Materials and Qualification Procedures for Ships

Procedure 0-1
Guidelines for Welding Procedure Qualification

1 Introduction

1.1 Scope

1.1.1 These guidelines refer to welding procedure qualification of hull construction welds and provide guidance for shipyards seeking to establish welding procedures.

1.1.2 The main text of this procedure relates to steel . The aluminium alloys are covered by Appendix E which identifies where the main text is applicable and where the specific requirements of **Appendix E** apply.

1.1.3 For materials other than steel and aluminium, the guidance can be adapted as appropriate. Where these guidelines are insufficient, similar qualification standards considered more suitable should be employed.

1.2 Related standards and Rules

1.2.1 These guidelines are based on the following ISO Specifications.

ISO 857 Welding, brazing and soldering processes- Vocabulary.
ISO 5817 Arc welded joints in steel, quality levels for imperfections.
ISO 9556
Part 1 Qualification of Welding Procedures for Fusion Welding General Rules .
Part 2 Welding procedure specification for arc welding of metallic materials.
Part 3 Welding procedure tests for arc welding of steel.
Part 4 Welding procedure tests for arc welding of Aluminium & its alloys.
ISO 10042 Arc welded joints in Aluminium and alloys, quality levels for imperfections.

1.2.2 Reference is also made in these guidelines to LR's Rules and Regulations for the Classification of Ships (hereinafter referred to as the Rules for Ships).

1.3 Other standards

1.3.1 These guidelines and ISO Standards (see 1.2.1) define general rules for the specification and qualification of welding procedures. The ISO Standards refer to several other standards with respect to detailed rules for specific applications.

1.3.2 In general, reference to ISO Standards is made without reproducing any part of these standards. Some of the referenced standards may still be under development and not yet published. Equivalent National Standards may be used where the equivalence is either stated or established, by agreement with LR.

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1.3.3 It is assumed that the welding procedure specifications are used in production by skilled welders, qualified in accordance with the requirements of Pt 3, Ch 10,2.12 of the Rules for Ships. Guidelines for Welder Qualification are provided in **Materials and Qualification Procedures for Ships, Book A, Procedure 0-2**.

1.4 Shipyard inspection

1.4.1 The shipyard is to be inspected regularly by the Surveyor, to confirm that welding facilities are maintained in good condition. This relates to such items as:

(a) Mechanical condition of all equipment, power sources and accessories.

(b) Efficiency and safety of all electrical equipment and accessories.

(c) The calibration of controls and indicators (and recorders if fitted) for power sources, wire feed controls, speed controls and current and voltage regulators.

(d) The condition of storage of welding consumables, both main and local.

(e) The calibration and operating efficiency of baking (drying) and holding ovens.

2 Definitions

Preliminary welding procedure specification (pWPS):

Draft welding procedure specification, which details welding conditions to be used by the manufacturer for testing purposes.

Welding procedure specification (WPS):

The WPS is the detailed instruction of how the welding procedure is to be applied to production after it has been approved. The WPS should always reference the PQR that qualifies it for approval. A WPS may have the support of more than one PQR. As an example, a WPS form is illustrated in **Appendix C**.

Procedure qualification record (PQR):

The PQR is a record of how the qualifying test weld was made, inspected and tested, and includes the results of inspection and testing. An example of a PQR form is shown in **Appendix D**. More than one WPS may be supported by a PQR.

Test assembly:

Welded assembly which is used in the approval test.

Test specimen:

The part or portion cut from the test assembly in order to perform a specified destructive test.

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Essential variable:

Variables which influence the mechanical and/or metallurgical properties of the welded joint.

Additional variable:

Variable which does not influence the mechanical and/or metallurgical properties of the welded joint, but is required to be stated on the WPS and PQR.

Throat thickness:

The minimum distance minus any convexity between the weld root and the face of a fillet weld.

Range of approval:

Extent of approval for an essential variable.

Welding processes:

For nomenclature and definitions see ISO 857.

The definitions of other terms are given in the appropriate ISO Standard.

3 Welding procedure variables

3.1 The main variables which need to be specified in the welding procedure include as a minimum the following:

Welding process(es) and/or equipment.

Parent metal, specification , shape and thickness.

Welding consumables (electrodes, gases, fluxes etc.).

The type of joint and edge preparation, and backing material.

The surface condition of, or any coating (e.g. primer) applied to, the edge preparation and the immediately adjacent surfaces of the parent metal.

Welding position.

Welding sequence (number and order of deposited weld beads).

Welding parameters (current, arc voltage, welding speed, etc.) to be used for each part of the weld joint.

Pre-heating and post-weld heat treatment.

Heat input and inter-pass temperature.

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4 Preparations for welding procedure test

4.1 In general, welding procedure qualification involves preparing and welding the assemblies, and performing inspections and tests indicated in these guidelines.

4.2 Before procedure qualification testing is witnessed, the shipyard should submit the preliminary pWPS for review together with the proposed test plan. This pWPS is to define all the relevant variables (**see 3.0**).

4.3 Preparation and welding of test assemblies shall be carried out in accordance with the pWPS . If tack welds are to be fused into the final joint they shall be included in the test assembly.

5. Test assembly requirements

The welded assembly should be one of a standardised form as detailed below and should be representative of the condition to be encountered during production welding.

5.1 Shape & dimensions of test assemblies

5.1.1 The test assembly should be of a sufficient size to ensure a reasonable heat distribution, be of sufficient length to enable all test specimens to be removed, including any retests, and allow sufficient discards from each end of the weld to remove the likely defective regions associated with starting and stopping of welding at the test assembly ends.

5.1.2 The thickness and (where appropriate) the pipe outside diameter of the test assembly should be selected to give the range required (**see Section 7.6**).

5.1.3 The orientation of the plate rolling direction relative to the weld direction is to be arranged, where Charpy tests are required to be taken from the heat affected zone (HAZ) as follows:

(a) Where the parent plates are required to be Charpy tested in the longitudinal direction for the application, the plate rolling direction should be arranged perpendicular to the weld.

(b) Where the parent plates are required to be Charpy tested in the transverse direction for the application, the plate rolling direction should be arranged parallel to the weld.

5.1.4 Unless otherwise agreed, the shape and minimum dimensions of the test assembly should be as follows.

a) Butt weld in plate

The butt weld test assembly should be in accordance with **Fig. 0-1.5.1**.

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b) Butt weld in pipe

The test assembly should be in accordance with **Fig 0-1.5.2** . More than one test assembly may be required for welding tests on small pipe diameters.

c) Deposited metal assembly

The test assembly should be in accordance with the deposited metal assembly requirements of the relevant Section of Ch 11 of the Rules for Materials.

d) Fillet weld in plate or pipe

The test assembly should be in accordance with **Fig. 0-1.5.3**.

5.2 Consumables not approved

In those cases where the consumables are not on the LR Approved List, it will be required additionally to weld and test one deposited metal assembly for each batch of consumables to be used for production (see 5.1.4 C). The testing shall be done as per the requirements of the relevant Section of Ch 11 of the Rules for Materials.

The above test is also required for fillet weld procedure qualification where butt weld tests have not been performed.

6 Examination and testing *Aluminium exceptions*

6.1 Witness of welding and testing

Welding and testing of test assemblies shall be witnessed by the Surveyor. The shipyard shall record all relevant parameters during the tests.

6.2 Non-destructive examination

6.2.1 Test assemblies shall be examined visually and non-destructively in accordance with **Table 0-1.6.1** after any required post-weld heat treatment and prior to the cutting of test specimens. Except for austenitic stainless steels, the NDE should be delayed for a minimum of 48 hrs for non PWHT test assemblies to account for possible hydrogen induced cracking.

