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(JWES/JSA)

**Specification and qualification of
welding procedures for metallic
materials — Welding procedure test —
Part 1: Arc and gas welding of steels and
arc welding of nickel and nickel alloys**

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Welding Engineering Society (JWES)/Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS Z 3422-1** : 2003), which has been technically revised.

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Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1 : Arc and gas welding of steels and arc welding of nickel and nickel alloys

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 15614-1** : 2017, Edition 2, and Amendment 1 : 2019, with some modifications of the technical contents.

The dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JC.

All new welding procedure tests based on **JIS** are to be carried out in accordance with this Standard from the date of its issue. However, this Standard does not invalidate previous welding procedure qualification records made to former national standards or specifications or previous issues of this Standard.

This Standard is part of a series of standards dealing with specification and qualification of welding procedures for metallic materials. Annex JB gives details of International Standards dealing with specification and qualification of welding procedures.

1 Scope

This Standard specifies how a preliminary welding procedure specification (hereafter referred to as pWPS) is qualified by welding procedure tests for the arc and gas welding of steels in all product forms and the arc welding of nickel and nickel alloys in all product forms. The principles of this Standard may be applied to other fusion welding processes upon agreement between the contracting parties.

Arc and gas welding are covered by the following processes :

- manual metal arc welding (metal-arc welding with covered electrode);
- self-shielded tubular-cored arc welding;
- submerged arc welding;
- gas-shielded metal arc welding (GMAW);
- gas-shielded arc welding with non-consumable electrode;
- plasma arc welding;
- oxy-acetylene welding.

This Standard applies to production welding, repair welding and overlay welding.

This Standard defines the conditions for the execution of welding procedure tests and the range of qualification for welding procedures for all practical welding operations within the qualification of this Standard.

The primary purpose of welding procedure qualification is to demonstrate that the joining process proposed for construction is capable of producing joints having the required mechanical properties for the intended application.

Two levels of welding procedure tests are given in order to permit application to a wide range of welded fabrication. Level 1 is based on requirements of ASME Section IX and Level 2 is based on the requirements of ISO 15614-1 : 2004. In Level 2, the extent of testing is greater and the ranges of qualification are more restrictive than in Level 1.

Procedure tests carried out to Level 2 automatically qualify for Level 1 requirements, but not vice-versa.

When no level is specified in a contract or application standard, all the requirements of Level 2 apply.

Either Level 1 or Level 2 shall be used, and they shall not be used intermixed.

Specification and qualification of welding procedures that were made in accordance with the previous edition (**JIS Z 3422-1** : 2003) may be used for any application for which the current edition is specified. In this case, the ranges of qualification of the previous edition remain applicable.

It is also possible to create a new range of welding procedure qualification record (hereafter referred to as WPQR) of qualification according to this Standard based on the existing qualified WPQR, provided the technical intent of the testing requirements of this Standard has been satisfied. Where additional tests have to be carried out to make the qualification technically equivalent, it is only necessary to perform the additional test on a test piece prepared according to this Standard.

NOTE The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 15614-1 : 2017 *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1 : Arc and gas welding of steels and arc welding of nickel and nickel alloys + Amendment 1 : 2019 (MOD)*

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

Part or all of the provisions of the following standards, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS Z 2242 *Method for Charpy pendulum impact test of metallic materials*

NOTE 1 Normative reference in the corresponding International Standard : ISO 148-1 *Metallic materials — Charpy pendulum impact test — Part 1 : Test method*

NOTE 2 The **JIS** cited above is not a corresponding standard to but equivalent to the **ISO** Standard given in NOTE 1 in the contents relevant to this Standard.

JIS Z 2320-1 *Non-destructive testing — Magnetic particle testing — Part 1 : General principles*

JIS Z 2343-1 *Non-destructive testing — Penetrant testing — Part 1 : General principles — Method for liquid penetrant testing and classification of the penetrant indication*

NOTE 1 Normative reference in the corresponding International Standard : ISO 3452-1 *Non-destructive testing — Penetrant testing — Part 1 : General principles*

NOTE 2 The **JIS** cited above is not a corresponding standard to but equivalent to the **ISO** Standard given in NOTE 1 in the contents relevant to this Standard.

JIS Z 3001-1 *Welding and allied processes — Vocabulary — Part 1 : General*

JIS Z 3001-4 *Welding and allied processes — Vocabulary — Part 4 : Imperfections in welding*

JIS Z 3001-7 *Welding and allied processes — Vocabulary — Part 7 : Arc welding*

JIS Z 3011 *Welding positions defined by means of angles of slope and rotation*

NOTE 1 Normative reference in the corresponding International Standard : ISO 6947 *Welding and allied processes — Welding positions*

NOTE 2 The **JIS** cited above is not a corresponding standard to but equivalent to the **ISO** Standard given in NOTE 1 in the contents relevant to this Standard.

