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**CHANGES IN THE RULES**

**General**

The present edition of the Rules includes additions and amendments decided by the Board as of December 1995, and supersedes the January 1994 edition of the same chapter.

The Rule changes come into force on 1st of July 1996.

This chapter is valid until superseded by a revised chapter. Supplements will not be issued except for an updated list of minor amendments and corrections presented in the introduction booklet. The introduction booklet is normally revised in January and July each year.

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

**Main changes**

- **Sec.2 Welding Procedures and Approval of Welders**
  - Item B308 has been amended and extended to include extra high strength steel.
  - Item B903 has been amended and extended to include extra high strength steel. New Figs. 10-12 have been added.
  - Table B2 and B4 have been amended.
  - A new table B5 on range of approval for type of joint has been added.
  - Table C2 has been amended.

- **Sec.3 Welding Consumables**
  - Item J101 has been amended and extended to include grade A (From IACS UR W23).
  - Item J103 has been amended.
  - Item J202 has been amended.
  - Table J1 has been amended.
  - A new Table J2 on butt weld test requirements has been added.
  - Item L201 on all-weld-metal tests has been amended.
  - A new item L202 on butt weld tests for duplex stainless steel wires has been added.
  - Item L401 has been supplemented with range of ferrite content.
  - Item L501 on pitting and crevice corrosion resistance has been amended.

**Corrections and Clarifications**

In addition to the above stated rule amendments, some detected errors have been corrected, and some clarifications have been made in the existing rule wording.

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

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SECTION 1
GENERAL REQUIREMENTS

A. General

A 100 Scope
101 This Chapter specifies the requirements for welding shops and -contractors, welders, welding consumables and welding procedures in general as well as procedures and methods for welding of clad steel plates and liquefied gas systems.

A 200 Basic requirements
201 Welding of important structures: hull, superstructure and deckhouse, machinery installations: boilers, pressure vessels and pipe systems and equipments: sternframes, rudders, rudder stocks and rudder horn are to be carried out by approved welders, with approved welding consumables and at welding shops and -contractors recognized by the Society. Manufacturers of boilers and pressure vessels Class I—I-II are to obtain the approval according to a detailed programme, available by the local surveyor.

A 300 Welding shops and -contractors
301 Welding shops and -contractors will have to prove their qualifications for the welding operations in question.
302 It is assumed that the welding shops and -contractors make use of the necessary equipment for carrying out inspection of the welding operations in a satisfactory manner.
303 Important welding operations are to be carried out under daily supervision of an inspector, who has the experience and qualifications which enable him to judge this type of work. The work of each welder is to be regularly examined.
304 The welding shops and -contractors are to keep a card index or register of all approved welders. The register is to give information on training of the welders and date and results of qualification tests. Information about the base metal, type of welding consumable, joint design and welding positions is to be stated in the event of re-qualification tests. The surveyor is to be allowed to examine the register at any time.

A 400 Welding consumables
401 Consumables for welding of ships, mobile offshore units, fixed offshore installations and other structures intended for classification are to be approved by the Society.
402 Type approval of welding consumables will be considered subject to compliance with the requirements given in Sec. 3.
403 All brand names under which a tested and approved welding consumable is marketed, are to be registered by the Society. In order to avoid duplication of tests, the manufacturer is to certify that the welding consumables marketed under alternative brand names are identical with the consumables tested for approval.

B. Testing

B 100 General
101 Testing of welds is to be carried out as specified in 200 to 300. Reference is also made to relevant paragraphs in Ch.1

Sec.2.

B 200 Tensile testing at ambient temperature
201 For tensile testing of all-weld-metal and butt welds two different types of test specimens may be used, round test specimens or flat test specimens (see Fig. 1) as described below:

A — Deposited metal tensile test

Normally, round test specimens with the following dimensions are to be used:

- Thickness of plate, t
- Width of weld
- Radius R

B — Butt weld tensile test for testing of the weld as a whole

Flat test specimens with the weld machined flush with the surface of the plate, are to be used. The dimensions are to be as follows:

- Thickness of plate, t
- Width of weld
- Radius R

C — Butt weld tensile test

Flat test specimens with the weld machined flush with the surface of the plate, are to be used. The dimensions are to be as follows:

- Thickness of plate, t
- Width of weld
- Radius R

![Fig. 1](image_url)

Tensile test specimen.

B 300 Bend testing
301 Flat bend test specimens, as given in Fig. 2 are to be used. Edges on tension side to be rounded to a radius of 1 to 2mm.
When the wrap around bend test, exemplified in Fig. 3 is used, e.g. for the side bend test of a weld, the length of the test specimen has to be greater than the length $11a$ shown in Fig. 2.

For butt weld bend test specimens, the weld is to be machined flush with the surface of the plate.

For transverse face-bend and root-bend test specimens for butt weld test the dimensions are to be as follows:

- $a = \text{as rolled thickness } t \text{ of the plate}$
- $b = 30 \text{ mm}$

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

For transverse side-bend test specimens for butt weld test the dimensions are to be as follows:

- $a = 10 \text{ mm}$
- $b = \text{as rolled thickness } t \text{ of the plate}$

If $t \geq 40 \text{ mm}$, the side-bend test specimen may be subdivided, each part being at least 20 mm wide.

When a longitudinal face-bend or root-bend weld test is required, a test specimen according to an appropriate standard will be accepted.
SECTION 2
WELDING PROCEDURES AND APPROVAL OF WELDERS

A. General

A 100 Scope

101 This Section specifies the requirements for welding procedures and welding procedure qualification tests as well as approval of welders.

A 200 Definitions

201 Welding procedure specification (WPS): A specification of materials, detailed methods, practices and parameters employed in the welding of a particular joint.

202 Welding procedure qualification test (WPQT): A test carried out in order to demonstrate that a weld made according to a specific procedure specification meets the given requirements.

203 Welding procedure qualification record (WPQR): The record of the actual parameters employed during welding of the qualification test piece, and results from the non-destructive testing and mechanical testing.

204 Non-destructive testing (NDT): Visual inspection, radiographic testing, ultrasonic testing, magnetic particle testing, penetrant testing and other non-destructive methods for revealing defects and irregularities.

B. Welding Procedures, Steel

B 100 Welding procedure specification, WPS

101 WPS subjected to approval is to contain as a minimum the following information as relevant for the welding operation:

— material: standard, grade and modification
— nominal thickness/diameter range (dimensions)
— welding process
— joint/groove design
— welding position and direction
— welding consumables: trade name, electrode/wire diameter, shielding gas, flux and recognized classification
— welding sequence (number and order of passes/layers)
— welding parameters: voltage, current, polarity and welding speed
— preheat and interpass temperature

B 200 Welding procedure qualification test, WPQT

201 When WPQT is required, the tests must be performed in the environment applicable to the actual production and meet the specified minimum requirements prior to commencing the production welding.

202 The qualification test is to be witnessed by the surveyor.

B 300 WPQT for butt welds on plates

301 The test assembly consists of two plates welded together. As far as possible the plates are to have a size which can simulate the heat transfer during the production welding. For manual or semiautomatic welding, a test assembly according to Fig. 1 is to be carried out with:

\[ l_{\text{min}} = 400 \text{ mm} \]
\[ L_{\text{min}} = 1000 \text{ mm} \]

Edge preparation and fit-up are to be as detailed in the WPS. The plates are to be joined and held by tack welds to provide the correct gap for the edge preparation used. 50 mm of each end of the test piece is to be discarded.

\[ \text{Fig. 1 Test assembly for butt welds on plates} \]

302 NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

— 100 % visual inspection
— 100 % radiographic or ultrasonic testing
— 100 % surface crack detection (dye penetrant or magnetic particle testing)

The soundness of the weld is to comply with requirements given in the relevant parts of the Rules.

303 The following mechanical tests are required from each assembly (see Fig. 2):

— 1 tensile test (flat specimen transverse to the weld)
— 1 root and 1 face bend tests when \( t \leq 20 \text{ mm} \) and 2 side bend tests when \( t > 20 \text{ mm} \)
— when the welding consumable is not approved, 1 extra tensile test (round specimen from the weld metal)
— 12 Charpy V-notch tests with the notch location as given in 308
Specimens for transverse tensile testing are to be in accordance with Sec.1 B201, type B. The tensile strength is not to be below the specified minimum tensile strength for the steel grade in question.

The round tensile specimen is to be machined to the dimensions shown in Sec.1 B201, type A, care being taken that the longitudinal axis coincides with the intersection between the midplane of the weld, and the midplane of the plates. If the section area of the weld metal is too small to allow sampling of the round specimen, an all-weld-metal tensile test is to be carried out according to the requirements given in Sec.3.

Transverse side bend, root bend and face bend specimens are to be machined to the dimensions shown in Sec.1 B300. For a mixed or heterogeneous butt joint, longitudinal bend test specimens may replace transverse bend test specimens.

The test specimens are to be bent on a mandrel with diameter 4xt, where t is the thickness of the specimen, except for extra high strength steels grades 550, 620, and 690 where the diameter is to be 5xt.

The bending angle is to be at least 120°. After bending, the test specimens are not to reveal any open defects in any direction greater than 3 mm. Defects appearing at the corners of a test specimen during testing are to be ignored in the evaluation.

The macrosection is to include about 10 mm of unaffected base material and is to be prepared and etched on one side to clearly reveal the fusion line and the HAZ. Cracks and lack of fusion are not accepted. The welded joints are to have a regular profile with smooth transitions to the base materials and without significant or excessive reinforcement.

The Charpy V-notch specimens are to be machined in accordance with the requirements given in Ch.1 Sec.2 (ISO 148). The specimens are to be sampled 2 mm below the surface of the parent material and transverse to the weld.

12 Charpy V-notch specimens are to be localized in the welded joint as follows:

- 3 specimens with the notch along the weld metal centreline
- 3 specimens with the notch in the fusion line
- 3 specimens with the notch in the HAZ, 2 mm from the fusion line (Note 1)
- 3 specimens with the notch in the HAZ, 5 mm from the fusion line (Note 1).

**Guidance note:**
HAZ impact test specimens are normally not required for grade NV A steels. If tested the average value for absorbed energy in weld metal, fusion line and HAZ is not to be less than 27 J at 20°C.

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

The V-notch is to be perpendicular to the plate surface. For plate thicknesses >50 mm and for one side welded assemblies with plate thickness >20 mm, one additional set of specimens is to be taken in the weld metal root area.

**Hull construction**

The test temperature and absorbed energy are to be in accordance with the following requirements:

Impact test temperatures:

- +20°C for grades B, A27S, A32, A36 and A40
- 0°C for grades D, D27S, D32, D36 and D40
- -20°C for grades E, E27S, E32, E36 and E40
- -40°C for grades F32, F36 and F40

The average value for absorbed energy in weld metal, fusion line and HAZ is not to be less than:

- for manual and semi-automatic welding in all welding positions except vertical:
  \[ \geq 47 \text{ J} \]
- for automatic welding:
  \[ \geq 34 \text{ J (NV 40 grades } \geq 41 \text{ J)} \]
- for manual and semi-automatic welding in vertical position:
  \[ \geq 34 \text{ J (NV 40 grades } \geq 41 \text{ J)} \]

For extra high strength structural steels the Charpy V-notch test temperature and the average value for absorbed energy in weld metal, fusion line and HAZ are to be the same as required for the base material.

**Pressure vessels and production/drilling plants related equipment, structures and systems**

The Charpy V-notch test temperature and the average value for absorbed energy in weld metal, fusion line and HAZ are to be the same as required for the base material.

