td>-40</td>
</tr>
<tr>
<td>VY</td>
<td>490</td>
<td>-60</td>
</tr>
</tbody>
</table>

**Figure 2** Multi-run weld. Butt weld test
### Welding consumables

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ min. (N/mm$^2$)</td>
<td>Temperature (°C)</td>
</tr>
<tr>
<td>II Y40</td>
<td>510</td>
<td>0</td>
</tr>
<tr>
<td>III Y40</td>
<td></td>
<td>-20</td>
</tr>
<tr>
<td>IV Y40</td>
<td></td>
<td>-40</td>
</tr>
<tr>
<td>V Y40</td>
<td></td>
<td>-60</td>
</tr>
</tbody>
</table>

**Test requirements:**

The test results shall all comply with the requirements given in Table 2. The position of fracture in the transverse tensile test shall be reported. The bend test specimens can be considered as complying with the requirements if, after bending, no crack or defect having any dimensions exceeding 3 mm can be seen on the outer surface of the test specimen.

### 3 Two-run technique

Where approval for use with two-run technique is requested, two butt weld test assemblies shall be prepared.

When a wire/flux combination is submitted for approval for use with the two-run technique only, no all weldmetal test assembly is required. In this case approval tests are limited to the butt weld tests described hereafter.

Two butt-weld test assemblies shall be prepared, using the following thicknesses:

- for grades I and IY: 12-15 mm and 20-25 mm
- for grades II to VY: 20-25 mm and 30-35 mm.
- for grades II Y40 to V Y40: 20-25 mm and 30-35 mm.

The maximum diameter of wire, grades of steel plate and edge preparation to be used shall be in accordance with that shown in Figure 4. Minor deviations from the stipulated edge preparation may be accepted, if requested by the manufacturer. The root gap is not to exceed 1 mm. Each butt weld shall be welded in two runs, one from each side, using amperage, voltage and travel speed in accordance with the recommendations of the manufacturer and normal good welding practice. After completion of the first run, the flux and welding slag shall be removed and the assembly shall be left in still air until it has cooled to 100°C, the temperature taken in the centre of the weld, on the surface of the seam.

**Test specimens:**

Two transverse tensile, two bend (one from each side welded) and three impact test specimens shall be taken from each test assembly as shown in Figure 3.

When approval is required for two-run technique only, one longitudinal tensile test specimen is also to be machined from the thicker plate tested as shown in Figure 3.

This tensile test specimen shall be cut with the longitudinal axis coinciding with the centre of the weld about 7 mm below the plate surface on the side from which the second run is made.

The impact test specimens shall be machined from each welded assembly from the positions and with the orientations shown in Figure 5. The test specimens shall be prepared according to Sec.3 [4].

**Test requirements:**

The test results are all to comply with the requirements given in Table 1 for the longitudinal tensile test specimens and Table 2 for the transverse tensile and impact test specimens. The bend test specimens can be considered as complying with the requirements if, after bending, no crack or defect having any dimensions exceeding 3 mm can be seen on the outer surface of the test specimen.
4 Annual tests

Multi-run technique:
One all-weld-metal test — one tensile and three impact tests.

Two-run technique:
One butt-weld test, plate thickness 20 mm minimum — one transverse tensile, two bend and three impact tests. One longitudinal tensile test is also to be prepared for wire/flux combinations approved solely for the two-run technique.

The preparation of the test assemblies and the mechanical requirements shall be in accordance with the requirements for the initial approval tests.

5 Upgrading and uprating

I requirements for annual testing shall be fulfilled in addition to the tests specified below:

For upgrading of notch toughness, impact testing to be carried out from the butt weld test assemblies welded in each respective position. Testing to be performed at the upgraded temperature. For two-run technique a butt weld of maximum thickness approved shall be welded and tested.

If uprating is requested in order to cover the welding of higher strength steels all butt weld tests shall be performed again. Material of higher strength to be used for a parent plate, see Sec.4 [7].
<table>
<thead>
<tr>
<th>Plate thickness (mm)</th>
<th>Typical edge preparation</th>
<th>Maximum diameter of wire (mm)</th>
<th>Grade of wire/flux combination</th>
<th>Grade of steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-15</td>
<td><img src="image1" alt="Diagram" /></td>
<td>5</td>
<td>I</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IY</td>
<td>A-32, A-36</td>
</tr>
<tr>
<td>20-25</td>
<td><img src="image2" alt="Diagram" /></td>
<td>6</td>
<td>I</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>II</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III</td>
<td>B, D or E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IIIY</td>
<td>Any grade of HT steel</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IVY</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>VY</td>
<td></td>
</tr>
<tr>
<td>30-35</td>
<td><img src="image3" alt="Diagram" /></td>
<td>7</td>
<td>II</td>
<td>B, D or E</td>
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<td>B, D or E</td>
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<td>IIIY</td>
<td>Any grade of HT steel</td>
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<td></td>
<td>IVY</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>VY</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>II Y40</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III Y40</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IV Y40</td>
<td></td>
</tr>
</tbody>
</table>

1 For testing of grade IY, IIY, IIIY and IVY combinations, the tensile strength of parent plate material is not to be less than 430 N/mm², and the chemical composition, including the refining element, should be reported for information.

**Figure 4** Two-run weld, butt weld test, root gap 0 - 0.7 mm.

**Figure 5** Two-run weld. Impact tests
SECTION 6 COMBINATIONS FOR USE IN ONE-SIDE AUTOMATIC WELDING PROCESSES

1 General
This welding process will be divided into the following grades:
— for normal strength steels: I, II and III
— for high strength steels with minimum yield strength up to 355 N/mm²: I Y, II Y, III Y, IV Y and V Y
— for high strength steels with minimum yield strength up to 390 N/mm²: II Y40, III Y40, IV Y40 and V Y40.

Approval will be considered subject to compliance with the specified tests and requirements in [2] and [3]. Separate tests are specified for:
— one-run welding
— multi-run welding.

Information regarding joint design, wire diameter, number of runs, tandem or multi-arc welding etc. shall be reported.

The welding conditions shall be the same as those indicated for wire/flux combinations in [5], with the amendments and additions made in [2] to [7].

2 One-run welding
Two test assemblies with 12-15 mm plate thickness shall be made. If a shipyard intends to apply the tested combination for one-side, one-run welding on thicker plates, special procedure tests shall be carried out on the thickest plate intended welded with this technique.

Test specimens:
The number of test specimens shall be as stipulated in [5] and as shown in Figure 1.

Test requirements:
The test results are all to comply with the requirements given in Table 1.

3 Multi-run welding
Two test assemblies, one assembly with 15 - 25 mm plate thickness and one with 35 mm thickness, shall be made as shown in Figure 1.

Test specimens:
The number of test specimens shall be as stipulated in [5] and as shown in Figure 1.

Test requirements:
The test results are all to comply with the requirements given in Table 1.
4 One-and multi-run welding

One test assembly with 15 to 25 mm plate thickness shall be welded by one-run welding technique and one shall be welded with 35 mm thickness by multi-run technique.

Test specimens:
The number of test specimens shall be as stipulated in [5] and as shown in Figure 1.

Test requirements:
The test results are all to comply with the requirements given in Table 1.
5 Testing requirements

Test specimens:
One longitudinal tensile, two transverse tensile, four transverse bend test (two face and two root bend) and six impact (three from the face side and three from the root side) test specimens shall be taken from each welded test assembly as shown in Figure 1.

The test specimens shall be prepared according to Sec.3 [4].

Macro- and microstructure:
One photomicrograph from the fusion zone of the thickest test assembly (one- or multi-run) shall also be forwarded for consideration.

Chemical analysis:
The chemical analysis of the deposited weld metal shall be supplied by the manufacturer and shall include all significant alloying elements.

The test results shall all comply with the requirements given in Table 1. The position of fracture in the transverse tensile test specimens shall be reported. The bend test specimens can be considered as complying with the requirements if, after bending, no crack or defect having any dimensions exceeding 3 mm can be seen on the outer surface of the test specimen.

Table 1 One - and multi run welding test requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Transverse (N/mm²)</th>
<th>Longitudinal</th>
<th>Temperature (°C)</th>
<th>KV (J) minimum average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rm min. (N/mm²)</td>
<td>ReH min. (N/mm²)</td>
<td>A5 min. (%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>400 - 560</td>
<td>305</td>
<td>20</td>
</tr>
<tr>
<td>I Y</td>
<td>490</td>
<td>490 - 660</td>
<td>375</td>
<td>22</td>
</tr>
<tr>
<td>II Y</td>
<td></td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV Y</td>
<td>510</td>
<td>510 - 690</td>
<td>400</td>
<td>0</td>
</tr>
<tr>
<td>V Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V Y40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III Y40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV Y40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V Y40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6 Annual tests

Combinations approved for one- or multi-run welding shall be tested as follows:
One test assembly with 12-25 mm plate thickness as shown in Figure 1 shall be welded.
When a combination is approved for both one- and multi-run welding, the test assembly shall be welded with the one-run technique.
One longitudinal and one transverse tensile test specimen, two bend (one face and one root bend) and six impact test specimens (three root and three face) shall be taken from the test assembly as shown in Figure 1.
The preparation of the test assemblies and the mechanical requirements shall be in accordance with the requirements for the initial approval tests.