6.2.2 Imperfections that are detected by visual or non-destructive examination shall be assessed in accordance with ISO 5817, Class B.

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Table 0-1.6.1 Examination and testing of test assembly

Test assembly	Type of test	Extent of testing
Butt-weld on plate/pipe Fig **0-1.6.1**, **0-1.6.2** and 0-1.6.3	Visual Surface crack detection * Radiographic or ultrasonic Transverse tensile Transverse bend ** Charpy V-notch Hardness Macro-examination	100% 100% 100% 2 specimens 2 root and 2 face specimens As per para **6.3.7** Required, see para **6.3.8** 1 specimen
Fillet weld on plate Fig **0-1.5.3**	Visual Surface crack detection * Macro-examination Fracture Hardness	100% 100% 3 specimens 2 specimens Required, see para **6.3.8**
* Penetrant testing or magnetic particle testing. For non-magnetic materials, penetrant testing. ** For test assembly thickness greater than 25 mm, four side bend specimens may be tested in place of two face and two root bend specimens.		

6.3 Destructive tests

6.3.1 General

6.3.1.1 Destructive tests should be carried out as detailed in Table 0-1.6.1. Test specimens should only be taken after satisfactory NDE results (see **6.2.2**).

6.3.1.2 The dimensions of test specimens and testing conditions shall be in accordance with Ch 11 of the Rules for Materials. The results of mechanical tests shall comply with these requirements ,unless the application to which the welding procedure relates, specifies more stringent requirements.

6.3.2 Transverse tensile testing

6.3.2.1 In general, the test specimens must be of the full plate thickness, with only the reinforcement removed from each surface. Sufficient dressing should be made to remove any minor undercut present at the as-welded surface.

6.3.2.2 The location of test specimens should be in accordance with Figs **0-1.6.1** and **0-1.6.3**.

6.3.2.3 If full thickness test specimens would be too large for either the capacity of the test machine grips or for the loading capacity of the machine, reduced thickness test specimens may be used. The reduced thickness specimens must form part of a set that encompasses the full thickness of the weld. To ensure this, it is recommended that there should be a minimum of 5mm overlap in the thickness direction between consecutive specimens. Two sets of specimens are to be tested.

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6.3.2.4 Steel: The tensile strength recorded for each specimen must not be less than the minimum required for the parent metal specified in the relevant chapter of Part 2 of the Rules for Ships. For thick plates, where a reduced strength is specified, the guaranteed minimum for the test thickness is to be achieved.

6.3.2.5 Austenitic and duplex stainless steel: The tensile strength recorded for each specimen must not be less than the minimum required of the transverse tensile test for the corresponding grades of consumable in Ch 11 of the Rules for Materials.

6.3.2.6 Where the parent metals are of different strength grading, the requirements for qualification are those appropriate to the lower strength grade.

6.3.3 Bend testing

6.3.3.1 The location of test specimens should be in accordance with Figs **0-1.6.1** and **0-1.6.3**.

6.3.3.2 Test specimens should be bent around a former with diameter equal to four times the thickness of the test specimen, or that bend ratio specified in Ch 11 of the Rules for Materials ,whichever is less severe.

6.3.3.3 Minimum angle of bend should be 120°.

6.3.3.4 It is recommended that the bending should be completed within about 15 seconds to minimise the possible effects of any hydrogen remaining at the time of testing.

6.3.3.5 After bending, the specimens are not to show any open defects with any dimension exceeding 3 mm. Defects appearing at the corners of the deformed specimens should be ignored unless these are due to lack of side-wall fusion.

6.3.3.6 If the difference between the relative strengths of the weld metal and parent metal prevents uniform bending of the transverse type of test specimen, then longitudinal specimens may be prepared. These are to be wide enough to encompass the full width of the weld metal, the HAZs on each side, plus a minimum of 5 mm of parent plate on each side. Four specimens are to be tested, two with the face, and two with the root, on the outside of the bend (in tension).

6.3.4 Macro-examination for butt weld

6.3.4.1 Specimens indicated in Fig. **0-1.6.1** or **0-1.6.3** are to be prepared and etched to reveal the weld metal and HAZ's so that the grain coarsened regions of the HAZ's and the solidification structure of the weld metal can be distinguished.

6.3.4.2 Examination is to be made for possible defects, aided by low power hand lens if desired. These are to be assessed in accordance with Class B of ISO 5817.

6.3.5 Macro-examination for fillet weld

6.3.5.1 Three macro-sections (**Fig. 0-1.5.3**) are to be prepared, one of which is to be from the stop/restart position, if present. Otherwise these are to be taken from the ends adjacent to the discards and in the middle of the length.

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6.3.5.2 The sections shall be prepared and etched to reveal the weld metal and HAZ's, so that the grain coarsened regions of the HAZ's and the solidification structure of the weld metal can be distinguished.

6.3.5.3 The sections are to be examined in accordance with **6.3.4.2** above.

6.3.6 Fracture tests for fillet weld

6.3.6.1 From the two lengths of welded assembly remaining after removal of the macro-sections, two lengths (not less than 100 mm each) are to be taken and fractured by folding the upright plate onto the through plate (**Fig 0-1.5.3**). Each weld is to be treated in this way after first cutting through the other weld bead.

6.3.6.2 The fracture surfaces are to be examined for possible defects. These are to be assessed in accordance with ISO 5817, Class B.

6.3.7 Charpy V-notch impact tests

6.3.7.1 Weld metal impact specimens

6.3.7.1.1 Three Charpy specimens are to be prepared and tested with their notches on the weld centreline (**Fig 0-1.6.2**) , and with the notch root perpendicular to the surface of the weld, in the following cases:

(a) Carbon and low alloy, normal and higher tensile steels.

(b) All types of Stainless steels.

6.3.7.1.2 For test assembly thickness greater than 50 mm another set of three Charpy specimens shall be taken from the weld root region.

6.3.7.2 Heat-affected zone (HAZ) impact specimens

6.3.7.2.1 Two sets of three Charpy specimens are required to be taken from the HAZ (**Fig 0-1.6.2**) at the following locations (see **6.3.7.2.2** for exceptions) :

a) Three specimens with their notches centred on the fusion line.

b) Three specimens with their notches centred on the HAZ, 2 mm from the fusion line.

6.3.7.2.2 HAZ impact specimens are not required when

a) the steel grade is of normal strength and the welding heat input, specified in the WPS, is less than 5 KJ/mm, or

b) the parent steel is one of the austenitic grades.

6.3.7.3 The Charpy impact test temperatures for all specimens (weld metal and HAZ) are to be as for the corresponding weld metal grade in Ch 11 of the Rules for Materials.

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6.3.7.4 The minimum average value for each set of three specimens is to be as required for the corresponding weld metal grade for the welding process, technique and position in Ch 11 of the Rules for Materials.

6.3.7.5 Sub-size Charpy specimens may be prepared only if the parent metal is too thin to permit the preparation of standard cross-section specimens (10 mm x 10 mm). In these cases, the minimum mean value of impact energy is to be;

Cross-section	Energy to fracture, J
10 mm x 7,5 mm	5/6 of normal minimum
10 mm x 5 mm	2/3 of normal minimum

6.3.7.6 Where specimens of 5 mm thickness cannot be taken because of the thickness or geometry of the welded test assembly, Charpy specimens are not required.

6.3.8 Hardness testing

6.3.8.1 This testing is to be in accordance with ISO 6507/1. Generally, hardness testing will only be required for welds in carbon and low alloy steels, other than normal strength steel.