In the case of reduced Charpy V-notch test specimens (10 x 7.5 mm and 10 x 5 mm), the impact energy values to be
obtained are to satisfy the following table:

<table>
<thead>
<tr>
<th>Table B1 Impact energy requirement for subsize specimens</th>
<th>Impact energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions of Charpy V-notch test specimen</td>
<td>KV</td>
</tr>
<tr>
<td>10 x 10 mm</td>
<td>KV</td>
</tr>
<tr>
<td>10 x 7.5 mm</td>
<td>5/6 KV</td>
</tr>
<tr>
<td>10 x 5 mm</td>
<td>2/3 KV</td>
</tr>
</tbody>
</table>

310 The average impact requirements are to be satisfied for each notch location, but one single value of three values from specimens from the same notch location may be below the average requirements, but not below 70% of minimum average.

311 Where the results from a set of three impact test specimens do not comply with the requirements, an additional set of three impact test specimens may be taken.

The results obtained are to be combined with the original results to form a new average which, for acceptance, is to be not less than the required value. Additionally, for these combined results not more than two individual values are to be less than the required average value, and of these, not more than one is to be less than 70% of the average value.

Further re-tests may be made at the surveyor’s discretion, but these are to be made on a new welded assembly (revised WPS) and are to include all tests required for the original assembly, even those which were previously satisfactory.

312 The hardness testing is to be in accordance with ISO 6507/1 or equivalent, and is only required for grades NV27S and higher. Normally, the Vickers method (HV5 or HV10) is used.

Indentations are to be made along traverses in the weld, HAZ and the parent metal approximately 1 mm below the surface. For each traverse a minimum of 3 indentations are to be made in the weld, HAZ (both sides) and parent metal (both sides). For HAZ the first indentation is to be placed as close to the fusion line as possible.

The values are to be reported for consideration.

313 When a butt weld is made between two plates of different grades, the test temperature and achieved impact energy are to comply with the minimum specified requirements for the lower steel grade (see 308).

In the same way, the tensile strength to be obtained on the welded assembly is to be in agreement with the requirements relating to the plate steel having the lower strength.

As an example the test temperature, impact energy and tensile strength for the butt welded joints given in Fig. 3 are those required for the plate of grade D in the left assembly and for the plate of grade E in the right assembly.

B 400 WPQT for butt welds on tubes

401 The test assembly is to be in accordance with Fig. 4.

NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

— 100% visual inspection
— 100% radiographic or ultrasonic testing
— 100% surface crack detection (dye penetrant or magnetic particle testing)

The soundness of the weld is to comply with requirements given in the relevant parts of the Rules.

403 The following mechanical tests are required from each assembly (see Fig. 5):

— 1 tensile test (flat specimen transverse to the weld)
— 1 root and 1 face bend tests when t ≤ 20 mm and 2 side bend tests when t > 20 mm
— 12 Charpy V-notch tests with the notch location as given in 308
— 1 macrosection test (metallographic examination + hardness measurements).

The results of mechanical testing are to comply with the relevant requirements given in 300.

**504** The results of mechanical testing are to comply with the relevant requirements given in 300.

**B 500** WPQT for full penetration T-, Y-, and K-joints

**501** WPQT's for full penetration groove welds between plates at right angles or inclined, i.e. T- or Y- and K- configurations, are to cover a weld length of minimum 350 mm (see Fig. 6).

**502** NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

— 100 % visual inspection
— 100 % ultrasonic testing
— 100 % surface crack detection (dye penetrant or magnetic particle testing).

The soundness of the weld is to comply with requirements given in the relevant parts of the Rules.

**503** The following mechanical tests are required from each assembly (see Fig. 7):

— 12 Charpy V-notch tests with the notch location as given in 308
— 1 macrosection test (metallographic examination + hardness measurements).

**504** The results of mechanical testing are to comply with the relevant requirements given in 300.

**B 600** WPQT for tubular joints

**601** The test assembly is to be in accordance with Fig. 8.

**602** NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

— 100 % visual inspection
— 100 % ultrasonic testing
— 100 % surface crack detection (dye penetrant or magnetic particle testing).

The soundness of the weld is to comply with requirements given in the relevant parts of the Rules.

**603** The following mechanical tests are required from each assembly (see Fig. 8):

— 12 Charpy V-notch tests sampled at 9 o'clock and with the notch location as given in 308
For automatic welding the length is to be:

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

For manual and semi-automatic welding the length is to be:

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

Weld and fit-up are to be as detailed in the WPS.

The test assembly is to be welded on one side only. For manual and semi-automatic welding, the stop/restart position is normally to be included in the test length and is to be clearly marked for subsequent examination.

The ends of the specimen are exempted from examination over a length of 50 mm.

**702** NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

- 100 % visual inspection
- 100 % surface crack detection (dye penetrant or magnetic particle testing)

The soundness of the weld is to comply with the specified requirements given in the relevant parts of the Rules.

If the stop/restart spot is included in the test length, special attention is to be paid to this position with respect to profile, proper fusion and absence of crater defects.

**703** The following tests are to be performed:

- two macrosection tests (metallographic examination, hardness measurements).

One of the macrosections is to be taken at the marked position of the stop/restart (for more details see 307).

For hardness testing, see 312.

**B 800 Retesting**

**801** If the WPQT fails to comply with any of the requirements for NDT one extra WPQT is to be welded and subjected to the same testing. If this additional test does not meet the relevant requirements, the actual WPQT is to be considered as not qualified and a respecification of the WPS is to be made prior to a new qualification test.

**B 900 Validity of qualified welding procedures**

**901** The validity of a qualified welding procedure is to be restricted to the workshop performing the qualification. Workshops or workshop branches under the same technical management and working in accordance with the same QA-program and -procedures are considered as one workshop.

**902** Qualification of a welding procedure remains valid provided the parameters are kept within the qualified ranges during production welding. The qualified ranges are given in 903. When one or more variations outside the qualification ranges occur, the welding procedure qualification is to be considered invalid, and the welding procedure is therefore to be respecified and requalified.

**903** A qualified welding procedure is to be used within the ranges of the parameters below.

**Base material**

The following changes are to lead to a new qualification:

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

b) More specifically, structural steels are grouped in three categories:

i) Normal strength steel, grades A, B, D and E or equivalent structural steels with tensile strength 400—490 N/mm².


The qualification on steel grades of higher toughness requirements will qualify the grades of lower toughness but not vice versa.

**Thickness**

Thickness, t, is defined as follows:

a) For a butt weld:

The base metal thickness, which for welds between dissimilar thicknesses is that of the thinner material.

b) For a fillet weld:

The base metal thickness, which for welds between dissimilar thicknesses is that of the thicker material. However, for each thickness range qualified, as in Table B2 there is an associated range of qualified throat thickness as given below.

c) For a set-on tubular joint:

The thickness of the brace
d) For a set-in or set-through tubular joint:

The thickness of the can
e) For a T-butt joint in plate:

The thickness of the prepared plate

The requirements to qualified thickness range for butt welds
are to be as given in Table B2.

<table>
<thead>
<tr>
<th>Table B2 Qualified thickness range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
</tr>
<tr>
<td>t in mm of test piece</td>
</tr>
<tr>
<td>t &lt; 12</td>
</tr>
<tr>
<td>12 ≤ t ≤ 100</td>
</tr>
<tr>
<td>t &gt; 100</td>
</tr>
</tbody>
</table>

1) The qualification range for vertical downward position is 0.5 t to 1.1 t.

The requirements to qualified thickness range for fillet welds are in addition to the requirements of Table B2, that the throat thickness, a, is to be in the range 0.75 a to 1.5 a. However, a throat thickness of 10 mm or more is to give qualification for all throat thicknesses above or equal to 10 mm.

**Diameter of tubes and tubular joints**

The qualification of a welding procedure test on diameter D is to include qualification for diameters in the following ranges as given in Table B3.

<table>
<thead>
<tr>
<th>Table B3 Qualified range for tube and tubular joint.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of the test piece</td>
</tr>
<tr>
<td>D (mm) 1) 2)</td>
</tr>
<tr>
<td>D ≤ 168.3</td>
</tr>
<tr>
<td>D &gt; 168.3</td>
</tr>
</tbody>
</table>

1) D is the outside diameter of the tube or outside diameter of the brace.
2) Qualification given for plates also covers tubes when the outside diameter is greater than 500 mm.

**Angle of tubular joints**

A WPQT carried out on a tubular joint with angle α is to qualify all tubular joint angles in the range of α ≤ α1 ≤ 90°.

**Welding consumables**

The following changes are to lead to a new qualification:

- any change in consumable grading
- change of consumable name when impact testing is required at temperatures below —20°C
- any significant change of mixture/composition (e.g. change from argon/mixed gas to CO₂ gas), flow rate, filling time and filling volume for shielding and backing gases.

**Welding positions**

The following changes are to lead to a new qualification.

- Change from one principal welding position (see Figs. 10, 11, 12) to another, unless complying with Table B4.

**Type of joint**

The range of approval for type of joint is given in Table B5. In addition the following changes are to lead to a new qualification:

- change from fillet weld to butt weld
- change of specified type of groove, root face and gap which may significantly affect penetration, fusion and delusion of the weld.

**Welding condition**

The following changes are to lead to a new qualification:

- any change of welding process
- change from spray arc to short arc or pulsed arc or vice versa
- change beyond ±15 % for voltage and current, and change of more than ±10 % for travel speed
- change of preheating/interpass temperature beyond ±25°C
— change of post weld heat treatment parameters.

**B 1000  Welding procedure qualification record, WPQR**

**1001** The parameters used during qualification welding, NDT-records and mechanical testing reports are to be presented in a WPQR for each qualification test. The WPQR is to contain sufficient references to establish where, when, how and by whom the test welding, NDT- and mechanical testing were performed.

---

**Table B4 Qualified principal positions for butt welds and fillet welds**

<table>
<thead>
<tr>
<th>Test weld Joint configuration</th>
<th>Butter positions</th>
<th>Qualified positions</th>
<th>Fillet welds Plates/tubes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2G+3G 1G 2G 3G 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td>Butt welds on plates</td>
<td>All</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td></td>
<td>1G, 2G, 4G</td>
<td>Tubes 2G+3G 1G 2G 3G 4G</td>
<td>Tubes 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td></td>
<td>1G, 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td>Butt welds in tubes</td>
<td>All</td>
<td>Tubes 2G+3G 1G 2G 3G 4G</td>
<td>Tubes 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td>2G + 5G = 6G</td>
<td>All</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td>1G</td>
<td>1G, 1G, 2G, 4G</td>
<td>Tubes 2G+3G 1G 2G 3G 4G</td>
<td>Tubes 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td>2G</td>
<td>1G, 2G, 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td>3G</td>
<td>1G, 2G, 4G</td>
<td>Tubes 2G+3G 1G 2G 3G 4G</td>
<td>Tubes 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td>5G</td>
<td>All</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td>Fillet welds</td>
<td>2F+3F 1F 2F 3F 4F 5F</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
</tr>
<tr>
<td></td>
<td>All</td>
<td>Tubes 2G+3G 1G 2G 3G 4G</td>
<td>Plates 2G+3G 1G 2G 3G 4G</td>
</tr>
</tbody>
</table>

1) Tubes with OD > 500 mm are considered equivalent to plates (apply only to the can in tubular joints)
2) Tubular joints are to be qualified separately.
3) The vertical downwards position is to be qualified separately.
Table B5  Range of approval for type of joint

<table>
<thead>
<tr>
<th>Type of joint in approval test piece</th>
<th>Range of approval</th>
<th>Range of approval</th>
<th>Range of approval</th>
<th>Range of approval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Butt welds on plate</td>
<td>T butt welds on plate</td>
<td>Butt welds on pipe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Welded from one side</td>
<td>Welded from both sides</td>
<td>Welded from one side</td>
<td>Welded from both sides</td>
</tr>
<tr>
<td></td>
<td>With backing</td>
<td>No backing</td>
<td>With gouging</td>
<td>No gouging</td>
</tr>
<tr>
<td>Welded from one side</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welded from both sides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welded from one side</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welded from both sides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butt weld on pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welded from one side</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welded from both sides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T butt weld on plate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welded from one side</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welded from both sides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key:
* indicates the WPS which is approved in the approval test
X indicates those welds for which the WPS is also approved
- indicates those welds for which the WPS is not approved

B 1100  WPQT for liquefied gas systems

1101  Welding shops which intend to build welded cargo tanks, process pressure vessels and/or piping systems for liquefied gases are to carry out WPQT for all types of butt welds in the construction.