7 Upgrading and uprating

Normal requirements for annual testing shall be fulfilled in addition to the tests specified below:
For upgrading of notch toughness, impact testing shall be carried out from the butt weld test assemblies welded in each respective position. Testing shall be performed at the upgraded temperature.
If uprating is requested in order to cover the welding of higher strength steels, all butt weld tests shall be performed again. Material of higher strength to be used for a parent plate, see Sec.4 [7].
SECTION 7 WIRES AND WIRE AND GAS COMBINATIONS FOR GAS METAL ARC WELDING

1 General
Wire/gas combinations, flux cored or flux coated wires with or without shielding gas will be divided into the following grades:
— for normal strength steels: I, II and III
— for high strength steels with minimum yield strength up to 355 N/mm\(^2\): I Y, II Y, III Y, IV Y and V Y
— for high strength steels with minimum yield strength up to 390 N/mm\(^2\): II Y40, III Y40, IV Y40 and V Y40.
Approval will be considered subject to compliance with the specified tests and requirements in [2] and [3].
The wires are divided into the following categories:
— for use in semi-automatic multi-run welding
— for use in automatic multi-run welding
— for use in automatic two-run welding
— for use with TIG welding.
For wires intended for automatic welding, the suffixes T, M and TM will be added to indicate two-run, multi-run or both welding techniques, respectively.
For wires intended for semi-automatic welding, the suffix S will be added to the grade mark.
For wires intended for both welding processes, the suffixes will be added in combination.
For wires intended for TIG welding, the suffixes T, M and TM will be added to indicate two-run, multi-run or both welding techniques, respectively.
The test assemblies shall be prepared by the relevant welding technique for which approval is requested, however, where approval is requested for both semi-automatic and automatic techniques, test assemblies need only be prepared by the semi-automatic technique. If approval of automatic two-run welding technique is requested, test assemblies are also to be prepared by this technique.
Where applicable, the composition of the shielding gas shall be reported. Unless otherwise agreed by the Society, additional approval tests are required when the shielding gas used is different from that used for the original approval tests.
Flux cored or flux coated wires may, at manufacturer's option, be submitted to a hydrogen test as detailed in Sec.3 [4.5], using the manufacturer's recommended welding conditions and adjusting the deposition rate to give a weight of weld deposit per sample similar to that deposited when using manual electrodes.
Wires complying with our requirements stipulated in Sec.3 [4.5] will have the suffix (H15), (H10) or (H5) added to the grade mark.

2 Semi-automatic multi-run welding
The term semi-automatic is used to describe processes in which the weld is made manually by a welder holding a gun through which the wire is continuously fed.
Where approval for use with semi-automatic welding is requested, all-weld-metal and butt-weld tests shall be carried out as specified in [2.1] and [2.2].

2.1 All-weld-metal test:
Two all-weld-metal test assemblies shall be welded in the downhand position as shown in Sec.4 Figure 1.
One test assembly shall be welded using a wire of 2.4 mm diameter or of the largest size manufactured and the other using a wire of 1.2 mm diameter or of the smallest size manufactured. Where wires are available in one diameter only, one test assembly is sufficient.
The weld metal shall be deposited according to the practice recommended by the manufacturer and the thickness of each layer of weld metal shall be in the range of 2 mm to 6 mm.

**Test specimens:**
One longitudinal tensile and three impact test specimens shall be taken from each test assembly as shown in Sec. 4 Figure 1.

The test specimens shall be prepared according to Sec. 3 [4].

**Test requirements:**
The test results are all to comply with the requirements given in Table 1.

### Table 1 Semi automatic multi-run welding, all-weld-metal test requirements (Also for wires intended for TIG welding)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$R_m$ (N/mm²)</td>
<td>$R_{eff}$ min. (N/mm²)</td>
</tr>
<tr>
<td>I</td>
<td>I Y</td>
<td>400 - 560</td>
<td>305</td>
</tr>
<tr>
<td>II</td>
<td>II Y</td>
<td>490 - 660</td>
<td>375</td>
</tr>
<tr>
<td>III</td>
<td>III Y</td>
<td>510 - 690</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>IV Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>V Y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Reduction of area to be reported for information

**Chemical analysis:**
The chemical analysis of the deposited weld metal in each test assembly shall be supplied by the manufacturer and shall include the content of all significant alloying elements.

### 2.2 Butt-weld test:
Butt-weld test assemblies as shown in Sec. 4 Figure 2 shall be prepared for each welding position (downhand, horizontal-vertical, vertical and overhead) for which the wire is recommended. One test assembly shall be prepared in the downhand position, using a 1.2 mm diameter wire for the first run or a wire of the smallest size manufactured and using a 2.4 mm diameter, or of the largest size manufactured for the remaining runs.

In the case where the wire is intended for downhand position only, an additional test assembly shall be prepared by the same welding procedure using wires of different diameter.

The other test assemblies shall be prepared in the vertical, horizontal-vertical and overhead positions using for the first run a wire of the smallest size manufactured and for the remaining runs the largest size of wire recommended by the manufacturer for the position concerned.

**Test specimens:**
One transverse tensile, two bend (one face and one root bend) and three impact test specimens shall be taken from each test assembly as shown in Sec.4 Figure 2. The test specimens shall be prepared according to Sec.3 [4].

Test requirements:
The test results shall comply with the requirements given in Table 2. The position of fracture in the transverse tensile test specimen shall be reported. The bend test specimens can be considered as complying with the requirements if, after bending, no crack or defect having any dimensions exceeding 3 mm can be seen on the outer surface of the test specimen.

2.3 Fillet weld test
Fillet weld test assemblies shall be made and tested in accordance with Sec.3 [6].

Table 2 Semi automatic multi-run welding - butt-weld test requirements (Also for wires intended for manually TIG welding)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test KV (J), minimum average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ min. (N/mm$^2$)</td>
<td>Temperature (°C)</td>
</tr>
<tr>
<td>I</td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I Y</td>
<td>490</td>
<td>20</td>
</tr>
<tr>
<td>II Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II Y40</td>
<td>510</td>
<td>0</td>
</tr>
<tr>
<td>III Y40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV Y40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V Y40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3 Automatic multi-run welding
Where approval for use with automatic multi-run welding is requested, all-weld-metal and butt-weld tests shall be carried out as specified in [3.1] and [3.2].

3.1 All-weld-metal test:
One all-weld-metal test assembly shall be welded in the downhand position as shown in Sec.5 Figure 1. The preparation of the assembly shall be as described in Sec.5 [2], except that the thickness of each layer is not to be less than 3 mm.

Test specimens:
Two longitudinal tensile and three impact test specimens shall be taken from the test assembly as shown in Sec.5 Figure 1.

The test specimens shall be prepared according to Sec.3 [4].

Test requirements:
The test results are all to comply with the requirements given in Table 3.

### Table 3 Automatic multi-run welding all-weld-metal test requirements. (Also for wires intended for TIG welding)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_{mv}$ min. (N/mm$^2$)</td>
<td>$R_{eH}$ min. (N/mm$^2$)</td>
</tr>
<tr>
<td>I</td>
<td>400 - 560</td>
<td>305</td>
</tr>
<tr>
<td>II</td>
<td>490 - 660</td>
<td>375</td>
</tr>
<tr>
<td>III</td>
<td>510 - 690</td>
<td>400</td>
</tr>
<tr>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y40</td>
<td></td>
<td></td>
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<tr>
<td>Y</td>
<td></td>
<td></td>
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<tr>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Reduction of area to be reported for information

### Chemical analysis:

The chemical analysis of the deposited weld metal shall be supplied by the manufacturer and shall include all significant alloying elements.

### 3.2 Butt-weld test:

One butt-weld test assembly shall be welded in the downhand position as shown in Sec.5 Figure 2.

The test assembly shall be prepared in accordance with that prescribed in Sec.5 [2].

**Test specimens:**

Two transverse tensile, four bend (two face and two root bend) and three impact test specimens shall be taken from the test assembly as shown in Sec.5 Figure 2.

The test specimens shall be prepared according to Sec.3 [4].