6.3.8.2 The object is to record the variation of hardness within the weld metal and HAZ regions, with a particular interest in the maximum values found. Where values are found greater than 350 HV in the HAZ and greater than 260 HV in the weld metal only low hydrogen welding consumables are to be used in the procedure and adequate consideration is to be given to the prevention of hydrogen cracking (also see **7.6.4** for restriction on the qualified base metal thickness range).

6.3.8.3 Hardness indentations and subsequent measurement of the indentations are to be made in those regions most likely to produce the highest hardness values. These will generally be those regions which are in the as-welded condition and have received no reheating by subsequent weld runs. Generally these will be in the last weld bead to be deposited and its adjacent HAZ.

6.3.8.4 Within the HAZ, the grain coarsened region (GCHAZ) will be the region of highest hardness, and a band approximately 0,5 mm wide parallel to and contiguous with the fusion line should be tested. This requires a test machine operator capable of distinguishing the different regions and interpreting the results from individually placed indentations. The indentations need to be small enough to fit comfortably within the 0,5 mm wide band, and this needs the indenting load to be changed according to the hardness being measured. For these reasons, the indenting load should be either 10 kg or 5 kg, and the Vickers Diamond pyramid method is preferred.

6.3.8.5 Examples of hardness surveys are shown in Appendix A. All hardness values should be recorded, and the maximum values in each region should be highlighted.

6.4 Re-testing

6.4.1 If a weld test fails any of the retests specified below the weld procedure will be considered unacceptable . Retesting will not be permitted unless modifications are made to correct the cause of failure.

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6.4.2 If any welded assembly fails on non-destructive examination to meet the requirements of ISO 5817 Class B, that assembly is rejected. A duplicate assembly may be welded using the same procedure and subjected to examination. If this fails to meet the requirements of ISO 5817 Class B, the procedure will be considered unacceptable.

6.4.3 If any test specimen, forming part of the destructive test (see **6.3**), fails to meet the requirements (except as in 6.4.4 and 6.4.5), two further test specimens are to be prepared from the same welded assembly and tested , as appropriate. If either fails, the procedure is considered unacceptable.

6.4.4 If the average value of a set of three Charpy V-notch specimens fails to meet the minimum average, or more than one of the three specimens fails to meet the minimum average, or any one specimen of the three fails to meet 70 per cent of the minimum average, re-testing is required as detailed in Ch 11 of the Rules for Materials.

6.4.5 If any macro-section or fracture surface examination fails to meet the requirements of ISO 5817, Class B in respect of slag inclusions, only one extra specimen is to be taken and examined. If this fails, one further specimen may be taken and examined before the procedure is rejected as unacceptable .

6.4.6 Where there is insufficient welded assembly remaining to provide the duplicate test specimens, a further assembly may be welded using the same procedure to provide the additional specimens.

7. Range of approval

7.1 Other workshops

A procedure approved for use in one yard or workshop is valid for use in all workshops operating under the same technical and quality control management.

7.2 Welding process and technique

The approval is valid only for the welding process used in the welding procedure test. For a given process it is not permitted to change from single run to multirun technique or vice versa.

7.3 Type of joint

A procedure qualified on butt weld is valid for fillet weld but not vice-versa.

7.4 Parent metal

7.4.1 Normal strength ship steel (Rules for Materials, Ch 3, Section 2)

Qualification on any steel grade will qualify that grade and all other grades of lower toughness.

7.4.2 Higher strength steel (Rules for Materials, Part 2, Ch 3, Section 3)

a) For each strength level, welding procedures are considered applicable to the same and lower toughness grades as that tested, without change of welding consumable.

b) For each toughness level, welding procedures are

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considered applicable to the same and lower strength grades as that tested, with the exception of high heat input processes, e.g.

the two-run technique with either submerged arc or gas shielded metal arc welding, electroslag and electrogas welding,

the consumable grading `A' for one-side welding with temporary backing material.

7.4.3 Austenitic stainless steel (Rules for Materials, Ch 3, Section 7)

Qualification on any grade qualifies for that grade and all other lower alloyed grades.

7.4.4 Dissimilar material joints

A Procedure Qualification test performed using dissimilar materials is restricted to that material combination.

7.4.5 All other steels

Qualification is restricted to the type/grade of material used for procedure qualification.

7.5 Welding consumable

Selection of a different welding consumable from that used in previous qualification tests requires re-qualification. The following exceptions apply:

(a) For manual welding, a change of brand or trade name from one approved electrode to another will not require re-qualification provided the approval grading is the same and it is shown that the electrode classification is also the same.

(b) For multirun semi-automatic and automatic welding, with the exception of high heat input techniques as defined in Rules for Materials, Ch 11, Section 7, a change of wire and/or flux brand or trade name provided the new combination has same approval grading and the flux is of the same type (e.g. basic rutile).

7.6 Thickness and diameter *back to 5.1.2*

7.6.1 For dissimilar thickness, t, refers to the thinner material for butt weld and to the thicker material for fillet weld .

7.6.2 For single-run or two-run butt welding techniques, approval of a procedure tested on a material thickness, t, will include approval for the range 0.5t to 1.1t.

7.6.3 For multi-run butt welding and any fillet welding techniques, approval of a procedure tested on a material thickness, t, will include approval for the following ranges:

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Thickness t, in mm	Range approved
t ≤ 3	t to 2t
3< t ≤ 12	3 mm to 2t
12<t ≤ 100	0.5t to 2t (but ≤ 150 mm)
t > 100	0.5t to 1.5t

7.6.4 Notwithstanding the above, the approval of maximum base metal thickness for any technique shall be restricted to the test assembly thickness if the hardness values are found greater than 350 HV during procedure testing.

7.6.5 The approval of a welding procedure test on outside diameter D shall include approval for diameters in the following ranges. These restrictions do not apply to the fillet welds.

Outside diameter D, in mm	Range approved
D<168.3	0.5D to 2D
D≥168.3	≥0.5D and plates.

Approval given for plates also covers pipes when the outside diameter is > 500 mm.

7.6.6 For fillet welds, in addition to the base metal thickness range (sec 7.6.3 and 7.6.4 above) the approval is also restricted to the throat thickness range as specified below.

Throat thickness a, in mm (of test assembly)	Range approved
a < 10	0,75a to 1,5a
a ≥ 10	10 mm and upwards

7.7 Welding position

For steel, approval for a test made in any position is restricted to that position. To qualify a range of positions, test assemblies are to be welded for each position and all applicable tests made on those assemblies, except that Charpy V-notch impact tests need be made on the highest heat input position only, and hardness tests need be made on the lowest heat input position only.
Welding position descriptions and identifying codes are specified in **Appendix B**.

7.8 Welding technique

The upper limit of approved weaving is that used during qualification testing. However, in no case should it exceed three times the core diameter of the

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welding electrode. Rapid sideways oscillations of the welding arc during machine welding are not allowed.

7.9 Current type

The approval is restricted to the type of current and polarity used in the procedure test.

7.10 Preheat temperature

The preheat temperature may be increased from that used during qualification testing, but not reduced.

7.11 Interpass temperature

The interpass temperature may be reduced from that used during qualification testing , but not increased.

7.12 Heat input

The heat input should not deviate by more than ± 25% from that used in the qualification test.

7.13 Post-weld heat-treatment

Addition or deletion of post-weld heat-treatment is not permitted. The holding temperature range approved is that used in the welding procedure test ±20 deg C unless otherwise specified. Heating rate, cooling rate and holding time shall be related to the production assembly.

7.14 Other variables

The range of approval relating to other variables may be taken according to established practice as represented in recognised National or International Standards.

8 Re-qualification of procedures

If the main welding variables, as detailed above, are significantly changed and fall outside the range of approval already qualified this will constitute a new procedure which will require to be qualified.