1102  For butt welds in tanks and pressure vessels, the test assemblies consist of two plates, each having a width of at least 150 mm and a length sufficient for making all necessary test specimens described in 1105. The test assemblies are to be so prepared that the principal direction of rolling is parallel to the direction of welding.

Guidance note:
The test plates must be of such dimensions that the cooling condition as far as possible will be the same as for the production welding.

---end---of---Guidance---note---

1103  For butt welds in piping systems the test assemblies are made by welding together two approximately 150 mm long pipes with the same diameter as the pipes used in the system to be represented.

1104  The test assemblies are to be subjected to radiographic testing after welding. X-rays, fine-grained film and lead screens are to be used for this testing. The radiographs are at least to meet the requirements in Pt.5 Ch.5 Sec.5 and Pt.5 Ch.5 Sec.6. Concerning magnetic particle, dye penetrant and ultrasonic testing reference is made to Pt.5 Ch.5 Sec.5.

Hardness testing is to be performed on weld metal, heat affected zone and parent material. The values are to be reported for consideration.

The weld is to be etched through the whole cross-section and is to show normal structure and penetration. The etching is to be done in such a way that the fusion line is clearly seen.

1105  From each test assembly for plates the following specimens are to be taken:
- one transverse weld tensile test specimen
- two side bend test specimens.

The test specimens are to be cut transverse to the longitudinal axis of the weld. The thickness of the test specimen is to be 10 mm and width equal to the plate thickness. If the plate thickness exceeds 40 mm the test sample may be divided into two, each having a width of at least 20 mm
- five sets of Charpy V test specimens (each set consists of 3 specimens)
- macrosection, microsection and hardness survey may also be required.

The Charpy V test specimens are to be cut with their longitudinal axis transverse to the longitudinal axis of the weld. When practicable, the test specimen is to be taken at a place half the distance from the centre to the surface of the plate. The notch is to be cut in a face of the test specimen originally perpendicular to the rolled surface. The specimens are to be taken at the following locations:
- 3 specimens with the notch in the centre line of the welds
- 3 specimens with the notch in the fusion line
- 3 specimens with the notch 1 mm from the fusion line
- 3 specimens with the notch 3 mm from the fusion line
- 3 specimens with the notch 5 mm from the fusion line.

For austenitic chromium-nickel steels, only 3 tests with the notch in the centre of the welds are required for design temperature below —105°C.

1106  From each test assembly for tubes, the following test specimens are to be taken:
- one transverse weld tensile test specimen
- two side bend test specimens.

The test specimens are to be cut transverse to the longitudinal axis of the weld. The thickness of the test specimen is to be 10 mm and the width equal to the wall thickness. If the wall thickness is less than 10 mm the side bend test is to be replaced by root bend test
- five sets of Charpy V test specimens (each set consists of 3 specimens). The test specimens are to be cut as stipulated in 1105
- macrosection, microsection and hardness survey may also be required.
For austenitic chromium-nickel steels, only 3 tests with the notch in the centre of the welds are required if the design temperature is below —105°C.

1107 The butt weld tensile test is to comply with the following requirements:

Generally, the tensile strength is not to be less than the specified minimum tensile strength for the parent material. In cases where the Society has approved the use of welding consumables which give lower tensile strength in the weld metal than that required for the parent material, the approved value for the welding consumable in question applies. The position of fracture is to be reported.

1108 The bend test specimens are to be capable of withstanding bending through an angle of 180° over a former with diameter four times the thickness of the specimen. The tests can be considered as complying with the requirements if, after bending, no crack or other open defects exceeding 3 mm in dimension can be seen on the outer surface.

1109 Charpy V testing is to be conducted at the temperature prescribed for the base material. See Pt 5 Ch 5 Sec 2. When specimens of 10 x 10 mm cross-section are used, the average value from 3 tests is not to be less than 27 J for weld metal. One single test may give a value below the required average but not lower than 19 J.

For fusion line and heat affected zone the requirement for minimum average value is the same as for the base material. Only one individual value may be below the specified average value provided it is not less than 70 % of that value.

For testing of thin materials where it is impossible to use a standard test specimen 10 x 10 mm, the larger of the following specimens is to be used:

- 10 x 7.5 mm,
- 10 x 5 mm,
- 10 x 2.5 mm.

The impact values are then reduced to respectively 5/6, 2/3 and 1/2 of the required values of the standard test specimen.

C. Welding Procedures, Aluminium

C 100 General

101 Requirements for liquefied gas systems are stated in special Programmes in Certification Notes No. 2.1.

102 Qualified welding procedures are required for all important joints in hulls and structures which are to be classed with Det Norske Veritas. The procedure tests are to be representative of the following:

- each base material/alloy and temper used in production
- the thickness and diameter range in question (see Tables B2 and B3)
- each type of consumable and welding process
- welding position (see Table C1)
- joint/groove design
- number of passes
- preheat (if any)
- volt-ampere characteristics
- shielding gas.

### Table C1 Qualified principal positions for butt welds and fillet welds

<table>
<thead>
<tr>
<th>Test weld Joint configuration</th>
<th>Principal positions</th>
<th>Qualified positions 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fillet welds</td>
<td>1F, 2F, 3F, 4F, 5F</td>
<td>1F, 1F, 1F, 1F, 1F, 2F, 3F, 3F, 3F, 3F, 3F, 4F, 4F, 4F, 5F, 5F, 5F</td>
</tr>
</tbody>
</table>

1) The vertical downwards position is to be qualified separately.

### C 200 WPQT for butt welds

201 Each test assembly consists of 2 plates with dimensions 300 x 150 mm. The plates are to be joined with a longitudinal butt weld. For extruded sections and pipes the assembly is to consist of 2 sections each 150 mm long (see Figs. 13 and 14).

202 The welding is to be carried out in accordance with the procedure to be used during production. Welding consumables are those recommended in Table C2.

203 The joint configurations are to comply with those intended to be applied for the production welding.
Table C2 Selection of suitable consumables for combinations of aluminium alloys

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NV-5052, NV-5754</td>
<td>5356, 5556, 5183</td>
<td>5356, 5556, 5183</td>
<td>5356, 5556, 5183</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NV-5154, NV-5454</td>
<td>5356, 5556, 5183</td>
<td>5356, 5556, 5183</td>
<td>5356, 5556, 5183</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NV-5086</td>
<td>5356, 5556, 5183</td>
<td>5356, 5556, 5183</td>
<td>5356, 5556, 5183</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
All consumables here are covered by the AWS specification. The prefix «ER» is omitted.

1) Other consumables may be used if allowable stresses are reduced, see Table C4.

Fig. 13
Location of test specimens for a butt weld on plate

207 For thickness below 10 mm one face bend and one root bend test specimens are to be taken. The width is to be 30 mm and the thickness equal to the plate thickness. The diameter of the bending mandrel is to be as given in Table C3.

Table C3 Former diameter for bend tests

<table>
<thead>
<tr>
<th>Base metal alloy</th>
<th>Condition</th>
<th>0, H111</th>
<th>H116, H32</th>
<th>H321, H34</th>
<th>T4</th>
<th>T5, T6</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV-5052, NV-5754</td>
<td></td>
<td>4t</td>
<td>4t</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NV-5154, NV-5454</td>
<td></td>
<td>4t</td>
<td>4t</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NV-5086, NV-5083, NV-5383</td>
<td></td>
<td>6t</td>
<td>6t</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>NV-6060, NV-6061, NV-6005A, NV-6082</td>
<td></td>
<td>-</td>
<td>-</td>
<td>6t</td>
<td>7t</td>
<td>-</td>
</tr>
</tbody>
</table>

208 Requirement:
No cracks or open defects exceeding 3 mm measured on the convex surface after bending are accepted. Smaller cracks developing from the edges of the specimens are not normally considered as significant, unless there is definite evidence that they result from inclusions or other defects.

«Wrap around» bending as shown in Fig. 15 is the preferred bending method.

209 One tensile specimen is to be taken from each of the welded assemblies. The test specimen, 25 mm wide and with full plate thickness and orientated transverse to the weld, is shown in Fig. 16.
The tensile strength of the test specimens is not to be less than specified for the parent alloy in Table C4.

One macrosection is to be prepared from the test assembly to reveal the weldment macrostructure. The macrosection is to be visually inspected using a magnification of 5 to 10X. The macrosection is to show a regular weld profile with a smooth transition to the base material without significant undercut or excessive reinforcement and show thorough fusion between adjacent layers of weld metal and base metal. There are to be no cracks, lack of fusion and incomplete penetration.

WPQT for fillet welds

The two plates are assembled and positioned edgewise so as to constitute a tee-assembly with no clearance. As far as possible the plates are to be of a sufficient size to ensure a reasonable heat distribution.

For fillet welds the test assembly is to be as defined in Fig. 9. For manual and semi-automatic welding the length of the test piece is to be:

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

For automatic welding the length is to be:

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

Weld and fit-up are to be as detailed in the WPS.

The test assembly is to be welded on one side only. For manual and semi-automatic welding, the stop/restart position is normally to be included in the test length and is to be clearly marked for subsequent examination.

The ends of the specimen are exempted from examination over a length of 50 mm.

NDT is to be carried out in accordance with the specification given for the production welding in question. The extent of the testing is to be as follows:

- 100% visual inspection
- 100% surface crack detection (dye penetrant).

The soundness of the weld is to comply with ISO 10042.2 level B.

If the stop/restart spot is included in the test length, special attention is to be paid to this position with respect to profile, proper fusion and absence of crater defects.

The following tests are to be performed:

2 macrosection tests (metallographic examination).

One of the macrosections is to be taken at the marked position of the stop/restart (for more details see B307).

Retesting

If any of the tests do not satisfy the specified requirements, new procedure tests in duplicate may be carried out. The results of both retests are to meet the specified requirements, otherwise the test is to be rejected.

HAZ softening adjacent to welds

The strength of a weldment is a function of the welding process, filler metal and the aluminium alloy in question. For design purposes it is assumed that around each weld there is a zone, the HAZ, in which the strength is reduced. The extent of the HAZ is assumed to have the same width as the weldment plus the plate thickness in each direction of the weld as shown in Fig. 17.

If the yield strength is to be measured for information this is to be carried out on a gauge length \( 2t + W \) of the weld (approximately 3t).
## D. Welding procedures, Ferritic-Austenitic Stainless Steel (Duplex)

### D 100 General

101 Welding shops which intend to build welded cargo tanks, parts of hull structure, process pressure vessels or piping systems in Ferritic-Austenitic stainless steels are to carry out WPQT for all types of butt welds and essential fillet welds in the construction. See Ch.3 Sec.1.

102 The WPQT’s are to cover all relevant dimensions, positions and material combinations. Details regarding essential variables, validity of the procedure and mechanical testing are to be as described in B with additional requirements as listed in 200.

### D 200 Additional testing

201 Butt welds and fillet welds are to be corrosion tested according to ASTM G48-76 Method A. The test specimen is to be in the as welded state after normal weld cleaning operation. The test specimens are to be exposed to the solution at a constant temperature of 20°C for 24 hours.