**Test requirements:**

The test results shall comply with the requirements given in Table 4. The position of fracture in the transverse tensile test specimen shall be reported. The bend test specimens can be considered as complying with the requirements if, after bending, no crack or defect having any dimensions exceeding 3 mm can be seen on the outer surface of the test specimen.
Table 4 Automatic multi-run welding - butt-weld test requirements. (Also for wires intended for TIG welding)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ min. (N/mm$^2$)</td>
<td>Temperature ($^\circ$C)</td>
</tr>
<tr>
<td>I</td>
<td>400</td>
<td>20</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>III</td>
<td></td>
<td>-20</td>
</tr>
<tr>
<td>I Y</td>
<td>490</td>
<td>20</td>
</tr>
<tr>
<td>II Y</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>III Y</td>
<td></td>
<td>-20</td>
</tr>
<tr>
<td>IV Y</td>
<td></td>
<td>-40</td>
</tr>
<tr>
<td>V Y</td>
<td></td>
<td>-60</td>
</tr>
<tr>
<td>II Y40</td>
<td>510</td>
<td>0</td>
</tr>
<tr>
<td>III Y40</td>
<td></td>
<td>-20</td>
</tr>
<tr>
<td>IV Y40</td>
<td></td>
<td>-40</td>
</tr>
<tr>
<td>V Y40</td>
<td></td>
<td>-60</td>
</tr>
</tbody>
</table>

4 Two-run welding

When approval for use with two-run technique is requested, two butt-weld test assemblies shall be prepared. For wires to be approved for use with the two-run technique only, no all weld metal test is required. In this case approval tests are limited to the butt weld tests described hereafter.

Two butt-weld test assemblies shall be prepared as specified in Sec.5 [3], except that one test assembly shall be 12-15 mm thick and the other shall be 20 mm thick.

If approval is required for welding of plates thicker than 20 mm, one assembly shall be prepared using a plate of 20 mm in thickness and the other using a plate of the greatest thickness for which approval is required.

The diameter of wire to be used for the test assemblies shall be in accordance with the manufacturer's recommendation and shall be reported for information.

The edge preparation of the test assemblies shall be as shown in Figure 1. Small deviations in the edge preparation may be allowed, if requested by the manufacturer. For assemblies using plate over 20 mm in thickness, the edge preparation used shall be reported for information.
Figure 1 Typical edge preparation of two-run technique for wires

Test specimens:
Two transverse tensile, two bend (one from each side welded) and three impact test specimens shall be taken from each test assembly as shown in Sec.5 Figure 3.
When approval is required for two-run technique only, one longitudinal tensile test specimen shall also be machined from the thicker plate tested as shown in Sec.5 Figure 3.
This tensile specimen shall be cut with the longitudinal axis coinciding with the centre of the weld about 7 mm below the plate surface on the side from which the second run is made.
The impact test specimens shall be machined from each welded assembly from the positions and with the orientations shown in Sec.5 Figure 5.
The test specimens shall be prepared according to Sec.3 [4].

Test requirements:
The test results shall all comply with the requirements given in Table 3 for the longitudinal tensile test specimens and Table 4 for the transverse tensile and impact test specimens. The bend test specimens can be considered as complying with the requirements if, after bending, no crack or defect having any dimensions exceeding 3 mm can be seen on the outer surface of the test specimen.

5 Annual test
Semi-automatic welding TIG welding and fillet welds:
— One all-weld-metal test - one longitudinal tensile and three impact tests.
Automatic multi-run welding only:
— One all-weld-metal test - one longitudinal tensile and three impact tests.
Automatic two-run welding only:
— One butt-weld test with 20 mm minimum plate thickness - one transverse tensile, two bend and three impact tests. One longitudinal tensile test shall also be prepared for wire/gas combinations approved solely for the two-run technique.

Wires approved for both semi-automatic and automatic multi-run welding:
— One all-weld-metal test in semi-automatic technique - one tensile and three impact tests.

The test assemblies and specimens shall be prepared and tested in accordance with the same procedures as those for the initial approval tests using wire which is of about the medium size manufactured, except in the case of the two-run technique where the size of wire shall be according to the initial testing procedure. The test results shall comply with the requirements for the initial approval tests.
6 Upgrading and uprating

Normal requirements for annual testing shall be fulfilled in addition to the tests specified below:
For upgrading of notch toughness, impact testing shall be carried out from the butt weld test assemblies welded in each respective position. Testing shall be performed at the upgraded temperature. For two-run technique a butt weld of maximum thickness approved shall be welded and tested.
If uprating is requested in order to cover the welding of higher strength steels, all butt weld tests shall be performed again. Material of higher strength to be used for a parent plate, see Sec.4 [7].
SECTION 8 COMBINATIONS FOR USE IN ELECTRO-SLAG AND ELECTRO-GAS WELDING PROCESSES

1 General
Consumables intended for these welding processes will be divided into the following grades:
— for normal strength steels: I, II and III
— for high strength steels with minimum yield strength up to 355 N/mm²: I Y, II Y, III Y, IV Y and V
— for high strength steels with minimum yield strength up to 390 N/mm²: II Y40, III Y40, IV Y40 and V Y40.
Approval will be considered subject to compliance with the specified tests and requirements in [2].

2 Initial test
The following information shall be reported for the Society's consideration:
— joint designation,
— wire diameter,
— type of consumable nozzle,
— shielding gas if used,
— welding parameters,
— weld direction relative to final rolling direction of plates,
— tensile strength and chemical composition including applied grain refining elements for the base material.
Two test assemblies, one assembly with 20 mm plate thickness and one with 35 mm thickness, shall be made as shown in Figure 1.
Test specimens:
Two longitudinal and two transverse tensile test specimens, two macro-sections, two side bend (alternatively one root bend and one face bend) and six impact (three with the notch located in the centre of the weld and three with the notch located 2 mm from the fusion line in the deposited metal) test specimens shall be taken from each test assembly as shown in Figure 1.
Figure 1 Electro-slag and electro-gas welding test assembly and location of specimens

Test requirements:
The test results are all to comply with the requirements given in Table 1.
### Table 1 Electro-slag and electro-gas welding test requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ (N/mm$^2$)</td>
<td>$R_{eH}$ min. (N/mm$^2$)</td>
</tr>
<tr>
<td>I</td>
<td>400 - 560</td>
<td>305</td>
</tr>
<tr>
<td>II</td>
<td>490 - 660</td>
<td>375</td>
</tr>
<tr>
<td>III</td>
<td>510 - 690</td>
<td>400</td>
</tr>
</tbody>
</table>

*Chemical analysis:*
Chemical analysis of the deposited weld metal shall be supplied by the manufacturer and shall include the content of all significant alloying elements.

*Photo macrographs:*
Two photo macrographs, approximately 2X magnification, one transverse and one longitudinal with respect to the weld shall be taken. The latter section shall be parallel to the plate surface.

### 3 Annual test

One test assembly, using 20 mm plate thickness shall be prepared.
Two longitudinal, two bend and two sets of three impact test specimens shall be taken. The notch of the impact specimens shall be located in the centre of the weld and 2 mm from the fusion line in the deposited metal.

One transverse photo macrograph shall be taken from the test assembly.
The preparation of the test assemblies and the mechanical properties shall be in accordance with the requirements for the initial approval tests.

### 4 Upgrading and uprating

For upgrading and uprating the full test scope from butt weld assemblies as specified in [2] is required.
SECTION 9 WELDING CONSUMABLES FOR WELDING OF STEEL GRADES VL 2-4, VL 2-4L, VL 4-4 AND VL 4-4L FOR LOW-TEMPERATURE

1 General
These welding consumables will be granted the following grades:
— for VL 2-4 and VL 2-4L: 5 (manual welding) and V (semi-automatic and automatic welding)
— for VL 4-4 and VL 4-4L: 5 Y (manual welding) and V Y (semi-automatic and automatic welding).
Approval will be considered subject to compliance with the specified tests and requirements in [2].
Covered electrodes shall satisfy the requirements for low hydrogen electrodes, and will have the suffix H15, H10 or H5 added to the grade mark.
Flux cored or flux coated wires may also, at manufacturer’s option, be submitted for hydrogen testing, and will have the suffix (H15), (H10) or (H5) added to the grade mark.
Testing shall be carried out as specified in [4]. (covered electrodes), 5. (wire/flux combinations) or [7]. (wire/gas combinations) with the additional requirements specified in [2].

2 Additional requirements
The base metal to be used for the butt weld tests shall be the same as that for which the welding consumable is intended.
Test requirements:
The butt-weld test results are all to comply with the requirements given in Table 1.
One additional butt-weld test shall be made in the downhand position. This test assembly shall be subjected to stress-relieving at 550 to 600°C prior to mechanical testing.
Test specimens:
One transverse tensile and three impact test specimens shall be taken from each test assembly. The impact specimens shall be broken at -60°C. Both single values and average values shall be reported. Welding consumables intended for VL 2-4 and VL 4-4 only, may be impact tested at -55°C.
Test requirements:
The test results shall comply with the requirements given in Table 1.