9 Test records

9.1 Welding procedure qualification record (PQR)

9.1.1 A written statement is to be made for each procedure qualification test performed. This is to include

(a) Details of the welding variables used in making the welded assembly.

(b) Details of the results of examination (inspection and destructive testing) performed on the welded assembly.

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9.1.2 Provided that the statement refers to all relevant variables as listed in the WPS, and there are no inconsistent features, and the test results satisfy the requirements of the Rules for Ships and these guidelines, the witnessing Surveyor may sign a statement on the PQR that the qualifying test assembly was made in accordance with the PQR and that it satisfied the requirements of that type of test assembly.

9.1.3 An example PQR form is presented in Appendix D. This is the preferred version of this type of form, although equivalent forms may be accepted.

9.1.4 The WPS can then be approved by LR for the ship application. A signature confirming approval of the WPS needs to be accompanied by a statement of the application for which it is approved. In ship applications this requires reference at least to the range of steel grades, thicknesses and positions to which it applies.

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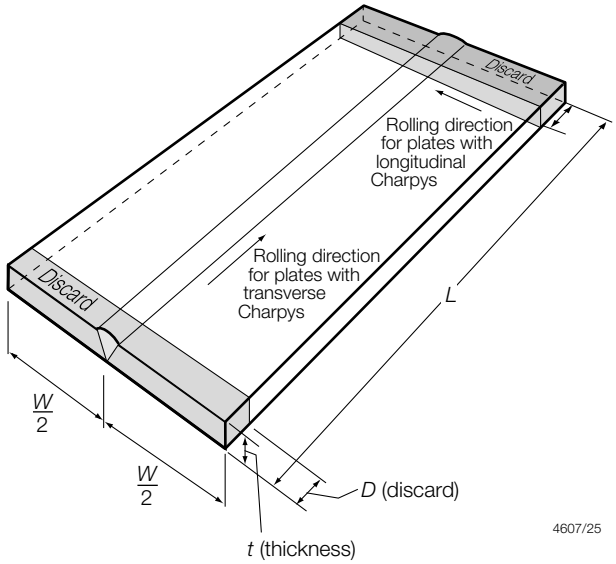
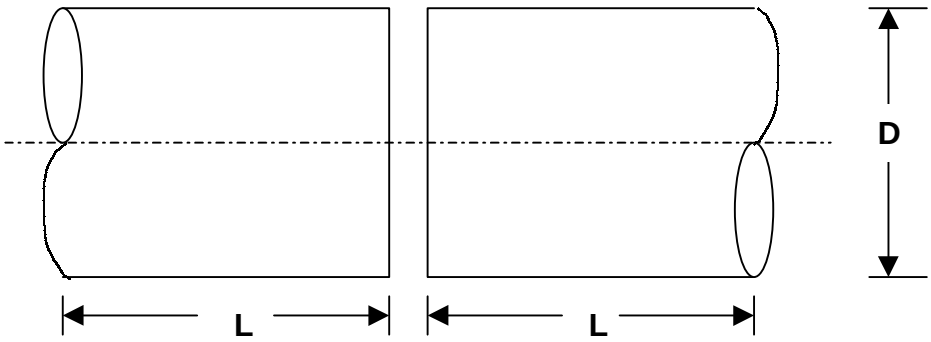


Welding Processes	L (min) mm.	W (min) mm.	D (min) mm.
Manual/Semi-automatic	**350**	**300**	**50**
Automatic	**1000**	**400**	**75**

Fig. 0-1.5.1
Test assembly for a butt weld in plate



L = 150 mm. Minimum
D= Outside diameter

Fig. 0-1.5.2
Test assembly for a butt weld in pipe.

Note:- Edge preparation and fit-up as detailed in the preliminary welding procedure specification (pWPS)

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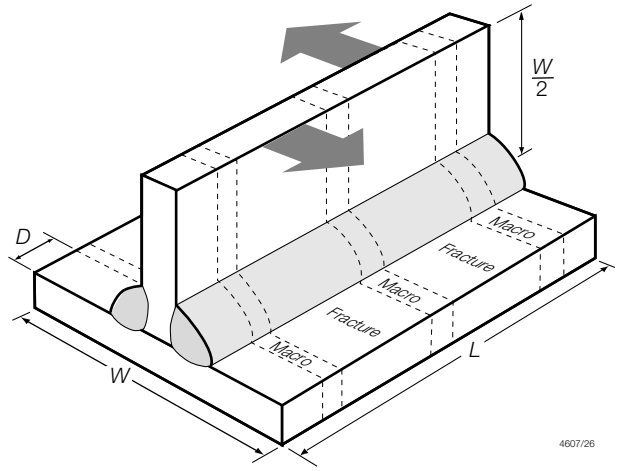

Welding Processes	L(min) mm.	W(min) mm.	D(min) mm.
Manual/Semi-automatic	350	300	50
Automatic	1000	300	75

Fig. 0-1.5.3
Test assembly for a fillet weld in plate

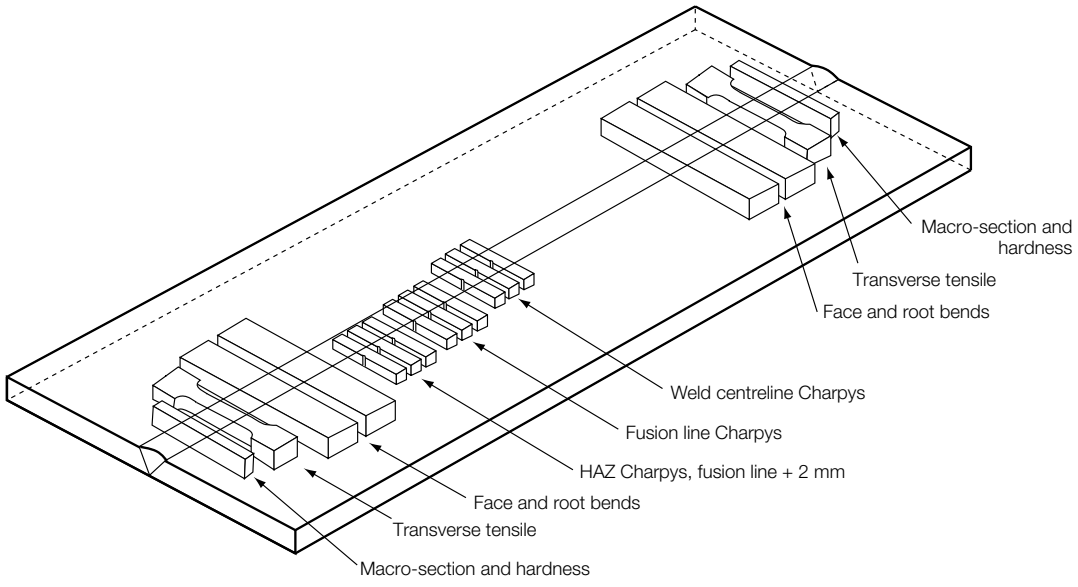

Fig. 0-1.6.1
Location of test specimens for a butt weld in a plate

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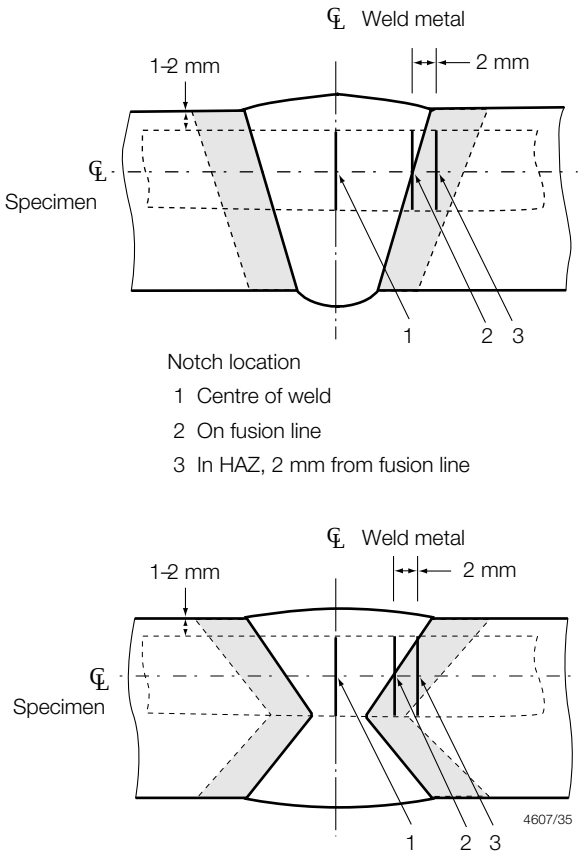