Test requirements:
- no pitting attack is to be visible on the test face(s)
- general weight loss is not to exceed 20 mg.

**Guidance note:**

Welds between Ferritic-Austenitic steels and other grades of stainless or C/Mn steels may not need to be corrosion tested.

D 201

Impact testing as described in B300.

Impact test temperature -20°C. The average value for absorbed energy is not to be less than 27 J.

203 Microstructural examination

The test samples are to comprise the weld metal, heat affected zone and base metal. The microstructure is to be suitably etched and examined at 400X magnification and is to be free from grain boundary carbides and precipitates.

The ferrite content in the weld metal root and unheated weld cap is to be determined in accordance with ASTM E 562 and be in the range of 25–70%.

### D 300 Validity of a qualified welding procedure

301 Reference is made to B900 and any change in the following additional essential variables which are to lead to a new qualification:

- variation in the heat input greater than ±15%.

### E. Approval of Welders

#### E 100 General

101 These requirements apply to the Society's approval of welders for fusion welding of steel and non-ferrous metals. The welding processes for which qualifications are required include those which are designated as manual or partly mechanized welding. Welders are to pass an approval testing in accordance with 200. Yards and workshops are required to keep records of the welders' qualifications and, when required, furnish copies of valid welders' certificates.

102 Welding operators using fully mechanized or fully automatic processes need generally not pass an approval testing. However, operators are to receive adequate training in setting or programming and operating the equipment. Appropriate records of training are to be maintained. Yards and workshops may be required to furnish valid approval test certificates.

#### E 200 Standards for approval testing

201 Welders are to be tested to a standard recognised by the Society, e.g. EN 287, ISO 9606, ASME Section IX, ANSI/ AWS D1.1.

202 Recognition of other standards is subject to submittal to the Society for evaluation.

---

**Table C4 Mechanical properties in the welded condition**

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Temper</th>
<th>Filler</th>
<th>Tensile strength $R_{p0.2}$ minimum (N/mm²)</th>
<th>Yield strength $R_{p0.2}$ minimum (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV-5052</td>
<td>0.F, H111, H32, H34</td>
<td>5356</td>
<td>170</td>
<td>65</td>
</tr>
<tr>
<td>NV-5754</td>
<td>0.F, H111, H24</td>
<td>5356-5183</td>
<td>190</td>
<td>80</td>
</tr>
<tr>
<td>NV-5154A</td>
<td>0, H111</td>
<td>5356-5183</td>
<td>215</td>
<td>85</td>
</tr>
<tr>
<td>NV-5454</td>
<td>0.F, H111, H34,</td>
<td>5356-5183</td>
<td>215</td>
<td>85</td>
</tr>
<tr>
<td>NV-5086</td>
<td>0.F, H111, H116, H32, H34</td>
<td>5356-5183</td>
<td>240</td>
<td>100</td>
</tr>
<tr>
<td>NV-5083</td>
<td>0. F $t &lt; 6$ mm, 0, F $t &gt; 6$mm, H116, H321, H116, H321</td>
<td>5183</td>
<td>270, 125</td>
<td>115</td>
</tr>
<tr>
<td>NV-5383</td>
<td>0, H111, H116, H321</td>
<td>5183</td>
<td>270, 115</td>
<td>115</td>
</tr>
<tr>
<td>NV-6060</td>
<td>T5</td>
<td>5356-5183</td>
<td>270, 125</td>
<td>115</td>
</tr>
<tr>
<td>NV-6061</td>
<td>T4</td>
<td>5356-5183</td>
<td>270, 115</td>
<td>115</td>
</tr>
<tr>
<td>NV-6063</td>
<td>T5 or T6</td>
<td>5356-5183</td>
<td>100, 65</td>
<td>65</td>
</tr>
<tr>
<td>NV-6005A</td>
<td>T5 or T6</td>
<td>5356-5183</td>
<td>100, 65</td>
<td>65</td>
</tr>
<tr>
<td>NV-6082</td>
<td>T4</td>
<td>5356-5183</td>
<td>170, 110</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>T5 or T6</td>
<td>5356-5183</td>
<td>170, 110</td>
<td>115</td>
</tr>
</tbody>
</table>
E 300 Certification

301 Welding and testing of weld assemblies are to be performed in the presence of the surveyor. Upon successful completion, the Society will certify that the welder has passed the approval testing.

302 Where certification is performed by other IACS members or independent organisations, e.g. accredited or nationally approved certification bodies, recognition of such certification will be evaluated on a case by case basis. The Society reserves the right, however, to require verification of welders' qualifications when deemed necessary. Such verification may include testing prior to production, extra NDT and/or welding production tests.
SECTION 3
TYPE APPROVAL OF WELDING CONSUMABLES

A. General

A 100 Scope

101 This Section specifies the requirements to be complied with for obtaining 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 and aluminium alloys. This section covers IACS UR W23.

A 200 Approval procedure

201 The surveyor is to be satisfied that the manufacturer's plant, methods of production and quality control of welding consumables are to be such as to ensure a reasonable uniformity in manufacture.

202 All test assemblies are to be prepared under the supervision of the surveyor, and all tests are to be carried out in his presence.

203 When welding consumables are manufactured in several factories of the same company, the complete series of approval tests are to be carried out in one of the works only. In the other factories, a reduced test programme, at least equivalent to annual tests included hydrogen testing for low hydrogen type consumables is permitted if the manufacturer can verify that the materials used and the fabrication process are identical with those used in the main works. This requirement is applicable to all manufacturers of filler products under licence (sister firms). However, should there be any doubt, complete test series may be required.

204 All welding consumables approved are to be subjected to an annual re-testing. On these occasions, samples of the approved consumables are to be selected by the surveyor and subjected to the tests detailed in subsequent sections of these Rules.

Use of a manufacturer's quality assurance system as an alternative to annual testing procedure may be accepted after agreement with the Society.

A 300 Approval testing

301 All weld tests may be performed by the manufacturer or anyone appointed by him.

302 The welding conditions used such as amperage, voltage, travel speed, etc. are to 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. is to be used for the preparation of the test assemblies.

303 The tests prescribed are to be carried out for each type of welding consumable for which approval is required.

304 The Society may request, in a particular case, additional tests or requirements as may be considered necessary.

A 400 Changes

401 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.

402 Upgrading 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.

A 500 Basic groups and grades

501 Welding consumables are divided into groups, depending on the strength of the filler metal and further divided into grades depending on the impact test temperature and the chemical composition of the filler metal.

The grades of welding consumables given in Table A1 are specified in this Section.

502 Welding consumables which have satisfied the requirements for a higher toughness grade, are also considered as complying with the requirements for a lower toughness grade of the same group.

### Table A1 Grades of welding consumables

<table>
<thead>
<tr>
<th>Grade of welding consumables</th>
<th>Normal strength steels</th>
<th>High strength steels</th>
<th>Extra high strength steels</th>
<th>Austenitic stainless steels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 Y</td>
<td>3/4/5 Y42</td>
<td></td>
<td>308/308Mo/308L</td>
</tr>
<tr>
<td>2</td>
<td>3 Y</td>
<td>3/4/5 Y46</td>
<td></td>
<td>309/309L/309Nb/309Mo</td>
</tr>
<tr>
<td>3</td>
<td>4 Y</td>
<td>3/4/5 Y50</td>
<td></td>
<td>310/310Nb/310Mo</td>
</tr>
<tr>
<td>4</td>
<td>5 Y</td>
<td>312</td>
<td></td>
<td>316/316 L</td>
</tr>
<tr>
<td>V</td>
<td>2/3/4 Y40</td>
<td>3/4/5 Y55</td>
<td></td>
<td>317/317 L</td>
</tr>
<tr>
<td>III</td>
<td>I Y</td>
<td>3/4/5 Y62</td>
<td></td>
<td>318</td>
</tr>
<tr>
<td>IV</td>
<td>II Y</td>
<td>3/4/5 Y69</td>
<td></td>
<td>330</td>
</tr>
<tr>
<td>V</td>
<td>III Y</td>
<td></td>
<td></td>
<td>347</td>
</tr>
<tr>
<td>V</td>
<td>IV Y</td>
<td></td>
<td></td>
<td>349</td>
</tr>
</tbody>
</table>

A 600 Testing procedure

601 The test welds are normally to be made on the material for which approval of the welding consumable is desired. Any grade of structural steel may, however, be used for the preparation of the all-weld-metal test assemblies.

602 The test specimens are to be made under controlled conditions, on metal deposited from the filler metal in question.

603 After being welded, the test assemblies are not to be subjected to any heat treatment.

604 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.

A 700 Test specimens

701 The test specimens referred to in this Section is de-
scribed in Ch. 1 Sec. 2 and Ch. 3 Sec. 1.

**Tensile tests:**

Round tensile test specimens are to be machined to the dimensions shown in Sec. 1 B201, type A, care being taken that the longitudinal axis coincides with the intersection between the midplane of the weld, and the midplane of the plates. Flat specimens of the form given in Sec. 1 B201, type C are to be prepared. The upper and lower surfaces of the weld are to 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.

**Charpy V-notch impact tests:**

Standard Charpy V-notch test specimens are to be prepared as shown in Ch. 1 Sec. 2. The test temperature for specimens tested at 0, –20, –40 and –60°C are to be controlled and kept within ±2°C of the prescribed temperature.

The test specimens are to 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 are to be cut at mid thickness of the weld
- for two-run welded test assemblies the specimens are to be cut on the 2nd run side, 2 mm below the surface
- for electroslag or electrogas welded test assemblies all specimens are to be cut 2 mm below the surface
- for one-side automatic welding processes, the test specimens are to be cut 2 mm below the face side and 2 mm below the root side of the test assembly.

The average absorbed energy value is to 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.

**Bend test:**

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

The test specimens are to be capable of withstanding bending through an angle of 120° over a former having a diameter three times the thickness of the specimen.

**A 800 Hydrogen test**

801 Low hydrogen consumables are to be subjected to a hydrogen test. The test is to be carried out in accordance with the mercury method specified in ISO 3690-1977, or any method such as the gas chromatic which correlates with that method. The glycerine method may be admitted at the discretion of the manufacturer. This method is described below.

Prior to welding, the consumables may undergo a normal drying process recommended by the manufacturer.

802 Four test specimens are to be prepared measuring 12 x 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 are to 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 is to be deposited by a 4 mm diameter electrode, using about 150 mm of the electrode. The welding is to be carried out with an arc as short as possible and with a current of approximately 150 A. All four test specimens are to 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 is to be used. For each test specimen, a new electrode is to be used.

Within 30 seconds of the completion of the welding of each specimen, the specimen is to be removed and the specimen quenched in water at approximately 20°C.

After 30 seconds in the water, the specimen is to be cleaned and dried and then placed in an apparatus suitable for the collection of hydrogen by displacement of glycerine. The last step is to be completed within 2 minutes after breaking the arc. The glycerine is to be kept at a temperature of 45°C during the test. All specimens are to be welded and treated identically.

The specimens are to be kept immersed in the glycerine for a period of 48 hours and, after removal, are to be cleaned in water and alcohol, dried and weighed to the nearest 0,1 gram to determine the amount of weld deposit.

803 The amount of gas given off is to be measured to the nearest 0,05 cm³ and corrected for temperature and pressure to 20°C and 760 mm Hg.

**A 900 Re-testing**

901 Tensile and bend tests:

Where the result of a tensile or bend test does not comply with the requirements, duplicate test specimens of the same type are to be prepared and satisfactorily tested. Where insufficient original welded assembly is available, a new assembly is to be prepared using welding consumables from the same batch. If the new assembly is made with the same procedure as the original assembly, only the duplicate re-test specimens needs to be prepared and tested. Otherwise, all test specimens should be prepared as for re-testing.