3 Annual test
Depending on whether it concerns electrodes, wire/flux combination or wire/gas combinations, the testing shall be carried out according to that prescribed in Sec4. [8], Sec.5 [2] or Sec.7 [5], respectively. Impact testing, however, shall be carried out according to [2] i.e. on one additional butt-weld assembly shall be welded. Test assembly shall be subjected to stress-relieving prior to mechanical testing.
### Table 1 Butt-welding of steel grades for low temperature application - test requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ min. (N/mm$^2$)</td>
<td>Temperature ($^\circ$C)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5/V (VL 2-4 and VL 2-4L)</td>
<td>400</td>
<td>-55 - 60</td>
</tr>
<tr>
<td>5Y/VY (VL 4-4 and VL 4-4L)</td>
<td>490</td>
<td>-55 - 60</td>
</tr>
</tbody>
</table>

The specified impact toughness requirements apply to welded connections of thickness $\leq$ 25 mm. Sufficient margin for impact toughness values shall be considered as per RU SHIP Pt.2 Ch.2 Sec.3 to comply the requirements for thicknesses $25 < t \leq 40$ mm.
SECTION 10 WELDING CONSUMABLES FOR LOW-ALLOY, HEAT-RESISTING STEELS (VL 0.3MO, VL 1CR 0.5MO AND VL 2.25CR 1MO)

1 General

The all-weld-metal and butt-weld tests are all to be carried out as specified in 4. (covered electrodes), 5. (wire/flux combinations) or [7] (wire/gas combinations) with the additional requirements specified in [2] to [4].

Covered electrodes shall satisfy our requirements for low hydrogen electrodes, and will have the suffix H15, H10 or H5 added to the grade mark.

Flux cored or flux coated wires may also, at manufacturer's option, be submitted for hydrogen testing, and will have the suffix (H15), (H10) or (H5) added to the grade mark. The base metal to be used for the butt-weld tests shall be the same as that for which the welding consumable is intended.

Steel grades A, B or D may, however, be used for the all-weld-metal tests when this is found to be convenient.

2 All weld metal test

The additional all-weld-metal test shall be performed. Two longitudinal tensile test specimens shall be taken from each test assembly as shown in Figure 1.

Pre- and post-heating:

The temperature ranges to be used for pre-heating, inter-pas temperature and annealing is shown in Table 1.

Table 1 Low alloy heat utility steels - pre and post heat temperature ranges

<table>
<thead>
<tr>
<th>Consumables for welding steel grade</th>
<th>Pre-heat and inter-pass temperature (°C)</th>
<th>Annealing Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL 0.3Mo</td>
<td>100 - 200</td>
<td>660 - 700</td>
</tr>
<tr>
<td>VL 1Cr 0.5Mo</td>
<td>200 - 300</td>
<td>680 - 720</td>
</tr>
<tr>
<td>VL 2.25Cr 1Mo</td>
<td>200 - 300</td>
<td>720 - 770</td>
</tr>
</tbody>
</table>

The finished test plates shall be uniformly heated to the annealing temperature, kept at this temperature for approximately 30 minutes and cooled in still air.

Tensile tests:

One specimen from each assembly shall be tested at room temperature (approximately 20°C), while the other shall be tested at 400°C ± 5°C. The elevated test temperature shall be properly controlled (e.g. by thermocouples).

Test requirements:

The test results are all to comply with the requirements given in Table 2.
Figure 1 All-weld-metal test

Table 2 All weld test temperature and tensile test requirements

<table>
<thead>
<tr>
<th>Consumables for welding steel grade</th>
<th>Test temperature (°C)</th>
<th>$R_m$ min. (N/mm$^2$)</th>
<th>$R_{eH}$ or $R_p$ 0.2 min. (N/mm$^2$)</th>
<th>$A_5$ min. (%)</th>
<th>$Z$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL 0.3Mo</td>
<td>20 400</td>
<td>440 1)</td>
<td></td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>VL 1Cr 0.5Mo</td>
<td>20 400</td>
<td>470 1)</td>
<td>305</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>VL 2.25Cr 1Mo</td>
<td>20 400</td>
<td>480 1)</td>
<td></td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

1) These values shall be reported for information

3 Butt weld test

The transverse tensile and bend tests shall be tested at room temperature.

Test requirements:
The tensile test results shall comply with the requirements given in Table 3.

Table 3 Butt-weld tensile test requirements

<table>
<thead>
<tr>
<th>Consumables for welding steel grade</th>
<th>$R_m$ min. (N/mm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL 0.3Mo</td>
<td>440</td>
</tr>
</tbody>
</table>
4 Chemical composition

The test specimen for chemical analysis of the deposited metal shall be made on a steel plate as shown in Figure 2.

Preparation of test assembly:
One such test specimen shall be made for each dimension of welding consumable to be approved. Chips for chemical analysis shall be machined, so that the distance between the final cut and the plate corresponds to at least 4 layers of weld.

![Figure 2 Test specimen for chemical analysis](image)

Each test specimen shall be analysed separately.

Test requirements:
The test results shall comply with the requirements given in Table 4.

<table>
<thead>
<tr>
<th>Consumables for welding steel grade</th>
<th>C Max. (%)</th>
<th>Si Max. (%)</th>
<th>Mn (%)</th>
<th>Cr (%)</th>
<th>Mo (%)</th>
<th>P Max. (%)</th>
<th>S Max. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL 0.3Mo</td>
<td>0.12</td>
<td>0.8</td>
<td>0.6 - 1.6</td>
<td>-</td>
<td>0.3 - 0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VL 1Cr 0.5Mo</td>
<td></td>
<td></td>
<td>0.4 - 1.0</td>
<td>0.7 - 1.4</td>
<td>0.4 - 0.7</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>VL 2.25Cr 1Mo</td>
<td></td>
<td></td>
<td>0.4 - 1.0</td>
<td>2.0 - 2.6</td>
<td>0.9 - 1.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5 Annual test
Chemical analyses of the deposited metal of two different dimensions of the approved combinations shall be carried out.
The preparation of the test assemblies and the test requirements shall be in accordance with the requirements for the initial approval tests specified in [4].
SECTION 11 WELDING CONSUMABLES FOR WELDING OF STEEL GRADES VL 1.5NI; VL 3.5NI; VL 5NI AND VL 9NI

1 General
The all-weld-metal and butt-weld tests shall be carried out as specified in [4] (covered electrodes), [5] (wire/flux combinations) or [7] (wire/gas combinations) with the additional requirements specified in [2].

Covered electrodes shall satisfy the requirements for low hydrogen electrodes, and will have the suffix H15, H10 or H5 added to the grade mark.

Flux cored or flux coated wires may also, at manufacturer's option, be hydrogen tested, and have the suffix (H15), (H10) or (H5) added to the grade mark.

The plate thickness for the butt-weld tests shall normally be between 11 mm and 20 mm. If plates with thickness less than 11 mm are used, the requirement regarding absorbed energy shall be agreed upon with the Society in each case.

Welding consumables approved for welding of a higher grade within this group may also be used for the lower grades.

2 All-weld-metal test:

Test specimens:
One longitudinal tensile and at least three impact test specimens shall be machined from each test assembly.

Test requirements:
The longitudinal tensile and impact test results shall satisfy the requirements given in Table 1.

3 Butt-weld test:

Test specimens:
One transverse tensile, three impact test specimens and two transverse bend tests shall be taken from each test assembly.

If the composition and mechanical properties of the deposited metal differ markedly from the composition and properties of the base metal, the two transverse bend tests may be replaced by longitudinal bend tests. If this is done, one face bend and one root bend test shall be carried out.

The dimensions of the longitudinal bend specimens shall be as follows:
- length minimum 150 mm
- width 38 mm
- thickness 10 mm.

The weld reinforcements shall be removed, and the root/face side of the specimens shall be machined so that the required thickness is obtained. The edges of the specimens may be rounded to a radius not exceeding 2 mm.

The obtained tensile strength shall not be below the specified minimum tensile strength for the base metal in question.

Test requirements:
The test results are all to comply with the requirements given in Table 1. The position of fracture in the transverse tensile test specimen shall be reported. The bend test specimens can be considered as complying with the requirements if, after bending through an angle of 180° over a former with a diameter of 4xt mm, no cracks or defects can be seen on the outer surface of the test specimen. The reduction of area shall be reported for information.
### Table 1 Annual test requirements

<table>
<thead>
<tr>
<th>Consumables for welding steel grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All-weld-metal</td>
<td>Butt weld</td>
</tr>
<tr>
<td></td>
<td>$R_m$ min. (N/mm$^2$)</td>
<td>$R_{eH,1)}$ min. (N/mm$^2$)</td>
</tr>
<tr>
<td>VL 1.5Ni</td>
<td>470540</td>
<td>390</td>
</tr>
<tr>
<td>VL 3.5Ni</td>
<td>570640</td>
<td>355355</td>
</tr>
<tr>
<td>VL 5Ni</td>
<td>470540</td>
<td>390</td>
</tr>
<tr>
<td>VL 9Ni</td>
<td>570640</td>
<td>355355</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

1) In case of no marked yield point, the proof stress at 0.2% elongation ($R_{p0.2}$) shall be reported.