Fig. 0-1.6.2 Notch location of impact specimens

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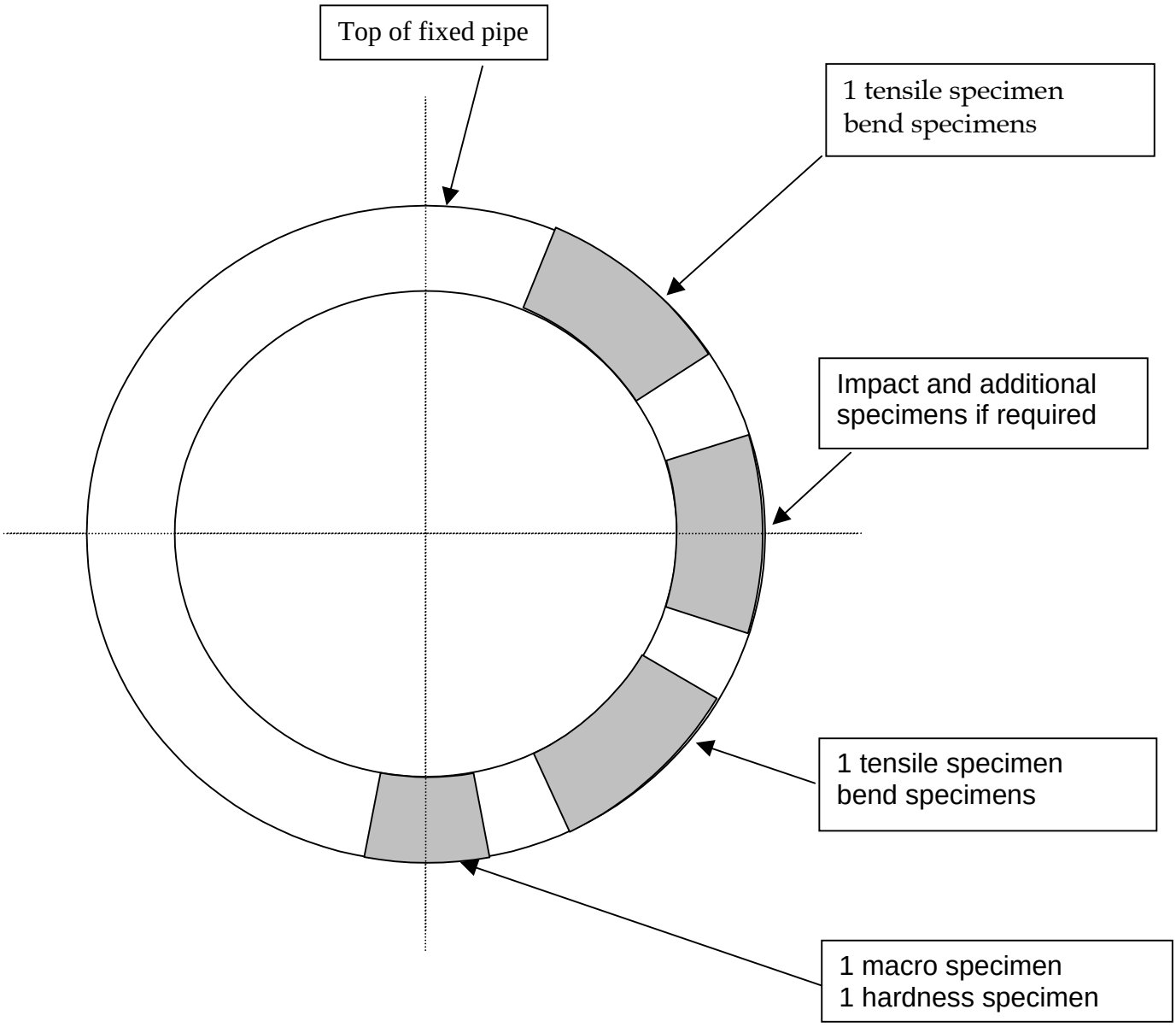

Fig. 0-1.6.3 Location of test specimen for butt weld in pipe

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APPENDIX A
Hardness testing locations

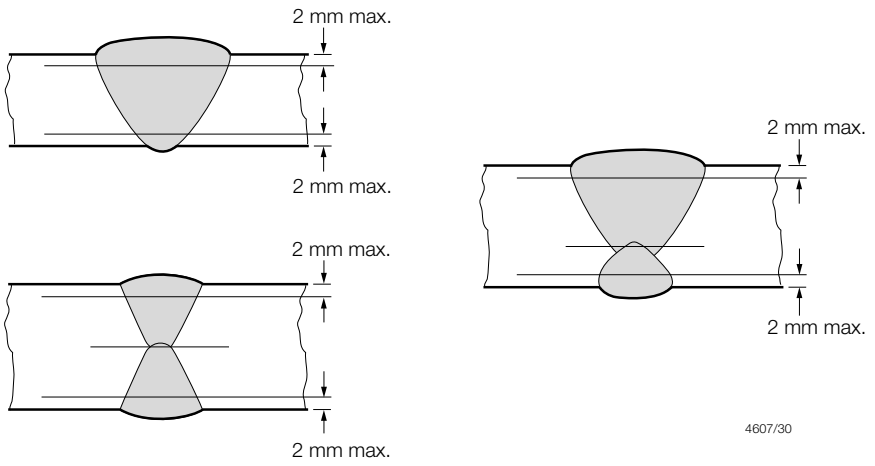

Fig. 0-1.A.1 Indication of the general location of hardness surveys in butt welds

Table 0-1.A.1 Recommended distances between indentations for hardness testing In the heat affected zone

Vickers indenting load	Distance between indentations, *S*, mm.
H_V5	0.7
H_V10	1.0
NOTE The distance of any indentations from the previous indentation is to be not less than the value allowed by ISO 6507/1	

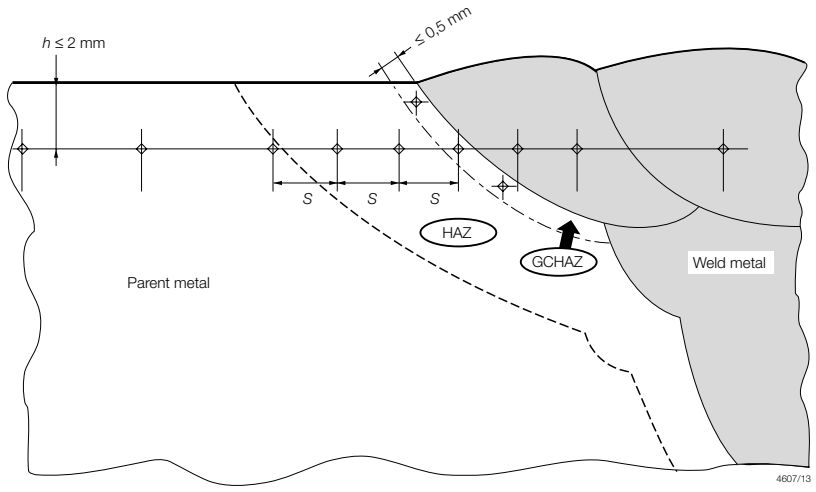

Fig. 0-1.A.2 Example showing the positions of the indentations for hardness testing in the weld, heat affected zone and parent metal of a butt weld