902 Charpy V-notch impact tests:

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 result is below 70% of the specified average value, the tests may be accepted.

**B. Covered Electrodes for Shielded Metal Arc Welding of Normal and High Strength Steels**

**B 100 General**

101 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/mm²: 2 Y, 3 Y, 4 Y and 5 Y
- for high strength steels with minimum yield strength up to 390 N/mm²: 2 Y40, 3 Y40 and 4 Y40

Approval will be considered subject to compliance with the specified tests and requirements in 200 and 300.

102 Electrodes complying with the requirements stipulated in 400 will be given the suffix H15, H10 or H5 added to the grade mark. Electrodes for high strength steels are to be hydrogen tested and are to satisfy the requirements for at least the suffix H15.

**B 200 All-weld-metal test**

201 Preparation of test assemblies:
Two all-weld-metal test assemblies are to be welded in the downhand position as shown in Fig. 1, one using 4 mm diameter electrodes and the other using the largest size manufactured. If an electrode is available in one diameter only, one test assembly is sufficient.

The weld metal is to 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 is to be left in still air until it has cooled below 250°C, the temperature being checked in the middle of the weld bead.

202 Test specimens:
One longitudinal tensile and three impact test specimens are to be taken from each test assembly as shown in Fig. 1.

203 Test requirements:
The test results are all to comply with the requirements given in Table B1.

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

---

**Table B1**

<table>
<thead>
<tr>
<th>Grade</th>
<th>$R_m$ N/mm²</th>
<th>$R_{-10}$ minimum, N/mm²</th>
<th>$A_5$ minimum, %</th>
<th>$Z$ %</th>
<th>Temperature °C</th>
<th>$KV, J$ minimum average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>400 - 560</td>
<td>305</td>
<td></td>
<td></td>
<td>20</td>
<td>47</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-20</td>
<td></td>
</tr>
<tr>
<td>2 Y</td>
<td>490 - 660</td>
<td>375</td>
<td>22</td>
<td>1)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3 Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-20</td>
<td></td>
</tr>
<tr>
<td>4 Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-40</td>
<td></td>
</tr>
<tr>
<td>5 Y</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-60</td>
<td></td>
</tr>
<tr>
<td>2 Y40</td>
<td>510 - 690</td>
<td>400</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3 Y40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-20</td>
<td></td>
</tr>
<tr>
<td>4 Y40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-40</td>
<td></td>
</tr>
</tbody>
</table>

1) Reduction of area to be reported for information.

---

**B 301 Butt-weld test**

301 Preparation of test assemblies:
Butt-weld test assemblies as shown in Fig. 2 are to 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 is to be prepared in this position.

302 Welding procedure for test assemblies:
The following welding procedure is to be applied when making the test assemblies:

**Downhand welding:**
First run with 4 mm diameter electrode. Remaining runs (except last two layers) with 5 mm diameter electrode or greater according to the normal welding practice with the electrode. The runs with the last two layers with the largest diameter of electrode manufactured.

Where a second downhand test is required, the following procedure is to be adapted:

---

**Fig. 1**
All-weld-metal test

---

DETO NORSKE VERITAS
One transverse tensile, two bend tests (face and root bend) and three impact test specimens are to be taken from each test assembly as shown in Fig. 2.

The test specimens are to be prepared according to A700.

Test requirements:
The test results are all to comply with the requirements given in Table B2. The position of fracture in the transverse tensile test specimen is to 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.

---

**Fig. 2**
Butt weld test assembly

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test $R_m$, minimum N/mm²</th>
<th>Temperature, °C</th>
<th>Impact test - KV, J, minimum average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>400</td>
<td>20</td>
<td>Downhand, horizontal-vertical and overhead</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>- 20</td>
<td></td>
</tr>
<tr>
<td>2 Y</td>
<td>490</td>
<td>0</td>
<td>Vertical (upward and downward)</td>
</tr>
<tr>
<td>3 Y</td>
<td></td>
<td>- 20</td>
<td>47</td>
</tr>
<tr>
<td>4 Y</td>
<td></td>
<td>- 60</td>
<td></td>
</tr>
<tr>
<td>5 Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Y40</td>
<td>510</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>3 Y40</td>
<td></td>
<td>- 20</td>
<td></td>
</tr>
<tr>
<td>4 Y40</td>
<td></td>
<td>- 40</td>
<td></td>
</tr>
</tbody>
</table>

**Table B3**

<table>
<thead>
<tr>
<th>Mark</th>
<th>Mercury method (ISO 3690-1977)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H15</td>
<td>15</td>
</tr>
<tr>
<td>H10</td>
<td>10</td>
</tr>
<tr>
<td>H5</td>
<td>5</td>
</tr>
</tbody>
</table>

1) 10 when Glycerine method is used.
2) 5 when Glycerine method is used.
3) Glycerine method is not allowed.
Preparation of fillet weld test assemblies:
Test assemblies as shown in Fig. 3 are to be prepared for each welding position (horizontal-vertical, vertical upwards, vertical downwards or overhead) for which the electrode is recommended by the manufacturer.

The first side is to be welded using the maximum size of electrode manufactured and the second side is to be welded using the minimum size of electrode manufactured and recommended for fillet welding. The length of the test assemblies L is to 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 electrode size and the welding current employed during testing.

Hardness testing/requirements:
Each test assembly is to be sectioned to form three macro-sections, each about 25 mm thick, as shown in Fig. 3.

Hardness readings are to be made in each section as indicated in Fig. 4. The hardness of the weld is to be determined and is to meet the requirements in Table B4.

The hardness of both heat affected zone (HAZ) and base metal is also to be determined and is to be reported for information.

<table>
<thead>
<tr>
<th>Table B4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method</strong></td>
</tr>
<tr>
<td>Vickers (50 or 100 N load)</td>
</tr>
<tr>
<td>Rockwell B (1000 N load)</td>
</tr>
</tbody>
</table>

Breaking test/requirements:
One of the remaining sections of the fillet weld is to 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 is to be gouged or machined and the section fractured using the same procedure. The fractured surfaces are to be examined and there is to be no evidence of incomplete penetration or internal cracking and they are to be reasonably free from porosity.

**B 600 Covered electrodes for gravity or contact welding**

**601** 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 500) and, where appropriate, butt weld tests similar to those for normal manual electrodes are to 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, are to be carried out in addition to the normal approval tests.

Preparation of test assembly:
The fillet welding is to 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 is to be reported for each electrode size.

**B 700 Deep penetration electrodes**

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

**702** 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 are to be carried out.

**703** When a manufacturer states that an electrode having deep penetrating properties, also can be used for downhand butt welding of thicker plates with bevelled edges, the electrode will be tested as a normal penetration electrode and the full series of tests in the downhand position are to be carried out, together with the deep penetration tests given below.

**704** When an electrode is recommended for deep penetration welding of but joint and horizontal-vertical fillets only, the tests given below are required.

Preparation of butt weld test assemblies:
Two plates of thickness equal to twice the diameter of the core of the electrode plus 2 mm are to be butt welded, with one downhand run of welding from each side, see Fig. 5. The joint edges are to be prepared square and smooth. The gap is not to exceed 0,25 mm after the tack welding. The test assembly is to be welded with an 8 mm diameter electrode or the largest size manufactured if this is less than 8 mm.

Butt weld test specimens:
Two transverse tensile, two bend (one face and one root bend) and three impact test specimens are to be taken from each test assembly as shown in Fig. 5. The test specimens are to be prepared according to A700.
Butt weld test requirements:
The transverse tensile strength is not to 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 is not to be less than 47 J at +20°C.

Preparation of fillet weld test assemblies:
A fillet weld test assembly is to be prepared as shown in Fig. 6. The welding is to 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 is to be 160 mm and the gap between the plates is not to exceed 0.25mm.

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

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

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

---

Fig. 5
Deep penetration butt weld tests

Butt weld test requirements:
The transverse tensile strength is not to 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 is not to be less than 47 J at +20°C.

Preparation of fillet weld test assemblies:
A fillet weld test assembly is to be prepared as shown in Fig. 6. The welding is to 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 is to be 160 mm and the gap between the plates is not to exceed 0.25mm.

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

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

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

---

Fig. 6
Deep penetration fillet weld test

B 800 Annual tests
801 Covered electrodes for normal and fillet welding are to be tested as follows:

Two all-weld metal test assemblies are to be prepared in accordance with 200. The extent of testing and mechanical requirements are to be as given in 200.

These requirements also applies to electrodes which are approved for fillet welding only.

802 Covered electrodes for gravity or contact welding are to be tested as follows:

One deposited metal test assembly using the gravity or other contact device as recommended by the manufacturer is to be prepared. If this electrode is approved also for normal manual arc welding, the annual test is to be performed according to 801.

803 Covered electrodes for deep penetration are to be tested as follows:

Two plates are to be prepared as given in 700. One transverse tensile test specimen, two bend (one face and one root) test and three impact test specimens are to be prepared. At each cut in the test assembly, the joints are to be examined to ensure that complete fusion has taken place.

804 For those electrodes which are approved for both normal penetration welding and for deep penetration welding in the downhand position, deep penetration weld tests are to be carried out in addition to the deposited 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 is to be carried out in accordance with A900.

B 900 Upgrading
901 An approved electrode may be granted a higher grade than that initially granted, provided that impact testing is carried out with satisfactory results at the temperature specified for the higher grade. However, for upgrading from grade 1 to grade 3, or from any grade to grade 2, 3, 4, 5 Y H15/Y H10/Y H5 and 2, 3, 4 Y40 H15/Y H10/Y H5, impact tests are to be carried out on specimens taken from butt weld test assemblies (downhand, horizontal-vertical, vertical or overhead as applicable), in addition to the normal requirements for annual testing. Upgrading of electrodes from grade H15 to grade H10 or H5 may also be considered, provided that hydrogen tests are carried out in accordance with 400. Welding consumables which have not previously been subjected to a hydrogen test, are to be tested according to 400 when upgrading to the grades 2, 3, 4, 5 Y H15/Y H10/Y H5 and 2, 3, 4 Y40 H15/H10/H5 is applied for.
C. Wire/Flux Combinations for Submerged Arc Welding

**C 100 General**

101 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/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 and IV Y40

Approval will be considered subject to compliance with the specified tests and requirements in 200 and 300.

102 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 are to be carried out.

C 200 Multi-run technique

201 Where approval for use with multi-run technique is requested, all-weld-metal and butt-weld tests are to be carried out as specified in 202 and 203.

202 All-weld-metal tests are to be performed as follows:

Preparation of test assembly:
One all-weld-metal test assembly is to be welded in the down-hand position as shown in Fig. 7.

The direction of deposition of each run is to alternate from each end of the plate. After completion of each run, the flux and welding slag is to be removed. Between each run, the assembly is to 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 is not to be less than the diameter of the wire, nor less than 4 mm.

Test specimens:
Two longitudinal tensile and three impact test specimens are to be taken from the test assembly as shown in Fig. 7.

The test results are to comply with the requirements given in Table C1.

### Table C1

<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>$R_{eH}$, minimum, 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>

1) Reduction of area to be reported for information.
Chemical analysis:
The chemical analysis of the deposited weld metal is to be supplied by the manufacturer and is to include the content of all significant alloying elements.

203 Butt weld tests are to be performed as follows:

Preparation of test assemblies:
One butt weld test assembly is to be welded in the downhand position as shown in Fig. 8.

The welding is to be carried out by the multi-run technique and the welding conditions are to be the same as those adopted for the deposited metal test assembly.

The back sealing run is to 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 are to be taken from the test assembly as shown in Fig. 8.