### 4 Annual test

Depending on whether it concerns electrodes, wire/flux combination of wire/gas combinations, the testing shall be carried out according to that prescribed in Sec.4 [6], Sec.5 [4] or Sec.7 [5], respectively. The test results shall, however, comply with the requirements given in Table 1.

### 5 Other welding consumables

Welding consumables with yield stress and/or tensile strength less than that specified in Table 1, may be approved for welding of steel grade VL 9 Ni. Approval testing shall be carried out according to the programme specified above.

The maximum permissible stress in welded vessels shall, however, in such cases be based on the mechanical properties obtained from the approval tests.
SECTION 12 WELDING CONSUMABLES FOR WELDING OF EXTRA HIGH STRENGTH STEELS

1 General

Depending on the impact test temperature, welding consumables for extra high strength steels are divided into the following grades:

— Grade 3/III, test temperature - 20°C
— Grade 4/IV, test temperature - 40°C
— Grade 5/V, test temperature - 60°C.

The following symbols are added to the grade mark to indicate yield strength of the base metal for which the welding consumable is intended:

<table>
<thead>
<tr>
<th>Symbols added to grade mark</th>
<th>Base material designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y42</td>
<td>VL 420</td>
</tr>
<tr>
<td>Y46</td>
<td>VL 460, VL 47</td>
</tr>
<tr>
<td>Y50</td>
<td>VL 500, VL 47</td>
</tr>
<tr>
<td>Y55</td>
<td>VL 550</td>
</tr>
<tr>
<td>Y62</td>
<td>VL 620</td>
</tr>
<tr>
<td>Y69</td>
<td>VL 690</td>
</tr>
</tbody>
</table>

Each higher quality grade includes the one (or those) below. Grade AEH and DEH steels according to RU SHIP Pt.2 Ch.2 Sec.2 shall be welded using welding consumables of at least quality grade 3/III, grade EEH steels using at least quality grade 4/IV and grade FEH steels using at least quality grade 5/V as shown in the following table:

<table>
<thead>
<tr>
<th>Consumable grade</th>
<th>Steel grades covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/IIIYxx</td>
<td>DEH and AEH</td>
</tr>
<tr>
<td>4/IVYxx</td>
<td>EEH, DEH and AEH</td>
</tr>
<tr>
<td>5/VYxx</td>
<td>FEH, EEH, DEH and AEH</td>
</tr>
</tbody>
</table>

1) "xx" indicates a number between 42 and 69. "EH" indicates extra high strength steel of grades 420 to 690

Welding consumables approved with grades 3/4/5 Y42, Y46 and up to Y50 are also considered suitable for welding steels of two strength levels below that for which they have been approved. Welding consumables approved with grades 3/4/5 Y55, Y62 and up to Y69 are also considered suitable for welding steels of one strength level below that for which they have been approved.

The Society may, in individual cases, restrict the range of application in (up to) such a way, that approval for any one strength level does not justify approval for any other strength level.

The all-weld-metal and butt-weld test assemblies analogous to those specified in [4] (Covered electrodes), [5] (wire/flux combinations) or [7] (wire/gas combination), respectively shall be prepared and tested, depending on the type of the welding consumables and welding process.

The base metal used shall be a fine-grained structural steel compatible with the properties of the weld metal, or the side walls of the weld shall be buttered with a weld metal of the same composition.

Test results shall satisfy the requirements of Table 1 and Table 2 accordingly.

Welding consumables other than solid wire-gas combinations in yield strength group Y50 and below shall satisfy the hydrogen test requirements for at least the suffix H10. Electrodes in yield strength group ranging from Y55 up to and including Y69 shall satisfy the hydrogen test requirements for the suffix H5. Hydrogen test for largest diameter should be performed.
Table 1 All-weld-metal test requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ (N/mm²)</td>
<td>$R_{eh}$ min. (N/mm²)</td>
<td>$A_5$ min. (%)</td>
<td>Temperature (°C)</td>
</tr>
<tr>
<td>3/III Y42</td>
<td>530 - 680</td>
<td>420</td>
<td>20</td>
<td>-20</td>
</tr>
<tr>
<td>4/IV Y42</td>
<td>570 - 720</td>
<td>460</td>
<td>20</td>
<td>-20</td>
</tr>
<tr>
<td>5/V Y42</td>
<td>610 - 770</td>
<td>500</td>
<td>19</td>
<td>-20</td>
</tr>
<tr>
<td>3/III Y46</td>
<td>670 - 830</td>
<td>550</td>
<td>18</td>
<td>-20</td>
</tr>
<tr>
<td>4/IV Y46</td>
<td>720 - 890</td>
<td>620</td>
<td>18</td>
<td>-20</td>
</tr>
<tr>
<td>5/V Y46</td>
<td>770 - 940</td>
<td>690</td>
<td>17</td>
<td>-20</td>
</tr>
</tbody>
</table>

1) For requirements regarding minimum individual values and retests, see Sec.3 [3] and Sec.3 [5], respectively.

Table 2 Butt weld test requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
<th>Bend ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ (N/mm²)</td>
<td>Temperature (°C)</td>
<td>KV (J) minimum average</td>
</tr>
<tr>
<td>3/III Y42</td>
<td>530 - 680</td>
<td>-20</td>
<td>47</td>
</tr>
<tr>
<td>4/IV Y42</td>
<td>570 - 720</td>
<td>-20</td>
<td>47</td>
</tr>
<tr>
<td>5/V Y42</td>
<td>610 - 770</td>
<td>-20</td>
<td>50</td>
</tr>
</tbody>
</table>

1) For requirements regarding minimum individual values and retests, see Sec.3 [3] and Sec.3 [5], respectively.
<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
<th>Bend ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$ (N/mm²)</td>
<td>Temperature (°C)</td>
<td>$KV$ (J) minimum average</td>
</tr>
<tr>
<td>3/III Y55</td>
<td>670-830</td>
<td>-20</td>
<td>55</td>
</tr>
<tr>
<td>4/IV Y55</td>
<td>-40</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>5/V Y55</td>
<td>-60</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>3/III Y62</td>
<td>720-890</td>
<td>-20</td>
<td>62</td>
</tr>
<tr>
<td>4/IV Y62</td>
<td>-40</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>5/V Y62</td>
<td>-60</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>3/III Y69</td>
<td>770-940</td>
<td>-20</td>
<td>69</td>
</tr>
<tr>
<td>4/IV Y69</td>
<td>-40</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>5/V Y69</td>
<td>-60</td>
<td>69</td>
<td></td>
</tr>
</tbody>
</table>

¹) D = mandrel diameter, t = specimen thickness

The chemical analysis of the deposited weld metal in each test assembly shall be supplied by the manufacturer and shall include the content of all significant alloying elements.

## 2 Annual tests

Depending on whether it concerns electrodes, wire/flux combination or wire/gas combinations, the testing shall be carried out according to that prescribed in Sec.4 [6], Sec.5 [5] or Sec.7 [5], respectively. The test results shall, however, comply with the requirements given in Table 1. The chemical composition of the deposited weld metal shall be determined and submitted for a review.

For fillers with Mark H10 and Mark H5 one hydrogen test is required.
SECTION 13 WELDING CONSUMABLES FOR WELDING OF AUSTENITIC AND NON-MAGNETIC STAINLESS STEELS

1 General
Approval of welding consumables for austenitic stainless steels will be considered subject to compliance with the specified tests and requirements in [2] to [5].
Parent plate material should preferably have a composition matching that of the electrode to be tested. Mild steel plates may, however, be applied provided that the groove faces are clad with at least two runs by the welding consumable which shall be tested.

2 All-weld-metal test
Preparation of test assemblies:
Two all-weld-metal test assemblies shall be prepared as shown in Figure 1, one using a Ø2.4-3.25 mm electrode and the other using the largest size manufactured.
For wire/gas combinations the wire size shall be Ø1.2 mm and the largest size manufactured.
For flux cored wire combinations the wire size shall be Ø1.2 or 1.6 mm and the largest size manufactured.
For wire/flux combinations the smallest and largest size manufactured shall be tested.
The weld metal shall be deposited in accordance with normal welding practice. The direction of deposition shall be reversed between subsequent layers, each bead not being wider than 4 times the core wire diameter and not exceeding 4 mm in thickness. Between each run, the assembly shall be left in still air until it has cooled below 100°C, the temperature being checked in the middle of the weld bead surface.
Test specimens:
Depending on the service temperature, the number of test specimens taken according to Figure 1 is as follows:
— service temperature below -105°C; two longitudinal tensile and three impact test specimens shall be taken.
— service temperature above -105°C; two longitudinal tensile test specimens only shall be taken.
The test specimens shall be prepared according to Sec.3 [4].
Figure 1 Test assemblies (all measures in mm)

Test requirements:
The test results shall comply with the requirements given in Table 1. Welding consumables intended for low temperature service shall be impact tested at -196°C (or other temperatures below -105°C). The average impact value for the three specimens is not to be less than 27J.