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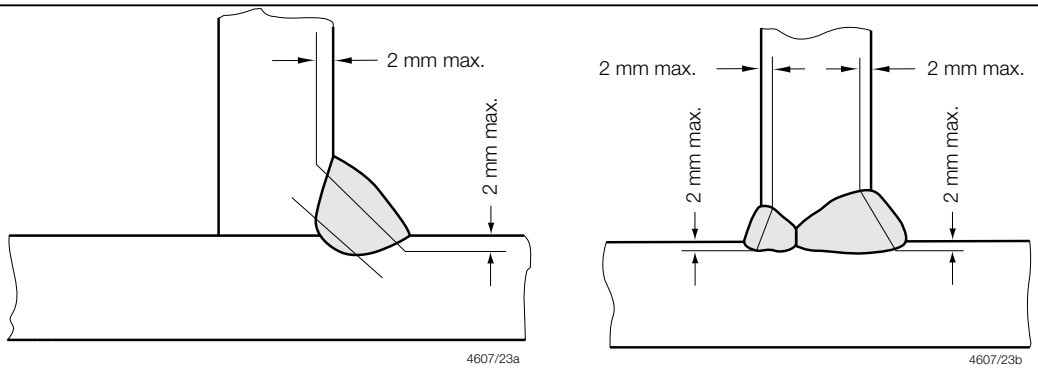

Fig. 0-1.A.3 Indication of the general location of hardness surveys in fillet welds and in T-welds

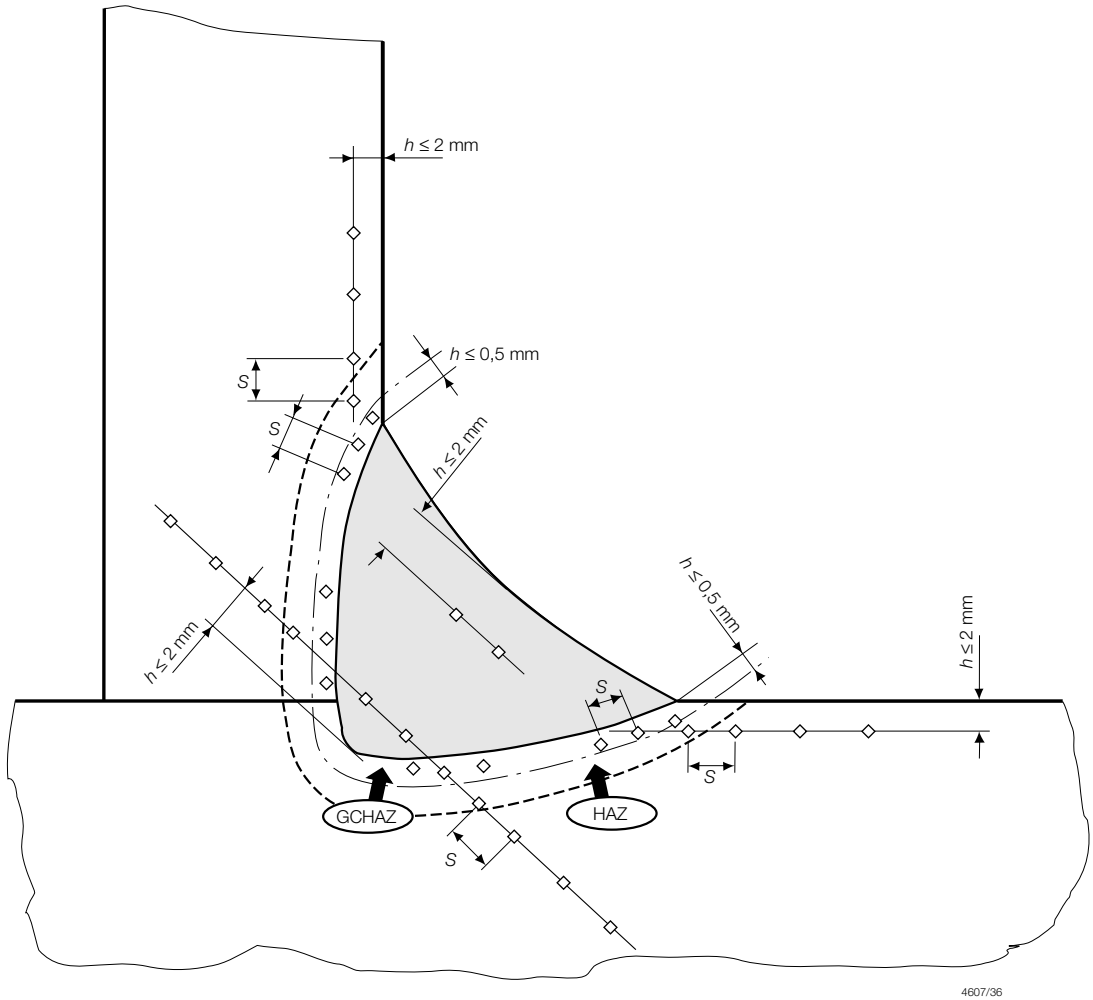

Fig. 0-1.A.4
Example showing the position of the indentations for hardness testing in the heat affected zone, weld metal and parent metal of a fillet weld (dimensions in mm.)

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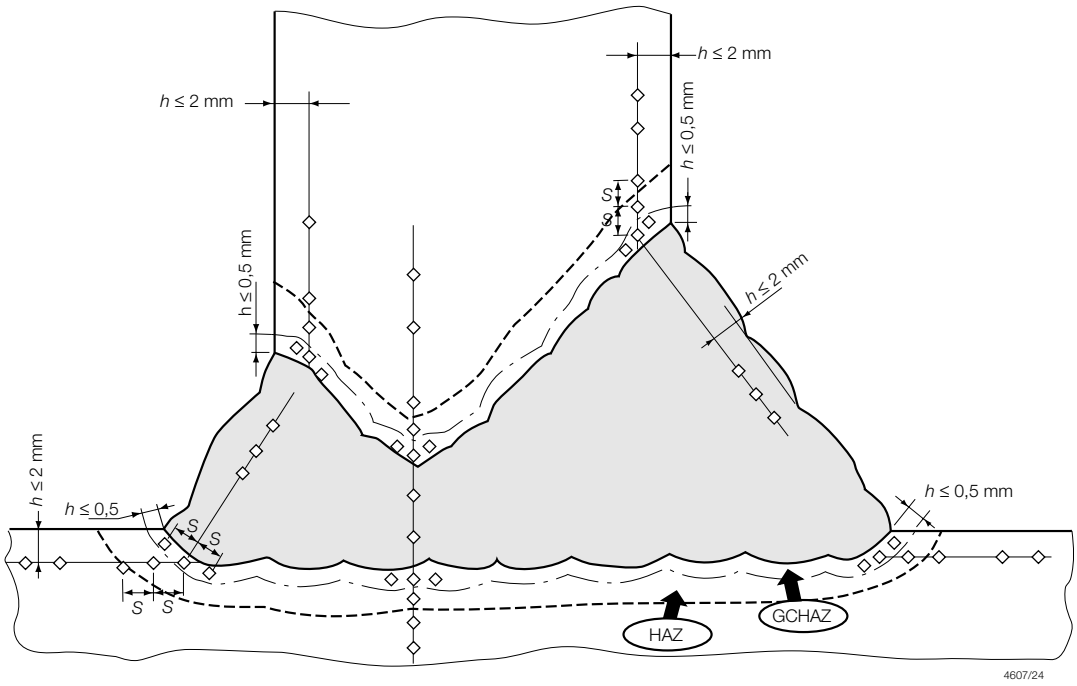

Fig.0-1.A.5
Example showing the position of the indentations for hardness testing on the heat affected zone, weld metal and parent metal of a T-weld (dimensions in mm.)