The test specimens are to be prepared according to A700.

Test requirements:
The test results are all to comply with the requirements given in Table C2. The position of fracture in the transverse tensile test is to 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>
<thead>
<tr>
<th>Grade</th>
<th>$R_m$ minimum, N/mm²</th>
<th>Temperature °C</th>
<th>KV, J, minimum average</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>400</td>
<td>20</td>
<td>34</td>
</tr>
<tr>
<td>II</td>
<td>490</td>
<td>-20</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>510</td>
<td>-20</td>
<td>41</td>
</tr>
</tbody>
</table>

C 300 Two-run technique

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

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

Preparation of test assemblies:
Two butt-weld test assemblies are to be prepared, using the following thicknesses:

- for grades I and IY 12—15 mm and 20—25 mm
- for grades II to IVY 20—25 mm and 30—35 mm.
- for grades IVY40 to IVY40 20—25 mm and 30—35 mm.

The maximum diameter of wire, grades of steel plate and edge preparation to be used are to be in accordance with that shown in Fig. 10. 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 is to 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 are to be removed and the assembly is to 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 are to be taken from each test assembly as shown in Fig. 9.

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 Fig. 9.

This tensile test specimen is to 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 are to be machined from each welded assembly from the positions and with the orientations shown in Fig. 11. The test specimens are to be prepared according to A700.

Test requirements:
The test results are all to comply with the requirements given in Table C1 for the longitudinal tensile test specimens and Table C2 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.

C.400 Annual tests

401 Wire/flux combinations approved are to be subjected to at least the following 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.

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

C.500 Upgrading

501 An approved wire/flux combination may be granted a higher grade than that initially granted, provided that impact testing is carried out with satisfactory results at the temperature specified for the higher grade. However, for upgrading from grade I(T/M) to grade III(T/M) or from any grade to grade II(Y(T/M) to VY(T/M) and II(Y40(T/M) to IV Y40(T/M), impact tests are to be carried out on specimens taken from butt weld test assemblies in addition to the normal requirements for
annual testing.

<table>
<thead>
<tr>
<th>Plate thickness (mm)</th>
<th>Typical edge preparation</th>
<th>Maximum diameter of wire/flux combination (mm)</th>
<th>Grade of steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-15</td>
<td></td>
<td>5</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IY A-32, A-36 1)</td>
</tr>
<tr>
<td>20-25</td>
<td><img src="image1" alt="Diagram" /></td>
<td>6</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td><img src="image2" alt="Diagram" /></td>
<td></td>
<td>III B, D or E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IY A-32, A-36, A-40 1)</td>
</tr>
<tr>
<td>30-35</td>
<td><img src="image3" alt="Diagram" /></td>
<td>7</td>
<td>IIIY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IVY Any grade of HT steel 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>II B, D or E</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>III B, D or E</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 490 N/mm², and the chemical composition, including the refining element, should be reported for information.

Fig. 10
Two-run weld, butt weld test, root gap 0 — 0.7mm.

Fig. 11
Two-run weld. Impact tests

D. Combinations for Use in One-side Automatic Welding Processes

D 100 General

101 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 and IV Y40.

Approval will be considered subject to compliance with the specified tests and requirements in 200 and 300.

102 Separate tests are specified for:

- one-run welding
- multi-run welding (including two-run welding).

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

103 The welding conditions are to be the same as those indicated for wire/flux combinations in C, with the amendments and additions made in 200 to 800.

D 200 One-run welding

201 Preparation of test assemblies:

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

Test specimens:
The number of test specimens are to be as stipulated in 500 and as shown in Fig. 12.

Test requirements:
The test results are all to comply with the requirements given in Table D1.
Test specimens:
The number of test specimens are to be as stipulated in 500 and as shown in Fig. 12.

Test requirements:
The test results are all to comply with the requirements given in Table D1.

D 400  One-and multi-run welding

401 Preparation of test assemblies:
One test assembly with 15 to 25 mm plate thickness is to be welded by one-run welding technique and one is to be welded with 35 mm thickness by multi-run technique.

Test specimens:
The number of test specimens are to be as stipulated in 500 and as shown in Fig. 12.

Test requirements:
The test results are all to comply with the requirements given in Table D1.

D 500  Testing

501 Mechanical 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 are to be taken from each welded test assembly as shown in Fig. 12.

The test specimens are to be prepared according to A700.

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

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

D 600  Requirements

601 The test results are all to comply with the requirements given in Table D1. The position of fracture in the transverse tensile test specimens is to 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 D1

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transverse</td>
<td>Longitudinal</td>
</tr>
<tr>
<td></td>
<td>Rm, minimum,</td>
<td>Rex, minimum,</td>
</tr>
<tr>
<td></td>
<td>N/mm²</td>
<td>%</td>
</tr>
<tr>
<td>I</td>
<td>400</td>
<td>400 - 560</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>305</td>
</tr>
<tr>
<td>III</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>490</td>
<td>490 - 660</td>
</tr>
<tr>
<td>YI</td>
<td></td>
<td>375</td>
</tr>
<tr>
<td>IV 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>II Y40</td>
<td>510</td>
<td>510 - 690</td>
</tr>
<tr>
<td>III Y40</td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>IV Y40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

D 700  Annual tests

701 Combinations approved for one- or multi-run welding are to be tested as follows:

One test assembly with 12—25 mm plate thickness as shown in Fig. 12 is to be welded.

When a combination is approved for both one- and multi-run
welding, the test assembly is to be welded with the one-run technique.

702 One longitudinal and one transverse tensile test specimen, to bend (one face and one root bend) and six impact test specimens (three root and three face) are to be taken from the test assembly as shown in Fig. 12.

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

D 800 Upgrading

801 An approved combination may be granted a higher grade than that initially granted, provided that impact testing is carried out with satisfactory results at the temperature specified for the higher grade. However, for upgrading from grade I(T/M) to grade III(T/M) or from any grade to grade II Y(T/M) to IV Y(T/M) and II Y40(T/M) to IV Y40 (T/M), impact tests are to be carried out on specimens taken from butt weld test assemblies in addition to the normal requirements for annual testing.

E. Wires and Wire/Gas Combinations for Metal Arc Welding

E 100 General

101 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/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 and IV Y40.

Approval will be considered subject to compliance with the specified tests and requirements in 200 and 300.

102 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 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.

103 The test assemblies are to 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.

104 Where applicable, the composition of the shielding gas is to 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.

105 Flux cored or flux coated wires may, at manufacturer's option, be submitted to a hydrogen test as detailed in A800, 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 B400 will have the suffix (H15), (H10) or (H5) added to the grade mark.

E 200 Semi-automatic multi-run welding

201 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 are to be carried out as specified in 202 and 203.

202 All-weld-metal tests are to be performed as follows:

Preparation of test assembly:

Two all-weld-metal test assemblies are to be welded in the downhand position as shown in Fig. 1.

One test assembly is to 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 of the smallest size manufactured. Where wires are available in one diameter only, one test assembly is sufficient.

The weld metal is to be deposited according to the practice recommended by the manufacturer and the thickness of each layer of weld metal is to be in the range of 2 mm to 6 mm.

Test specimens:

One longitudinal tensile and three impact test specimens are to be taken from each test assembly as shown in Fig. 1.

The test specimens are to be prepared according to A700.

Test requirements:

The test results are all to comply with the requirements given in Table E1.

Table E1

<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, N/mm²</td>
</tr>
</tbody>
</table>

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

203 Butt-weld tests are to be performed as follows:
Preparation of test assembly:
Butt-weld test assemblies as shown in Fig. 2 are to be prepared for each welding position (downhand, horizontal-vertical, vertical and overhead) for which the wire is recommended.

One test assembly is to 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 for the remaining runs.

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

The other test assemblies are to be prepared in the vertical, horizontal-vertical and overhead positions using for the first run a wire of 1,2 mm diameter or of the smallest size manufactured and using 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 are to be taken from each test assembly as shown in Fig. 2.

The test specimens are to be prepared according to A700.

Test requirements:
The test results are all to comply with the requirements given in Table E2. The position of fracture in the transverse tensile test specimen is to 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.

Where approval for use with automatic multi-run welding is requested, all-weld-metal and butt-weld tests are to be carried out as specified in 301 and 302.

301 All-weld-metal tests are to be performed as follows:
Preparation of test assembly:
One all-weld-metal test assembly is to be welded in the downhand position as shown in Fig. 7.

The preparation of the assembly is to be as described in C201, 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 are to be taken from the test assembly as shown in Fig. 7.

The test specimens are to be prepared according to A700.

Test requirements:
The test results are all to comply with the requirements given in Table E3.
The chemical analysis of the deposited weld metal is to be supplied by the manufacturer and is to include all significant alloying elements.

**302 Butt-weld tests are to be performed as follows:**

**Preparation of test assembly:**
One butt-weld test assembly is to be welded in the downhand position as shown in Fig. 8.

The test assembly is to be prepared in accordance with that prescribed in C202.

**Test specimens:**
Two transverse tensile, four bend (two face and two root bend) and three impact test specimens are to be taken from the test assembly as shown in Fig. 8.

The test specimens are to be prepared according to A700.

**Test requirements:**
The test results are all to comply with the requirements given in Table E4. The position of fracture in the transverse tensile test specimen is to 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.

**Wires approved are to be subjected to at least the following tests:**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R_m$, minimum, N/mm²</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>490</td>
<td>20</td>
</tr>
<tr>
<td>IV Y</td>
<td>490</td>
<td>0</td>
</tr>
<tr>
<td>V Y</td>
<td></td>
<td>-40</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>
</tbody>
</table>

**Table E4**

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 are to be taken from each test assembly as shown in Fig. 9.

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 Fig. 9.

This tensile specimen is to 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 are to be machined from each weld assembly from the positions and with the orientations shown in Fig. 11.

The test specimens are to be prepared according to A700.

**Test requirements:**
The test results are all to comply with the requirements given in Table E3 for the longitudinal tensile test specimens and Table E4 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.

**E 500 Annual tests**

**501 Wires approved are to be subjected to at least the following tests:**

Semi-automatic welding only:
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 is also to 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.

502 The test assemblies and specimens are to 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 is to be according to the initial testing procedure.

503 The test results are to comply with the requirements for the initial approval tests.

E 600 Upgrading

601 An approved wire may be granted a higher grade than that initially granted, provided that impact testing is carried out with satisfactory results at the temperature specified for the higher grade. However, for upgrading from grade I(T/M) to grade III(T/M) or from any grade to grade II Y(T/M) to V Y(T/M) and II Y40(T/M) to IV Y40(T/M), impact tests are to be carried out on specimens taken from butt weld test assemblies in addition to the normal requirements for annual testing.

F. Combinations for Use in Electro-slag and Electro-gas Welding Processes

F 100 General

101 Consumables intended for these welding processes will be divided into the following grades:
— for normal strength steels: I and II
— for high strength steels with minimum yield strength up to 355 N/mm²: I Y, II Y
— for high strength steels with minimum yield strength up to 390 N/mm²: II Y40.

Approval will be considered subject to compliance with the specified tests and requirements in 200.

F 200 Initial tests

201 The following information is to 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.

Preparation of test assemblies:
Two test assemblies, one assembly with 20 mm plate thickness and one with 35 mm thickness, are to be made as shown in Fig. 14.

Test specimens:
Two longitudinal and two transverse tensile test specimens, 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 at the fusion boundary) test specimens are to be taken from each test assembly as shown in Fig. 14.