3 Butt weld test:
The results of transverse tensile test shall comply with the requirements of Table 3.
Impact test specimens are normally not required for service temperature above -105°C. If service temperature below -105°C the impact test shall be performed at -196°C with average energy 27J.
Testing for hot cracks shall be performed as specified in item Sec.3 [4.4].

4 Chemical composition
Chemical analysis shall be carried out for all dimensions of welding consumables manufactured. The analysis shall be carried out as stipulated in Sec.10 [4] and shall be reported for approval.
The chemical composition of the core wire shall be reported.
Test requirements:
The chemical composition of the weld metal shall be in the range given in Table 2.
## 5 Corrosion Test

Testing of resistance to intergranular corrosion (IC) shall be performed on test specimens with intersecting butt welds using the copper sulphate - sulphuric acid method (Strauss test). No cracks may be detected and the metallographically measured depth of penetration of the attack at the grain boundaries shall not exceed 0.05 mm.

In the case of special corrosion conditions or particular materials, the Society may require other corrosion tests as an additional or alternative measure.

### Table 1 All-weld-metal test requirements

<table>
<thead>
<tr>
<th>Electrode grade</th>
<th>Yield stress, (R_{p0.2} \text{ min} (N/mm}^2))</th>
<th>Tensile strength, (R_{mv} \text{ min} (N/mm}^2))</th>
<th>Elongation, (A5 \text{ min. } (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL 308 Mo</td>
<td>290</td>
<td>550</td>
<td>25</td>
</tr>
<tr>
<td>VL 308</td>
<td>290</td>
<td>550</td>
<td>25</td>
</tr>
<tr>
<td>VL 308 L</td>
<td>270</td>
<td>520</td>
<td>25</td>
</tr>
<tr>
<td>VL 309</td>
<td>290</td>
<td>550</td>
<td>25</td>
</tr>
<tr>
<td>VL 309 L</td>
<td>270</td>
<td>520</td>
<td>25</td>
</tr>
<tr>
<td>VL 309 Nb</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>VL 309 Mo</td>
<td>290</td>
<td>550</td>
<td>25</td>
</tr>
<tr>
<td>VL 309 MoL</td>
<td>270</td>
<td>520</td>
<td>25</td>
</tr>
<tr>
<td>VL 310</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>VL 310 Nb</td>
<td>290</td>
<td>550</td>
<td>18</td>
</tr>
<tr>
<td>VL 310 Mo</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>VL 312</td>
<td>350</td>
<td>660</td>
<td>16</td>
</tr>
<tr>
<td>VL 316</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>VL 316 L</td>
<td>270</td>
<td>520</td>
<td>22</td>
</tr>
<tr>
<td>VL 317</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>VL 317 L</td>
<td>270</td>
<td>520</td>
<td>22</td>
</tr>
<tr>
<td>VL 318</td>
<td>290</td>
<td>550</td>
<td>18</td>
</tr>
<tr>
<td>VL 330</td>
<td>270</td>
<td>520</td>
<td>18</td>
</tr>
<tr>
<td>VL 347</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>VL 349</td>
<td>360</td>
<td>690</td>
<td>18</td>
</tr>
</tbody>
</table>

1) The values for reduction of area to be reported for information
Table 2 Chemical composition - test requirements

<table>
<thead>
<tr>
<th>Electrode grade</th>
<th>C max. (%)</th>
<th>Cr (%)</th>
<th>Ni (%)</th>
<th>Mo (%)</th>
<th>Nb, Ta (%)</th>
<th>Mn max. (%)</th>
<th>Si max. (%)</th>
<th>P max. (%)</th>
<th>S max. (%)</th>
<th>W (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL 308 Mo</td>
<td>0.08</td>
<td>18.0 - 21.0</td>
<td>9.0 - 11.0</td>
<td>2.0 - 3.0</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 308</td>
<td>0.08</td>
<td>18.0 - 21.0</td>
<td>9.0 - 11.0</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 308 L</td>
<td>0.03</td>
<td>18.0 - 21.0</td>
<td>9.0 - 11.0</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 309</td>
<td>0.15</td>
<td>22.0 - 25.0</td>
<td>12.0 - 14.0</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 309 L</td>
<td>0.03</td>
<td>22.0 - 25.0</td>
<td>12.0 - 14.0</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 309 Nb</td>
<td>0.12</td>
<td>22.0 - 25.0</td>
<td>12.0 - 14.0</td>
<td>-</td>
<td>0.7 - 1.0</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 309 Mo</td>
<td>0.12</td>
<td>22.0 - 25.0</td>
<td>12.0 - 14.0</td>
<td>2.0 - 3.0</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 309 MoL</td>
<td>0.03</td>
<td>22.0 - 25.0</td>
<td>12.0 - 14.0</td>
<td>2.0 - 3.0</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 310</td>
<td>0.20</td>
<td>25.0 - 28.0</td>
<td>20.0 - 22.5</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td>0.75</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 310 Nb</td>
<td>0.12</td>
<td>25.0 - 28.0</td>
<td>20.0 - 22.0</td>
<td>-</td>
<td>0.7 - 1.0</td>
<td>2.5</td>
<td>0.75</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 310 Mo</td>
<td>0.12</td>
<td>25.0 - 28.0</td>
<td>20.0 - 22.0</td>
<td>2.0 - 3.0</td>
<td>-</td>
<td>2.5</td>
<td>0.75</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 312</td>
<td>0.15</td>
<td>28.0 - 32.0</td>
<td>8.0 - 10.5</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 316</td>
<td>0.08</td>
<td>17.0 - 20.0</td>
<td>11.0 - 14.0</td>
<td>2.0 - 3.0</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 316 L</td>
<td>0.03</td>
<td>17.0 - 20.0</td>
<td>11.0 - 14.0</td>
<td>2.0 - 3.0</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 317</td>
<td>0.08</td>
<td>18.0 - 21.0</td>
<td>12.0 - 14.0</td>
<td>3.0 - 4.0</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 317 L</td>
<td>0.03</td>
<td>18.0 - 21.0</td>
<td>12.0 - 14.0</td>
<td>3.0 - 4.0</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 318</td>
<td>0.08</td>
<td>17.0 - 20.0</td>
<td>11.0 - 14.0</td>
<td>2.0 - 3.0</td>
<td>6xC - 1.0</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 330</td>
<td>0.25</td>
<td>14.0 - 17.0</td>
<td>33.0 - 37.0</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>VL 347</td>
<td>0.08</td>
<td>18.0 - 21.0</td>
<td>9.0 - 11.0</td>
<td>8xC - 1.0</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>VL 349</td>
<td>0.13</td>
<td>18.0 - 21.0</td>
<td>8.0 - 10.5</td>
<td>0.35 - 0.65</td>
<td>0.75 - 1.2</td>
<td>2.5</td>
<td>1.0</td>
<td>0.04</td>
<td>0.03</td>
<td>1.25 - 1.75</td>
</tr>
</tbody>
</table>

1) Tantalum maximum 0.10%. Titanium maximum 0.15%.

Table 3 Butt weld test requirements

<table>
<thead>
<tr>
<th>Electrode grade</th>
<th>Tensile strength, Rm (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL 308 Mo</td>
<td>550</td>
</tr>
<tr>
<td>VL 308</td>
<td>550</td>
</tr>
<tr>
<td>VL308 L</td>
<td>520</td>
</tr>
<tr>
<td>VL 309</td>
<td>550</td>
</tr>
<tr>
<td>VL 309 L</td>
<td>520</td>
</tr>
<tr>
<td>VL 309 Nb</td>
<td>550</td>
</tr>
</tbody>
</table>
6 Austenitic welding consumables for welding of non-magnetic stainless steels

Testing is performed in analogous manner as described in items [2] to [5] and comply with the requirements of Table 5 and Table 6.

Welding consumables for welding of non-magnetic stainless steels are approved according to a quality grade corresponding to the chemical composition (material no.) of the weld metal. Table 4 contains a number of examples. The testing and approval of steel in the left-hand column encompasses the steel(s) in the right-hand column, subject to separate consideration of the corrosion conditions in each case.