JIS Z 3060 *Method for ultrasonic testing for welds of ferritic steel*

JIS Z 3090 *Visual testing method of fusion-welded joints*

NOTE 1 Normative reference in the corresponding International Standard : ISO 17637 *Non-destructive testing of welds — Visual testing of fusion-welded joints*

NOTE 2 The **JIS** cited above is not a corresponding standard to but equivalent to the **ISO** Standard given in NOTE 1 in the contents relevant to this Standard.

JIS Z 3104 *Methods of radiographic examination for welded joints in steel*

JIS Z 3106 *Methods of radiographic examination for welded joints in stainless steel*

JIS Z 3110 *Non-destructive testing of welded joints — Methods of radiographic testing for X- and gamma-ray techniques with digital detectors*

NOTE 1 Normative reference in the corresponding International Standard : ISO 17636-2 *Non-destructive testing of welds — Radiographic testing — Part 2 : X- and gamma-ray techniques with digital detectors*

NOTE 2 The **JIS** cited above is not a corresponding standard to but equivalent to the **ISO** Standard given in NOTE 1 in the contents relevant to this Standard.

JIS Z 3121 *Methods of tensile test for butt welded joints*

NOTE 1 Normative reference in the corresponding International Standard : ISO 4136 *Destructive tests on welds in metallic materials — Transverse tensile test*

NOTE 2 The **JIS** cited above is not a corresponding standard to but equivalent to the **ISO** Standard given in NOTE 1 in the contents relevant to this Standard.

JIS Z 3122 *Methods of bend test for butt welded joint*

NOTE 1 Normative reference in the corresponding International Standard : ISO 5173 *Destructive tests on welds in metallic materials — Bend tests*

NOTE 2 The **JIS** cited above is not a corresponding standard to but equivalent to the **ISO** Standard given in NOTE 1 in the contents relevant to this Standard.

JIS Z 3128 *Sampling method of impact test specimen from welded joint*

NOTE 1 Normative reference in the corresponding International Standard : ISO 9016 *Destructive tests on welds in metallic materials — Impact tests — Test specimen location, notch orientation and examination*

NOTE 2 The **JIS** cited above is not a corresponding standard to but equivalent to the **ISO** Standard given in NOTE 1 in the contents relevant to this Standard.

JIS Z 3253 *Shielding gases for fusion welding and thermal cutting*

NOTE 1 Normative reference in the corresponding International Standard : ISO 14175 *Welding consumables — Gases and gas mixtures for fusion welding and allied processes*

NOTE 2 The **JIS** cited above is not a corresponding standard to but equivalent to the **ISO** Standard given in NOTE 1 in the contents relevant to this Standard.

JIS Z 3420 *Specification and qualification of welding procedures for metallic materials — General rules*

JIS Z 3421-1 *Specification and approval of welding procedures for metallic materials — Welding procedure specification for arc welding*

NOTE 1 Normative reference in the corresponding International Standard : ISO 15609-1 *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 1 : Arc welding*

NOTE 2 The **JIS** cited above is not a corresponding standard to but equivalent to the **ISO** Standard given in NOTE 1 in the contents relevant to this Standard.

ISO 5817 *Welding — Fusion-welded joints in steel, nickel, titanium and their al-*

loys (beam welding excluded) — Quality levels for imperfections

- ISO 6520-1 *Welding and allied processes — Classification of geometric imperfections in metallic materials — Part 1 : Fusion welding*
- ISO 9015-1 *Destructive tests on welds in metallic materials — Hardness testing — Part 1 : Hardness test on arc welded joints*
- ISO 15609-2 *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 2 : Gas welding*
- ISO 15613 *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test*
- ISO 17636-1 *Non-destructive testing of welds — Radiographic testing — Part 1 : X- and gamma-ray techniques with film*
- ISO 17638 *Non-destructive testing of welds — Magnetic particle testing*
- ISO 17639 *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*
- ISO 17640 *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment*
- ISO/TR 15608 *Welding — Guidelines for a metallic materials grouping system*
- ISO/TR 17671-1 *Welding — Recommendations for welding of metallic materials — Part 1 : General guidance for arc welding*
- ISO/TR 18491 *Welding and allied processes — Guidelines for measurement of welding energies*
- ISO/TR 20174 *Welding — Grouping systems for materials — Japanese materials*

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions, and those given in JIS Z 3001-1, JIS Z 3001-4, JIS Z 3001-7 and JIS Z 3420 apply.

3.1

run out length

length of a run produced by the melting of a covered electrode

Note 1 to entry See ISO/TR 17671-2.