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APPENDIX B
Welding positions of test assemblies

Table 0-1.B.1 Equivalent welding position descriptions and identifying codes

LR			ISO			AWS		
	Butt	Fillet		Butt	Fillet		Butt	Fillet
Downhand	D	D	Flat	PA	PA	Flat	1G	1F
Horizontal-vertical	X	X	Horizontal-vertical	PC	PB	Horizontal	2G	2F
Vertical-upward	Vu	Vu	Vertical-upward	PF	PF	Vertical	3G*	3F*
Vertical-downward	Vd	Vd	Vertical-downward	PG	PG	Vertical	3G*	3F*
	O	O	Overhead	PE	-	Overhead	4G	4F
			Horizontal-overhead	-	PD			

NOTES
* These codes need further identification of the direction of progression: 'upward' or 'downward'

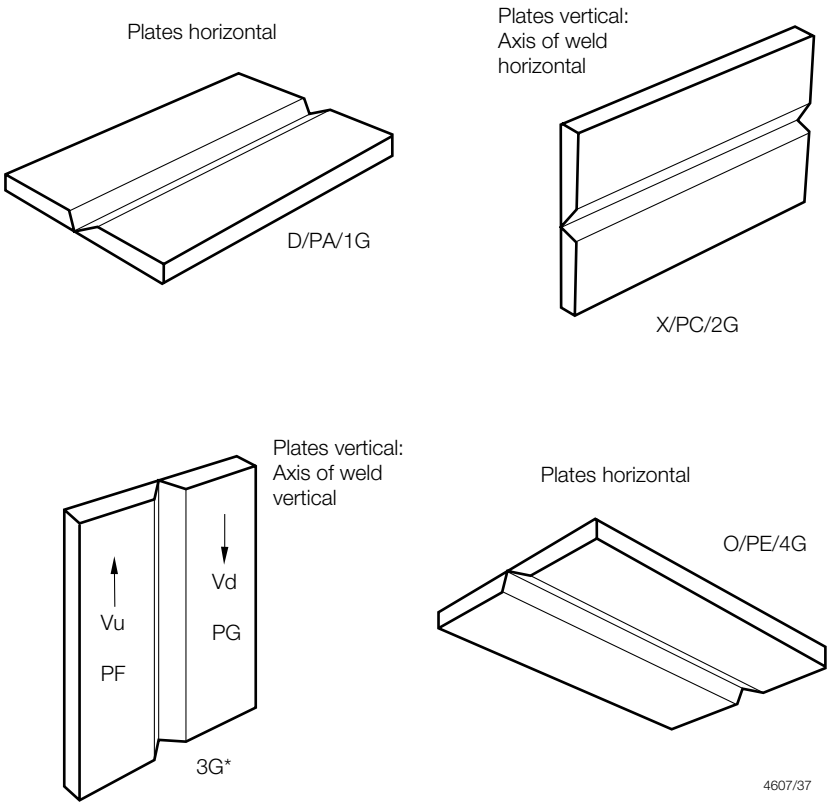

Fig. 0-1.B.1 Positions of test assemblies for butt welds (*see* Table 0-1.B1)

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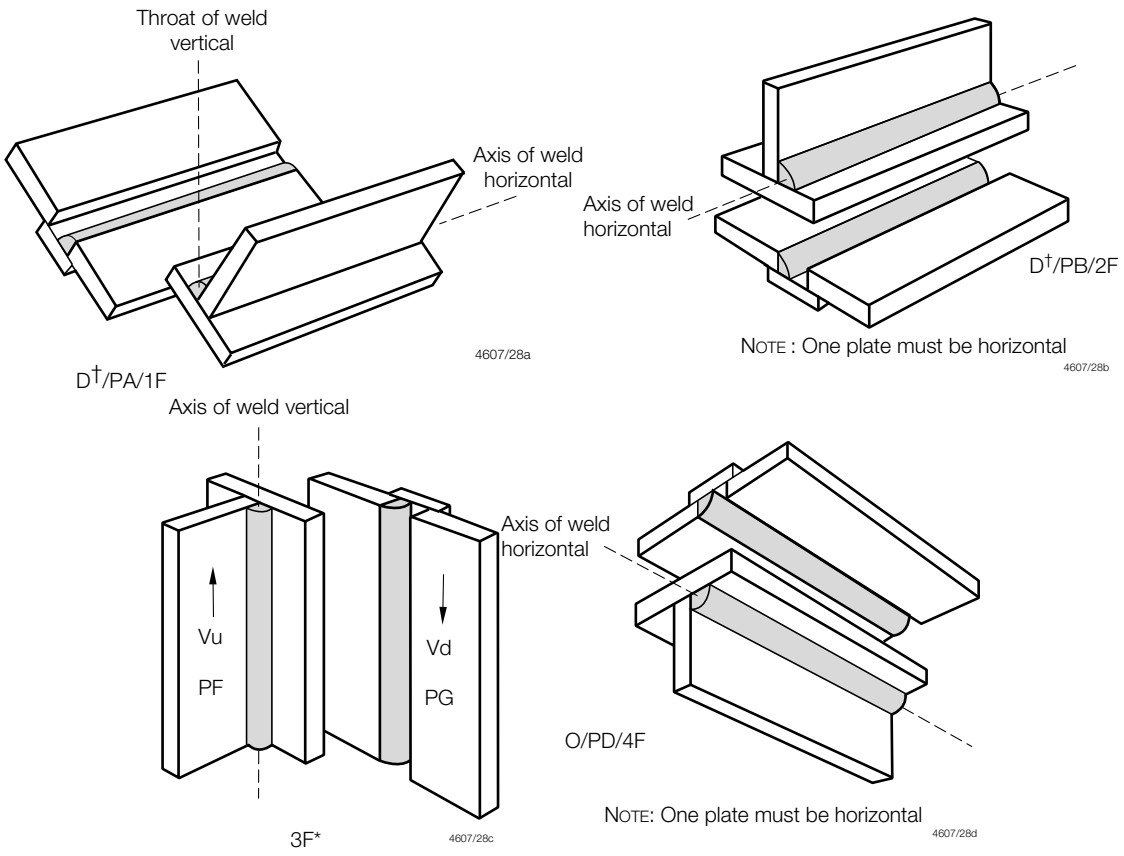

Fig. 0-1.B.2 Positions of test assemblies for fillet welds (see Table 0-1.B.1)

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APPENDIX C
Welding Procedure Specification (WPS) form

WELDING PROCEDURE SPECIFICATION (WPS)

Location:
Manufacturer's Welding Procedure Reference No.:

Manufacturer:
Welder's Name:
Welding Process:
Joint Type:
Weld Preparation Details (Sketch):

Examiner or test body:

Method of Preparation and Cleanng:
Parent Material Specification:

Material Thickness (mm):
Outside Diameter (mm):
Welding Position:

Joint Design	Welding Sequences

Welding Details

Run	Process	Size of Filler Metal	Current A	Voltage V	Type of Current/ Polarity	Wire Feed Speed	Travel Speed	Heat Input