![Fig. 14 Electro-slag and electro-gas welding test assembly and location of specimens](image)

Test requirements:
The test results are all to comply with the requirements given in Table F1.

| Table F1 |
|----------|----------|----------|----------|
| Grade    | Tensile test | Impact test |
|          | $R_m$ N/mm² | $R_{-1}$ N/mm² | $A_5$, minimum, % | Temperature $\theta$, $K_V$ minimum average |
| I        | 400 - 560   | 305       | 22       | 20 |
| II       | 400 - 560   | 305       | 22       | 0 |
| I Y      | 490 - 660   | 375       | 22       | 20 |
| II Y     | 490 - 660   | 375       | 22       | 0 |
| II Y40   | 510 - 690   | 400       | 22       | 34 |

Chemical analysis:

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Chemical analysis of the deposited weld metal is to be supplied by the manufacturer and is to include the content of all significant alloying elements.

Photomacrographs:
Two photomacrographs, approximately 2X magnification, one transverse and one longitudinal with respect to the weld are to be taken. The latter section is to be parallel to the plate surface.

F 300 Annual tests
301 Combinations approved are to be subjected to at least the following tests:
One test assembly, using 20 mm plate thickness is to be prepared.
Two longitudinal, two bend and three impact test specimens are to be taken. The notch of the impact specimens is to be located in the centre of the weld.
One transverse photomacrograph is also to be taken from the test assembly.
302 The preparation of the test assemblies and the mechanical properties are to be in accordance with the requirements for the initial approval tests.

G. Welding Consumables for Welding of Steel Grades NV 2-4, NV 2-4L, NV 4-4 and NV 4-4L for Low-Temperature Applications

G 100 General
101 These welding consumables will be granted the following grades:
— for NV 2-4 and NV 2-4L: 5 (manual welding) and V (semi-automatic and automatic welding)
— for NV 4-4 and NV 4-4L: 5Y (manual welding) and VY (semi-automatic and automatic welding)

Approval will be considered subject to compliance with the specified tests and requirements in 200.
102 Covered electrodes are to 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.

103 Testing is to be carried out as specified in B (covered electrodes), C (wire/flux combinations) or E (wire/gas combinations) with the additional requirements specified in 200.

G 200 Additional requirements
201 The base metal to be used for the butt weld tests is to be the same as that for which the welding consumable is intended.
Impact tests:
The specimens are to be broken at —60°C. Both single values and average values are to be reported.
Welding consumables intended for NV 2-4 and NV 4-4 only, may be impact tested at —55°C.
Test requirements:
The butt-weld test results are all to comply with the requirements given in Table G1.
202 One additional butt-weld test is to be performed as follows:
Preparation of test assembly:
One butt-weld test is to be made in the downhand position. This test assembly is to be subjected to stress-relieving at 550 to 600°C prior to mechanical testing.
Test specimens:
One transverse tensile and three impact test specimens are to be taken from each test assembly.
Test requirements:
The test results are all to comply with the requirements given in Table G1.

Table G1

<table>
<thead>
<tr>
<th>Grade</th>
<th>Tensile test $R_m$ minimum, N/mm²</th>
<th>Impact test - KV, J</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temperature °C</td>
<td>$K_V, J$ average</td>
</tr>
<tr>
<td>5/N</td>
<td>-55</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>-60</td>
<td>34</td>
</tr>
<tr>
<td>5Y/NY</td>
<td>-55</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>-60</td>
<td>34</td>
</tr>
</tbody>
</table>

H. Welding Consumables for Low-Alloy, Heat-Resisting Steels (NV 0.3Mo, NV 1Cr 0.5Mo and NV 2.25Cr 1Mo)

H 100 General

101 The all-weld-metal and butt-weld tests are all to be carried out as specified in B (covered electrodes), C (wire/flux combinations) or E (wire/gas combinations) with the additional requirements specified in 200.
102 Covered electrodes are to 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.

H 200 Additional requirements

201 The base metal to be used for the butt-weld tests is to 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.
202 The all-weld-metal test is to be performed as follows:
Two longitudinal tensile test specimens are to be taken from each test assembly as shown in Fig. 15.
Pre- and post-heating:
The temperature ranges to be used for pre-heating, inter-pass temperature and annealing is shown in Table H1.
The finished test plates are to 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 is to be tested at room temperature (approximately 20°C), while the other is to be tested at 400 ± 5°C. The elevated test temperature is to be properly controlled (e.g. by thermocouples).

Test requirements:
The test results are all to comply with the requirements given in Table H2.

---

**Table H2**

<table>
<thead>
<tr>
<th>Consumables for welding steel grade</th>
<th>Test temperature °C</th>
<th>$R_m$, minimum, N/mm²</th>
<th>$R_{eH}/R_{p0.2}$, minimum, N/mm²</th>
<th>$A_5$, minimum, %</th>
<th>$Z$, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV 0.3Mo</td>
<td>20</td>
<td>440</td>
<td>305</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>NV 1Cr 0.5Mo</td>
<td>20</td>
<td>470</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NV 2.25Cr 1Mo</td>
<td>20</td>
<td>480</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) These values are to be reported for information.

---

**Table H3**

<table>
<thead>
<tr>
<th>Consumables for welding steel grade</th>
<th>$R_m$, minimum, N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV 0.3Mo</td>
<td>440</td>
</tr>
<tr>
<td>NV 1Cr 0.5Mo</td>
<td>470</td>
</tr>
<tr>
<td>NV 2.25Cr 1Mo</td>
<td>480</td>
</tr>
</tbody>
</table>

---

203 Butt-weld tests are to be performed as follows:

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

Test requirements:
The tensile test results are to comply with the requirements given in Table H3.

---

**H 300 Chemical composition**

301 The test specimen for chemical analysis of the deposited metal is to be made on a steel plate as shown in Fig. 16.

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

Test requirements:
The test results are to comply with the requirements given in Table H4.

H 400 Annual tests

401 Consumables approved are to be subjected to at least the following tests:

<table>
<thead>
<tr>
<th>Consumables for welding steel grade</th>
<th>C maximum %</th>
<th>Si maximum %</th>
<th>Mn %</th>
<th>Cr %</th>
<th>Mo %</th>
<th>P maximum %</th>
<th>S maximum %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV 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>0,04</td>
<td>0,03</td>
</tr>
<tr>
<td>NV 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></td>
<td></td>
</tr>
<tr>
<td>NV 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>

I. Welding Consumables for Welding of Steel Grades NV 1,5Ni, NV 3,5Ni, NV 5Ni and NV 9Ni

1 100 General

101 The all-weld-metal and butt-weld tests are all to be carried out as specified in B (covered electrodes), C (wire/flux combinations) or E (wire/gas combinations) with the additional requirements specified in 200.

102 Covered electrodes are to 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.

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

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

1 200 Additional requirements

201 The all-weld-metal tests are to be performed as follows:

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

Test requirements:
The longitudinal tensile and impact test results are to satisfy the requirements given in Table I1.

202 The butt-weld tests are to be performed as follows:

Bend tests:
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 are to be carried out.

The dimensions of the longitudinal bend specimens are to be as follows:

<table>
<thead>
<tr>
<th>Length</th>
<th>minimum 150 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>38 mm</td>
</tr>
<tr>
<td>Thickness</td>
<td>10 mm</td>
</tr>
</tbody>
</table>

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

Charpy V-notch impact tests:
At least three impact test specimens are to be machined from each test assembly.

Test requirements:
The test results are all to comply with the requirements given in Table I1. The position of fracture in the transverse tensile test specimen is to 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 40 mm, no cracks or defects can be seen on the outer surface of the test specimen. The reduction of area is to be reported for information.

I 300 Annual test

301 Depending on whether it concerns electrodes, wire/flux combination of wire/gas combinations, the testing is to be carried out according to that prescribed in B900, C400 or E600, respectively. The test results are, however, to comply with the requirements given in Table I1.
J 400 Other welding consumables

401 Welding consumables with yield stress and/or tensile strength less than that specified under 300, may be approved for welding of steel grade NV 9 Ni. Approval testing is to be carried out according to the programme specified above.

The maximum permissible stress in welded vessels is, however, in such cases to be based on the mechanical properties obtained from the approval tests.

J. Welding Consumables for Welding of Extra High Strength Steels

J 100 General

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

<table>
<thead>
<tr>
<th>Grade</th>
<th>Test Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/III</td>
<td>20°C</td>
</tr>
<tr>
<td>4/IV</td>
<td>40°C</td>
</tr>
<tr>
<td>5/V</td>
<td>60°C</td>
</tr>
</tbody>
</table>

The maximum permissible stress in welded vessels is, however, in such cases to be based on the mechanical properties obtained from the approval tests.

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>NV 420</td>
</tr>
<tr>
<td>Y46</td>
<td>NV 460</td>
</tr>
<tr>
<td>Y50</td>
<td>NV 500</td>
</tr>
<tr>
<td>Y55</td>
<td>NV 550</td>
</tr>
<tr>
<td>Y62</td>
<td>NV 620</td>
</tr>
<tr>
<td>Y69</td>
<td>NV 690</td>
</tr>
</tbody>
</table>

Each higher quality grade includes the one (or those) below. Grade A.. and D.. steels according to Pt. 2 Ch. 2 Sec. 1 are to be welded using welding consumables of at least quality grade 3/III, grade E.. steels using at least quality grade 4/IV and grade F.. 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>
</table>

Welding consumables approved with grades .Y42,...Y46 and .Y50 are also considered suitable for welding steels in the two strength levels below that for which they have been approved. Welding consumables approved with grades .Y55,.Y62 and .Y69 are also considered suitable for welding steels in the 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.

102 The all-weld-metal and butt-weld tests are all to be carried out as specified in B (covered electrodes), C (wire/flux combinations) or E (wire/gas combination) with the additional requirements specified in 200.

103 Covered electrodes in yield strength group Y50 and below are to satisfy the hydrogen test requirements for at least the suffix H10. Electrodes in yield strength group ranging from Y55 up to and including Y69 are to satisfy the hydrogen test requirements for the suffix H5.

104 The plate thickness for the butt-weld tests is normally to be 120° over a former having a diameter which relates to the thickness of the test specimen as shown in Table J2. The bend test specimens can be considered as complying with the requirements if, after bending, no crack or other open defect exceeding 3 mm in dimensions can be seen on the outer surface.

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

203 The following requirements are to be met:

The test results are all to comply with the requirements given in Table J2. The position of fracture in the transverse tensile test specimen is to be reported. The bend test specimens are to be bent through an angle of 120° over a former having a diameter which relates to the thickness of the test specimen as shown in Table J2. The bend test specimens can be considered as complying with the requirements if, after bending, no crack or other open defect exceeding 3 mm in dimensions can be seen on the outer surface.
The chemical analysis of the deposited weld metal in each test assembly is to be supplied by the manufacturer and is to include the content of all significant alloying elements.

**J 300 Annual tests**

### 301 Depending on whether it concerns electrodes, wire/flux combination or wire/gas combinations, the testing is to be carried out according to that prescribed in B800, C400 or E500, respectively. The test results are, however, to comply with the requirements given in Table J1.

### K. Welding Consumables for Welding of Austenitic Stainless Steels

#### K 100 General

101 Approval of welding consumables for austenitic stain-
less steels will be considered subject to compliance with the specified tests and requirements in 200 to 500.

### K 200 All-weld-metal test

#### 201 Preparation of test assemblies:

Two all-weld-metal test assemblies are to be prepared as shown in Fig. 17, one using a 2.4 – 3.25 mm Ø electrode and the other using the largest size manufactured.

For wire/gas combinations the wire size is to be 1.2 mm Ø and the largest size manufactured.

For flux cored wire combinations the wire size is to be 1.2 or 1.6 mm Ø and the largest size manufactured.
For wire/flux combinations the smallest and largest size manufactured are to be tested.