Table 4 Austenitic welding consumables for welding of non-magnetic stainless steels

<table>
<thead>
<tr>
<th>Grade</th>
<th>Testing and approval relating to steel</th>
<th>Steels covered by the approval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Designation</td>
<td>Designation</td>
</tr>
<tr>
<td>3954</td>
<td>X2CrNiMnMoNb21-16-5-3</td>
<td>X4CrNiMnMoN19-13-8, 1.3948</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X2CrNiMoN22-15, 1.3951</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X2CrNiMoN18-14-3, 1.3952</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X2CrNiMoN18-15, 1.3953</td>
</tr>
<tr>
<td>3984</td>
<td>X2CrNiMnMoNb23-17-6-3</td>
<td>X2CrNiMnMoNn21-15-7-3, 1.3914</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X2CrNiMoN22-15, 1.3951</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X2CrNiMoN18-14-3, 1.3952</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X2CrNiMnMoNn21-6-5-3, 1.3964</td>
</tr>
</tbody>
</table>

1) Steels in accordance with the BWB Material Performance Sheets having the corresponding material number.
Table 5 All weld metal test requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>Minimum yield strength $(N/mm^2)$</th>
<th>Tensile strength $(N/mm^2)$</th>
<th>Minimum elongation $(%)$</th>
<th>Minimum notch impact energy $(J)$</th>
<th>Test temperature $(\degree C)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3954</td>
<td>430</td>
<td>700 – 950</td>
<td>30</td>
<td>70 (49)</td>
<td>+ 20</td>
</tr>
<tr>
<td>3984</td>
<td>510</td>
<td>850 – 1050</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Means value of three specimens; for individual values 49J requirement applies

Table 6 Chemical composition requirements

<table>
<thead>
<tr>
<th>Grade</th>
<th>C max. $(%)$</th>
<th>Cr $(%)$</th>
<th>Ni $(%)$</th>
<th>Mo $(%)$</th>
<th>Mn $(%)$</th>
<th>Si max. $(%)$</th>
<th>P max. $(%)$</th>
<th>S max. $(%)$</th>
<th>N $(%)$</th>
<th>Nb $(%)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3954</td>
<td>0.03</td>
<td>21.0-23.0</td>
<td>16.0-19.0</td>
<td>3.4-4.0</td>
<td>7.0-9.0</td>
<td>1.0</td>
<td>0.025</td>
<td>0.015</td>
<td>0.15-0.35</td>
<td>0.10-0.30</td>
</tr>
<tr>
<td>3984</td>
<td>0.03</td>
<td>21.0-23.5</td>
<td>15.5-18.0</td>
<td>4.5-6.5</td>
<td>1.0</td>
<td>0.025</td>
<td>0.010</td>
<td>0.3-0.5</td>
<td>0.10-0.30</td>
<td></td>
</tr>
</tbody>
</table>

7 Annual test

Depending on whether it concerns electrodes, wire/flux combination or wire/gas combinations, the testing shall be carried out according to that prescribed in Sec.4 [6], Sec.5 [4] or Sec.7 [5], respectively.

For welding consumables which are not intended for low temperature service impact test is not required.

Annual testing for welding consumables which are intended for low temperature service at -105°C or lower impact testing at the respective temperature shall be performed.

Chemical composition analysis of two different dimensions shall be carried out.
SECTION 14 WELDING CONSUMABLES FOR WELDING OF FERRITIC-AUSTENITIC STAINLESS STEELS (DUPLEX STEELS)

1 General
Approval of welding consumables for ferritic austenitic stainless steels (duplex steels) will be considered subject to compliance with the specified tests and requirements below.
Parent plate material should preferably have a composition matching that of the electrode to be tested.

2 All weld metal test
Two all-weld-metal test assemblies shall be prepared as shown in Sec.13 Figure 1, one using a 2.4-3.5 mm Ø electrode and the other using the largest size manufactured.
For wire/gas combinations the wire size shall be 1.2 mm and the largest size manufactured.
For flux cored wire/gas combination the wire size shall be 1.2 or 1.6 mm and the largest size manufactured.
For wire/flux combinations the smallest and largest size manufactured shall be tested.
The weld metal shall be deposited in accordance with normal welding practice. The direction of deposition shall be reversed between subsequent layers, each bead being not wider than 4 times the core wire diameter and not exceeding 4 mm in thickness. Between each run, the assembly shall be left in still air until it has cooled below 150°C, the temperature being checked in the middle of the weld bead surface.
Test specimens:
Two longitudinal tensile and three impact test specimens shall be taken from each test assembly as shown in Sec.13 Figure 1.
The test specimens shall be prepared according to Sec.3 [4].
Test requirements:
The tensile strength, yield point and elongation shall be reported. For information, the value for reduction of area is also to be reported. The results of the tensile tests are not to be less than that specified for the base material, for which the consumable is intended. Table 1 to be used for reference.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile strength (N/mm²) Rm</th>
<th>Minimum strength 1) (N/mm²) Rp0.2</th>
<th>Elongation (%) A5</th>
<th>Impact energy Charpy V-notch 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNS S31803 (1.4462)</td>
<td>Minimum 620</td>
<td>450</td>
<td>25</td>
<td>-20</td>
</tr>
<tr>
<td>UNS S32750 (1.4410)</td>
<td>Minimum 690</td>
<td>550</td>
<td>25</td>
<td>-20</td>
</tr>
</tbody>
</table>

3 Butt weld test
Butt-weld test assemblies as shown in Sec.4 Figure 2 shall be prepared for each welding position for which the wire is recommended.
The test assemblies shall be prepared using wire or electrode of one of the smaller sizes manufactured and for the remaining runs wires or electrodes of the largest size for the position concerned.
Test specimens:
One transverse tensile, two bend and three impact test specimens shall be taken from each test assembly as shown in Section 4 Figure 2.

The test specimens shall be prepared according to Sec.3 [4].

Test requirements:

The result of the transverse tensile test is not to be less than that specified for the base metal, for which the consumable is intended.

The impact test specimens shall be tested at -20°C and minimum average impact energy shall be 27 J for full size test specimens.

The bend test specimens can be considered as complying with the requirements if, after bending, no crack or defect having any dimension exceeding 3 mm can be seen on the outer surface of the test specimen.

If requested testing for hot cracks to be performed as specified in item Sec.3 [4.4].

4 Chemical composition

Chemical analysis shall be carried out for all dimensions of welding consumables manufactured. The analysis shall be carried out as stipulated in Sec.10 [4] and shall be reported for approval.

The chemical composition of the core wire shall also be reported.

5 Microstructural examination

The ferrite/austenite-ratio of the weld shall be determined in accordance with ASTM E562. The ferrite content in average shall be in the range of 30 to 70%.

6 Corrosion test

For the determination of pitting and crevice corrosion resistance, one test according to ASTM G48, Method A is required. The 25Cr test specimen shall be exposed to the solution at a constant temperature of 40°C for 24 hours. The 22Cr test specimen shall be exposed to the solution at a constant temperature of 20°C for 24 hours. No pitting attack shall be visible on the test faces at 20X magnification, and the general weight loss shall be less than 4.0 g/m².

In the case of special corrosion conditions or particular materials, the Society may require other corrosion tests as an additional or alternative measure.

7 Annual tests

Depending on whether it concerns electrodes, wire/flux combination or wire/gas combinations, the testing shall be carried out according to that prescribed in Sec.4 [6], Sec.5 [4] or Sec.7 [5], respectively.

Chemical composition analysis of two different dimensions shall be carried out.
SECTION 15 WELDING CONSUMABLES FOR WELDING OF ALUMINIUM ALLOYS FOR GENERAL AND LOW-TEMPERATURE SERVICE

1 General

Approval of welding consumables for aluminium alloys will be considered subject to compliance with the specified tests and requirements in [2] and [3]. The welding consumables shall have a suitable hardness and smooth surface free from slivers, depressions, scratches or foreign matters that would adversely affect the welding properties when operating the welding equipment.

Tolerances for dimensions shall be kept within the limits guaranteed in the manufacturer’s specifications. The recommended and used composition for the shielding gases shall be reported.

2 Deposited weld metal test

For the testing of the chemical composition of the deposited weld metal, a test piece according to Figure 1 shall be prepared. The size depends on the type of the welding consumable (and on the welding process) and shall give a sufficient amount of pure weld metal for chemical analysis. The base metal used shall be compatible with the weld metal in respect of chemical composition.

![Figure 1 Deposited weld metal test assembly](image)

The chemical composition of the deposited weld metal shall be determined. The results of the analysis shall not exceed the limit values specified by the manufacturer.

3 Butt weld test

The testing of the welded joints shall be performed on butt-weld test assemblies according to Figure 2 and Figure 3 made in an analogous manner to Sec.4 [3], Sec.5 [2.2], Sec.7 [2.2] or Sec.7 [3.2] respectively.

Butt weld test assemblies according to Figure 2 with a thickness of 10 to 12 mm shall be prepared for each welding position (down hand, horizontal-vertical, vertical-upward and overhead) for which the consumable is recommended by the manufacturer; except that consumables satisfying the requirements for down hand and vertical-upward positions will be considered as also complying with the requirements for the horizontal-vertical position subject to the agreement of the Society.