Filler Metal Classification and Trade Name:
Any Special Baking or Drying:
Gas/Flux – Shielding:
– Backing:
Gas Flow Rate – Shielding:
– Backing:
Tungsten Electrode Type/Size:
Details of Back Gouging/Backing:
Preheat Temperature:
Interpass Temperature:
Post Weld Heat Treatment and/or Ageing:

Time, Temperature, Method:

Heating and Cooling Rates:

Other information:
e.g. Weaving (maximum width of run):
Oscilation (amplitude, frequency, dwell time):

Pulse welding details:

Stand of distance:
Plasma welding details:
Torch angle:

Manufacturer

Name, date and signature

Examiner or test body

Name, date and signature

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APPENDIX D
Welding Procedure Qualification Record (PQR) form (to be continued

Lloyd's Register

WELDING PROCEDURE QUALIFICATION RECORD (PQR)

Date of issue	
LR Office	
Qualification: Codes/Standards	PQR certificate number **00001 0000011/1**

p WPS* number and revision	Date of welding	Manufacturer's name and address
Test place/location shop/site		
RANGE OF APPROVAL		
Welding process(es)	Single pass/multipass	
Joint type(s)	Parent metal group(s)	Test joint details (sketch with dimensions) of weld preparation
Plate thickness range	Pipe outside diameter range	
Filler metal type/designation	Heat treatment	
Gas/flux	Type of welding current	
Welding positions	Progression (up/down)	
WELD AND FILLER METAL DETAILS		
Parent Materials	Test piece position	
Welding process	Joint type	Bead sequence detail (sketch to include weld metal thickness and back gouging where applicable)
Filler material	Shielding gas/flux flow rate	
Make/type/diameter	Gas composition	
Composition	Flux type	
Other information		
Preheat and interpass temperature (method) and control		
Postweld heat treatment temperature (method) and control		

PROCEDURE DETAIL

RUN NUMBER	*PROCESS*	*SIZE OF FILLER MATERIAL*	*CURRENT A*	*VOLTAGE V*	*AC/DC POLARITY*	*WIRE FEED/ TRAVEL SPEED*	*HEAT INPUT kJ/mm*

Date	Welder's name	WPQ certificate number

*Manufacturer's Preliminary Welding Procedure Specification

NOTICE: This certificate is subject to the terms and conditions overleaf, which form part of this certificate.

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APPENDIX D
Welding Procedure Qualification Record
(PQR) form (conclusion)

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WELDING PROCEDURE QUALIFICATION RECORD (PQR) - CONTINUED

Page 2 of 2

Date of issue	
LR Office	
PQR certificate number	00001 0000011/1

TEST RESULTS

NON-DESTRUCTIVE EXAMINATION (STATE 'ACCEPTABLE', 'UNACCEPTABLE' OR 'NONE')

Visual	Magnetic particle	Liquid penetrant	Radiography	Ultrasonics

DESTRUCTIVE TESTS

TEST	*TENSILE*	*YIELD*	*% ELONGATION*	*% REDUCTION OF AREA*	*FRACTURE*	*TEST*
Units						
Transverse tensile						
All-weld tensile						

BEND TESTS

ORIENTATION	*FORMER DIAMETER*	*RESULTS*
Root/face/side		
Root/face/side		
Root/face/side		
Root/face/side		
Longitudinal		

FILLET WELD FRACTURE (RESULTS)

1.
2.
3.

Macro examination

IMPACT TESTS

RUN NUMBER	*NOTCH LOCATION/ ORIENTATION*	*TEMP °C*	*VALUES (J)* 1	2	3	*AVERAGE (J)*	*REMARKS*
Requirement							
Size							
Type							
Retest							

HARDNESS SURVEY

Type	Load	Location of hardness measurements (sketch)

	HARDNESS RANGE
Parent Material	
H.A.Z.	
Weld	

Additional test(s) and result(s), eg. chemical analysis, micro examination, ferrite measurement

We certify that the foregoing statements are correct and the test welds were prepared, welded and tested in accordance with the specified Codes or Standards

Signature - Manufacturer	Name in BLOCK CAPITALS	Date
Signature - Surveyor to Lloyd's Register	Name in BLOCK CAPITALS	Date

NOTICE: This certificate is subject to the terms and conditions overleaf, which form part of this certificate

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Appendix E : Aluminium Alloys Specific Requirements

General : The guidelines given in Procedure 0-1 shall be followed for the welding procedure qualification for Aluminium alloys with the following exceptions (For easy reference the clause numbers shown below are the same as that of the corresponding clauses of the main text of Procedure 0-1).

6. **Examination and testing**: *back to main document*

As per table 0-1.6.1 requirements except that

6.1 (Table 0-1.6.1) : For test piece thickness ≥ 12 mm, four side bend specimens may be tested in place of two face and two root bend specimens.

6.2.1 Non-destructive examination may be carried out without 48 hours delay.

6.2.2 Imperfections that are detected by visual or non-destructive examination shall be assessed in accordance with ISO 10042, Class B.

6.3.2 The tensile strength recorded for each specimen must not be less than the minimum required of the transverse tensile test for the corresponding grade of material in Pt 2, Ch 11, Section 9 of the Rules for Ships.

6.3.3.2 Test specimen should be bent over a former having diameter as specified in Pt 2, Ch 11, Section 9 of the Rules for Ships.

6.3.3.3 The minimum angle of bend should be 180 Degrees.

6.3.4, 6.3.5 & 6.3.6 :

For Macro examination and Fracture test the acceptance criteria shall be as per ISO 10042, Class B.

6.3.7 & 6.3.8 :

Hardness and Charpy V-notch impact tests are not required.

7 Range of approval: As per Section 7 of Procedure 0-1 except that:

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7.3 Type of joint *back to main document*

7.3.1 The range of approval for the types of joint in relation to the type of joint used in the procedure qualification test is as follows:

7.3.1.1 Butt weld *back to main document*

7.3.1.1.1 Joint welded from one side without backing qualifies for all types of butt welds.

7.3.1.1.2 Joint welded from one side with backing qualifies also for welding from both sides with gouging.

7.3.1.1.3 Joint welded from both sides without gouging qualifies also for welding from both sides with gouging and from one side with backing.

7.3.1.1.4 Joint welded from both sides with gouging only qualifies that condition.

7.3.1.1.5 Joint welded in any condition qualifies for all types of fillet welds.

7.3.1.2 Fillet weld *back to main document*

7.3.1.2.1 Fillet weld in plate qualifies for fillet weld in pipe and vice-versa.

7.4 Parent metal *back to main document*

The Aluminium alloys are categorised into three groups:

Group A :

Aluminium-magnesium alloys with Mg content < 3.5% (alloy 5754)

Group B :

Aluminium-magnesium alloys with 4% < Mg < 5.6% (alloys 5083 & 5086)

Group C :

Aluminium-magnesium-silicon alloys (alloys 6005A, 6061 and 6082)

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Qualification on any grade qualifies for all other grades of that group. In addition the qualification made on Group B alloy also qualifies the procedure for Group A alloys.

7.5 Welding consumables *back to main document*

7.5.1 The approval range covers the welding consumables with the same, or higher strength, approval grading as the welding consumable used for the procedure qualification test.

7.7 **Welding position** *back to main document*

Welding in the vertical position with downward progression is not normally practised. If it is tested, it qualifies only that position and progression. In the following list, test welding of one position qualifies the procedure for use in that position and in those positions which follow it in the list:

(a) Overhead.

(b) Vertical upward.

(c) Horizontal vertical*.

(d) Downhand.

*Testing in this position also qualifies for welding in the vertical upwards position.

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