The weld metal is to be deposited in accordance with normal welding practice. The direction of deposition is to 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 is to 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 Fig. 17 are as follows:

— service temperature below —103°C; two longitudinal tensile and three impact test specimens are to be taken.
— service temperature above —103°C; two longitudinal tensile test specimens only are to be taken.

The test specimens are to be prepared according to A700.

Test requirements:
The test results are all to comply with the requirements given in Table K1. Welding consumables intended for low temperature service are to be impact tested at —196°C (or other temperatures below —103°C). The average impact value for the three specimens is not to be less than 34J.

K 300 Chemical composition
301 Chemical analysis is to be carried out for all dimensions of welding consumables manufactured. The analysis is to be carried out as stipulated in H300 and is to be reported for approval.
302 The chemical composition of the core wire is also to be reported.

Test requirements:
The chemical composition of the weld metal is to be in the range given in Table K2.

K 400 Possible additional tests
401 Normally, butt weld tests are not required. Butt weld tests may, however, be required if a welding consumable is to be approved for welding positions or materials for which it is not mainly intended.
402 The manufacturer is to inform about the welding position and materials for which the welding consumable is to be applied.

K 500 Annual tests
501 Annual testing for welding consumables which are not intended for low temperature service, comprises chemical analysis only. Welding consumables of two different dimensions are to be tested.
502 Annual testing for welding consumables which are intended for low temperature service at —103°C or lower, comprises impact testing at the respective temperature, in addition to chemical analysis. Welding consumables of two different dimensions are to be tested.

Test assemblies (all measures in mm)

Fig. 17
Table K1

<table>
<thead>
<tr>
<th>Electrode grade</th>
<th>Yield stress, $R_{p0.2}$ minimum, N/mm²</th>
<th>Tensile strength, $R_m$ minimum, N/mm²</th>
<th>Elongation, $A_5$ minimum, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV 308 Mo</td>
<td>290</td>
<td>550</td>
<td>25</td>
</tr>
<tr>
<td>NV 308</td>
<td>290</td>
<td>550</td>
<td>25</td>
</tr>
<tr>
<td>NV 308 L</td>
<td>270</td>
<td>520</td>
<td>25</td>
</tr>
<tr>
<td>NV 309</td>
<td>290</td>
<td>550</td>
<td>25</td>
</tr>
<tr>
<td>NV 309 L</td>
<td>270</td>
<td>520</td>
<td>25</td>
</tr>
<tr>
<td>NV 309 Nb</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>NV 309 Mo</td>
<td>290</td>
<td>550</td>
<td>25</td>
</tr>
<tr>
<td>NV 309 MoL</td>
<td>270</td>
<td>520</td>
<td>25</td>
</tr>
<tr>
<td>NV 310</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>NV 310 Nb</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>NV 310 Mo</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>NV 312</td>
<td>350</td>
<td>660</td>
<td>16</td>
</tr>
<tr>
<td>NV 316</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>NV 316 L</td>
<td>270</td>
<td>520</td>
<td>22</td>
</tr>
<tr>
<td>NV 317</td>
<td>290</td>
<td>550</td>
<td>22</td>
</tr>
<tr>
<td>NV 317 L</td>
<td>270</td>
<td>520</td>
<td>22</td>
</tr>
<tr>
<td>NV 320</td>
<td>290</td>
<td>550</td>
<td>18</td>
</tr>
<tr>
<td>NV 330</td>
<td>270</td>
<td>520</td>
<td>18</td>
</tr>
<tr>
<td>NV 347</td>
<td>290</td>
<td>550</td>
<td>18</td>
</tr>
<tr>
<td>NV 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 K2

<table>
<thead>
<tr>
<th>Electrode grade</th>
<th>C maximum %</th>
<th>Cr %</th>
<th>Ni %</th>
<th>Mo %</th>
<th>Nb-Ta %</th>
<th>Mn maximum %</th>
<th>Si maximum %</th>
<th>P maximum %</th>
<th>S maximum %</th>
<th>W %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>NV 310 L</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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>NV 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>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>-</td>
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<tr>
<td>NV 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>
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<td>0.04</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>NV 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>0.90</td>
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<td>-</td>
<td></td>
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<tr>
<td>NV 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>
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<td>0.90</td>
<td>0.04</td>
<td>0.03</td>
<td>1.25 - 1.75</td>
</tr>
</tbody>
</table>

1) Chromium % minimum 1.9 x % Ni. Tantalum % maximum 0.10%. Titanium % maximum 0.15%.

L. Welding Consumables for Welding of Ferritic-Austenitic Stainless Steels (Duplex Steels)

L 100 General

101 Approval of welding consumables for ferritic austenitic stainless steels (duplex steels) will be considered subject to
compliance with the specified tests and requirements below.

102 Parent plate material should preferably have a composition matching that of the electrode to be tested.

L 200 Test assemblies

201 All-weld-metal tests

Two all-weld-metal test assemblies are to be prepared as shown in Fig. 17, 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 is to be 1,2mm and the largest size manufactured.

For flux cored wire/gas combination the wire size is to be 1,2 or 1,6 mm and the largest size manufactured.

For wire/flux combinations the smallest and largest size manufactured are to be tested.

The weld metal is to be deposited in accordance with normal welding practice. The direction of deposition is to 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 is to 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 are to be taken from each test assembly as shown in Fig. 17. The test specimens are to be prepared according to A700.

The tensile strength, yield point and elongation are to 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 metal, for which the consumable is intended.

The impact test specimens are to be tested at —20°C and minimum average impact energy is to 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.

L 300 Chemical composition

301 Chemical analysis is to be carried out for all dimensions of welding consumables manufactured. The analysis is to be carried out as stipulated in H300 and is to be reported for approval.

302 The chemical composition of the core wire is also to be reported.

L 400 Microstructural examination

401 The ferrite/austenite-ratio of the weld is to be determined. The ferrite content in average is to be in the range of 25 to 70%.

L 500 Corrosion test

501 For the determination of pitting and crevice corrosion resistance, one test according to ASTM G48, Method A is required. The test specimen is to be exposed to the solution at a temperature of 20°C for 24 hours. No pitting attack shall be visible on the test faces, and the general weight loss is to be less than 20 mg.

L 600 Annual tests

601 Annual test for welding consumables comprises chemical analysis only. Welding consumables of two different dimensions are to be tested.

M. Welding Consumables for Welding of Aluminium Alloys for General and Low-Temperature Service

M 100 General

101 Approval of welding consumables for aluminium alloys will be considered subject to compliance with the specified tests and requirements in 200 to 400.
The welding consumables are to 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 are to be kept within the limits guaranteed in the manufacturers specifications.

The recommended and used composition for the shielding gases is to be reported.

Preparation of test assemblies:
Two test assemblies with dimensions as shown in Fig. 18 are to be welded in the flat position, one using the smallest wire size manufactured and the other using the largest size manufactured.

Application of backing strips is optional, i.e. the joint may be welded without backing strip with the root of weld chipped out to sound metal and re-welded from the second side. The metal for the backing strip is to be the same as that for the test plates. The test assemblies are neither to be preheated nor postheated treated. The welding is to be carried out at ambient temperature.

Testing

Non-destructive examination:
Prior to testing the backing strip is to be chipped off. The radiographic test will be considered as passed, provided the requirements in ASME Boiler and Pressure Vessel Code, Sec. VIII, Div. 2, A1-511 are satisfied.

Mechanical testing:
One longitudinal and one transverse tensile test specimen and two side bend test specimen ("wrap around" bending) are to be taken as shown in Fig. 18.

The test specimens are to be prepared according to A700.

Mechanical test requirements:
The tensile strength, yield point and elongation are to be reported for the Society's consideration. The tensile- and yield strength for both weld metal and welded joint are not to 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 are to be evaluated in each particular case.

The bend test specimens can be considered as complying with the requirements if, after bending through an angle of 180° over a former with diameter four times the thickness of the specimen, no crack or defect having any dimensions exceeding 3 mm can be seen on the outer surface of the test specimen.

One test assembly is to be welded in the flat position. Testing of this assembly is to be carried out as prescribed above for the initial testing.
SECTION 4
WELDING OF CLAD STEEL PLATES

A. General

A 100 Scope
101 The requirements in this Section specify welding of steel plates with austenitic stainless steel cladding.

B. Welding

B 100 Welding methods — deposited metal
101 For welding of steel plates with austenitic stainless steel cladding, only electrodes approved by the Society are to be used, and welding is to be carried out only by certified welders.
102 The welding may be carried out by means of shielded metal-arc welding, automatic or semi-automatic arc welding under inert gas and/or flux or a combination of these methods.
103 The weld joint is to have the same resistance to corrosion as the cladding metal, and the corrosion-resistant deposited metal is to have at least the same thickness as the cladding metal.
104 The chemical composition of the weld metal in the top layer on the clad side is to correspond to the composition of the cladding metal. The cladding deposited by welding is to have at least the same thickness as the cladding on the original plate.

B 200 Groove preparation
201 Proper groove shape in connection with correct welding sequence is to be employed. The edges are to be prepared with a cutting tool or by grinding.
202 Clad steel may be flame-cut provided this is done from the base plated side. It is recommended that the cutting face is removed in a depth of about 2 mm. When shearing is used, the cladding side must face upwards.
203 If there are alignment difficulties or if the welded connection is highly stressed, an edge preparation involving the removal of the cladding, adjacent to the weld is recommended.

B 300 Welding procedure
301 When welding clad materials, mixing of base metal and weld deposit, as well as mixing of the two types of high alloyed weld deposit is to be held at a minimum. Low welding current and small welding consumable dimensions are to be used. The degree of dilution is preferably to be kept below 30%. The degree of dilution is defined as the amount of base metal in the weld metal.
302 The use of low-alloyed or non-alloyed consumables on the cladding is not allowed.
303 At least two layers of the alloyed weld metal are to be deposited when welding the backing from the clad side, even if it is necessary to chip or grind off part of the first stainless bead to make room for the second pass. At least, the first bead is to be made with an over-alloyed consumable (e.g. N V 309).
304 The mild steel backing is as far as possible to be welded before the stainless cladding and is to be welded with suitable mild steel consumable. Care must be taken to prevent the root bead from penetrating into the cladding. Tack welds are to be of sufficient size, have full penetration and an even surface, so that they may be covered by the first weld bead without removal.

Guidance note:
For the top layer on the backing only extensively dried, extra-low hydrogen type of electrodes with grade-suffix HH are to be used.

---end of Guidance note---

305 When welding pipes where there is access only from the outside, the entire cross-section is to be built up by alloyed weld metal corresponding to the cladding. The sides of the groove are preferably to be covered with an over-alloyed consumable (buttering) before joining.

Fig. 1
Examples on most commonly used grooves

EXAMPLE ON WELDING SEQUENCE

Weld groove face to be ground smooth.

Root bead (1) of mild steel is not to penetrate the cladding.
The root bead is back-gauged or ground.

First bead on the clad side to be welded with an over-alloyed consumable (309-type), top layer to match the composition of the cladding (308-type).

**RECOMMENDED TYPES OF JOINTS**

3. to be welded with an over-alloyed consumable.
4. to be welded with a consumable matching the composition of the cladding.

Backing to be ground back enough to give room for at least two high-alloyed layers.

Butt weld between clad plate and mild steel plate; the cladding is welded with an over-alloyed type of consumable.

Only to be used in assemblies subjected to low stresses; consumable to match the cladding.

To be used in assemblies subject to high stresses; consumable to be of over-alloyed type to compensate for the mixing with mild steel backing.

Assembly subjected to high stresses; root beads can be welded with over-alloyed consumables and the top layer with ordinary stainless steel consumable, or root bead is welded with a mild steel consumable and the top layer with over-alloyed consumable.

**Fig. 2**

Examples on welding sequence