Additionally one test assembly according to Figure 3 with a thickness of 20 to 25 mm shall be welded in the down hand position only.

\[ T = \text{Flat tensile test specimen} \]
\[ BC = \text{Face bend test specimen} \]
\[ BR = \text{Root bend test specimen} \]
Notes:
1) Edge preparation shall be single V or double V with 70° angle.
2) Back sealing runs are allowed in single V weld assemblies.
3) In case of double V assembly both sides shall be welded in the same welding position.

**Figure 2 Butt weld test assembly for positional welding**

1) Edge preparation shall be a single V with 70° angle.
2) Back sealing runs are allowed.

**Figure 3 Additional butt weld test assembly in down hand position**

On completion of welding, assemblies must be allowed to cool naturally to ambient temperature.

Welded test assemblies and test specimens must not be subjected to any heat treatment.
6000 series assemblies should be allowed to naturally ageing for a minimum period of 72 hours from the completion of welding before testing is carried out.

The test specimens shown in Figure 2 and Figure 3 shall be taken from the butt weld test assemblies.

The test specimens shall be prepared according to Sec.3 [4].

The tensile strength shall comply with the requirements specified in the Table 1. Yield point and elongation shall be reported for the Society's consideration. The yield strength for both weld metal and welded joint shall not be less than that specified for the parent material (in soft condition), for which the consumable is intended. For materials in deformation hardened or aged condition, the choice of consumable and requirements to mechanical properties shall be evaluated in each particular case.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Filler</th>
<th>Tensile strength $R_{m}$, minimum (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VL-5754</td>
<td>5356, 5183</td>
<td>190</td>
</tr>
<tr>
<td>VL-5086</td>
<td>5356, 5183</td>
<td>240</td>
</tr>
<tr>
<td>VL-5083</td>
<td>5183</td>
<td>275</td>
</tr>
<tr>
<td></td>
<td>5356, 5183</td>
<td>275</td>
</tr>
<tr>
<td></td>
<td>5356</td>
<td>275</td>
</tr>
<tr>
<td>VL-5383 or VL-5456</td>
<td>5183</td>
<td>290</td>
</tr>
<tr>
<td>VL-5059</td>
<td>5183</td>
<td>330</td>
</tr>
<tr>
<td>VL-6061</td>
<td>5356, 5183</td>
<td>170</td>
</tr>
<tr>
<td>VL-6005A</td>
<td>5356, 5183</td>
<td>170</td>
</tr>
<tr>
<td>VL-6082</td>
<td>5356, 5183</td>
<td>170</td>
</tr>
</tbody>
</table>

The bend test specimens shall be bent on a mandrel with maximum diameter as given in the formula below. The bending angle shall be at least 180°. After bending, the test specimens shall not reveal any open defects in any direction greater than 3 mm. «Wrap around» bending is the preferred bending method.

$$d = \frac{100 t_s}{A} t_s$$ (1)

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)

The macrographic specimen shall be examined for imperfections such as lack of fusion, cavities, inclusions, pores or cracks.

**4 Annual tests**

The annual tests shall entail the preparation and testing of the deposited weld metal test assembly as prescribed under [2] (Figure 1) and of the down hand butt weld test assembly according to [3] (Figure 2).
SECTION 16 WELDING CONSUMABLES FOR COPPER AND COPPER ALLOYS

1 General

Approval of welding consumables for copper alloys will be considered subject to compliance with the specified Welding consumables for welding of copper and copper alloys are classified into the quality grades shown in Table 1 on the basis of the chemical composition (type of alloy) and mechanical (strength) properties.

— SCU1 Al-bronze or Mn-bronze;
— SCU2 Al-bronze or Ni-Mn-bronze;
— SCU3 Al-bronze, Ni-Al-bronze or Mn-Al-bronze;
— SCU4 Mn-Al-bronze.

2 All weld metal test

Only one all weld test piece to be welded in the down-hand position. Testing of the all weld test assembly shall consist of two longitudinal tensile tests. Tensile strength, yield strength and elongation shall comply with the requirements specified in Table 1.

Table 1 Welding consumables for copper and copper alloys

<table>
<thead>
<tr>
<th>Quality grade</th>
<th>Minimum 0,2 %-proof stress [N/mm²]</th>
<th>Tensile strength [N/mm²]</th>
<th>Minimum elongation [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CuNi30Fe</td>
<td>120</td>
<td>360-490</td>
<td>30</td>
</tr>
<tr>
<td>CuNi30Mn</td>
<td>120</td>
<td>360-490</td>
<td>30</td>
</tr>
<tr>
<td>SCU1</td>
<td>175</td>
<td>370 min.</td>
<td>20</td>
</tr>
<tr>
<td>SCU2</td>
<td>195</td>
<td>410 min.</td>
<td>20</td>
</tr>
<tr>
<td>SCU3</td>
<td>245</td>
<td>500 min.</td>
<td>16</td>
</tr>
<tr>
<td>SCU4</td>
<td>275</td>
<td>550 min.</td>
<td>18</td>
</tr>
</tbody>
</table>

3 Butt weld test

Testing of the butt weld test assembly shall be performed in a manner analogous to that prescribed in Sec.15 [3] (Sec.15 Figure 2) as in the case of aluminium alloys. The tensile strength shall comply with the requirements of Table 1.

The bend test specimens shall be bent on a mandrel with maximum diameter as given in the equation below. The bending angle shall be 180°. After bending, the test specimens shall not reveal any open defects in any direction greater than 3 mm.

\[ d = \frac{100 t_s}{A} \]  \hspace{1cm} (1)

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).
4 Chemical composition
For determination of the chemical composition, ASTM E478 shall be used. For copper-nickel alloys ASTM E 75 shall be applied. At least two dimensions shall be tested.

5 The chemical composition shall not exceed the limits specified by the manufacturer. Annual tests
The annual tests shall entail the preparation and testing of a butt-weld test piece in accordance with [3] welded in the down-hand position.
SECTION 17 WELDING CONSUMABLES FOR NICKEL AND NICKEL ALLOYS

1 General
Approval of welding consumables for nickel and nickel alloys will be considered subject to compliance with the specified tests and requirements in [2] and [3].
Welding consumables for nickel and nickel alloys are classified by the alloy type and on the basis of the chemical composition and mechanical (strength) properties.
Parent plate material should have a composition matching that of the consumable to be tested.
Test plan shall be submitted for a review and verification prior start of approval process. The Society may require other tests to be performed or stipulate other values for the required properties if they are more appropriate to the character of the welding consumables or are necessitated by the intended use of the material.

2 All weld metal test
Depending on the nature of the welding consumables and welding process, the test assembly shall be welded and tested as specified in corresponding items Sec.4 (covered electrodes), Sec.5 (wire/flux combinations) or Sec.7 (wire/gas combination). Impact testing is required only if consumable is intended for low temperature application.
The yield stress and tensile strength of the weld deposit shall be at least equal to the parent material tensile properties. The average and single Charpy V-notch toughness shall not be less than specified for the type of alloy at the corresponding test temperature.

3 Butt weld test
Depending on the nature of the welding consumables and on the welding process concerned the test assembly shall be welded as specified in corresponding items Sec.4 (covered electrodes), Sec.5 (wire/flux combinations) or Sec.7 (wire/gas combination) and tested as specified herein.
Test specimens:
One transverse tensile, two transverse bend tests shall be taken from each test assembly. Longitudinal face bend may be required in addition.
If the composition and mechanical properties of the deposited metal differ markedly from the composition and properties of the base metal, the two transverse bend tests may be replaced by longitudinal bend tests. If this is done, one face bend and one root bend test shall be carried out. Longitudinal bend test then shall be carried out as specified in Sec.11 [2].
Impact test shall be carried out if approval is requested for low temperature applications. Suitability of the consumable for low-temperature applications is indicated separately in the approval certificate.
The tensile strength and impact test results shall not be less than specified for the type of alloy. The bend tests shall not disclose any open defects in any direction exceeding 3 mm.

4 Chemical composition
Chemical analysis shall be carried out for all dimensions of welding consumables manufactured. The analysis shall be carried out as stipulated in Sec.10 [3] and shall be reported for approval.
The results of the analysis shall not exceed the limits specified in the standards or by the manufacturer, the narrower tolerances being applicable in each case. The chemical composition of the core wire shall also be reported.
5 Annual test
The annual tests shall entail the preparation and testing of all weld test piece in accordance with [2] welded in the down-hand position. Chemical composition analysis of two different dimensions shall be carried out.
SECTION 18 STANDARDS REFERRED TO IN THIS DOCUMENT

1 Referred standards

— ISO 3690 - *Welding and allied processes - Determination of hydrogen content in ferritic steel arc weld metal*
— AWS A4.3 – *Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding*
— ASTM E478 *Standard Test Methods for Chemical Analysis of Copper Alloys*
— ASTM E75 *Standard Test Methods for Chemical Analysis of Copper Nickel and Copper Nickel Zinc Alloys*
CHANGES – HISTORIC

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