4 pWPS

The pWPS shall be prepared in accordance with JIS Z 3421-1 or ISO 15609-2.

5 Welding procedure test

The welding and testing of test pieces shall be in accordance with Clause 6 and Clause 7.

The welder or welding operator who undertakes the welding procedure test satisfactorily in accordance with this Standard is qualified according to the relevant national/International Standard being applied, provided that the relevant testing requirements of that standard are met.

6 Test piece

6.1 General

The welded joint to which the welding procedure will relate in production shall be represented by making a standard test piece or pieces, as specified in **6.2**.

If required by the application standard, the direction of plate rolling shall be marked on the test piece when impact tests are required to be taken in the heat-affected zone and shall be mentioned in the impact test report.

Other general matters shall be according to either of the following levels.

- a) **Level 1** Any butt joint test qualifies all joint configurations.
- b) **Level 2** Where the joint requirements and/or dimension of the test piece are not covered by the standard test pieces as shown in this Standard, the use of **ISO 15613** shall be required.

6.2 Shape and dimensions of test pieces

6.2.1 General

The length or number of test pieces shall be sufficient to allow all required tests to be carried out.

Additional test pieces, or longer test pieces than the minimum size, may be prepared in order to allow for extra testing and/or for re-testing specimens.

For all test pieces except branch connections (see Figure 4) and T-joints (T-butt weld or fillet weld; see Figure 3), the material thickness, t , and the diameter, D , shall be the same for both plates and pipes on the required length of the test piece to be welded.

The thickness and/or pipe outside diameter of the test pieces shall be selected in accordance with **8.3.2** and **8.3.3**.

6.2.2 Butt joint in plate with full penetration

The test piece shall be prepared in accordance with Figure 1.

6.2.3 Butt joint in pipe with full penetration

The test piece shall be prepared in accordance with Figure 2.

NOTE The word “pipe”, alone or in combination, is used to mean “pipe”, “tube” or “hollow section”.

6.2.4 T-joint

The test piece shall be prepared in accordance with Figure 3. This test piece applies to fully penetrated butt welds or fillet welds.

6.2.5 Branch connection

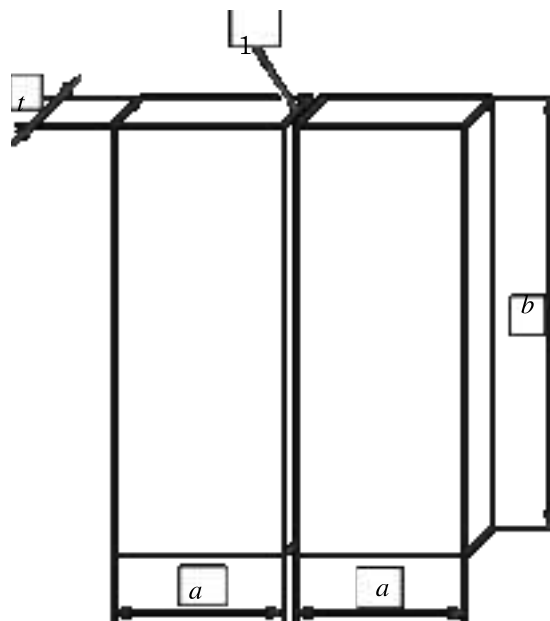
Test pieces of branch connection shall be according to either of the following levels.

- a) **Level 1** No specific test piece required.
- b) **Level 2** The test piece shall be prepared in accordance with Figure 4. The angle α is the minimum one used in production. This test piece applies to fully penetrated joints (set-on, set-in or set-through joint) and for fillet welds.

6.3 Welding of test pieces

Preparation and welding of test pieces shall be carried out in accordance with the pWPS, which they shall represent. Welding positions and limitations for the angle of slope and rotation of the test piece shall be in accordance with **JIS Z 3011**. If tack welds are to be fused into the final joint, they shall be included in the test piece.

The welding and the testing of the test piece shall be verified by the examiner or examining body.



Key

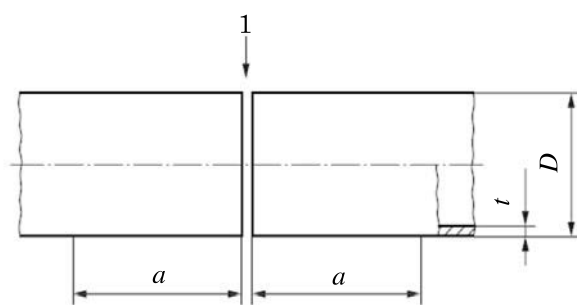
1 : joint preparation and fit-up as detailed in the pWPS

a : minimum dimension 150 mm

b : minimum dimension 350 mm

t : material thickness

Figure 1 Test piece for a butt joint in plate with full penetration



Key

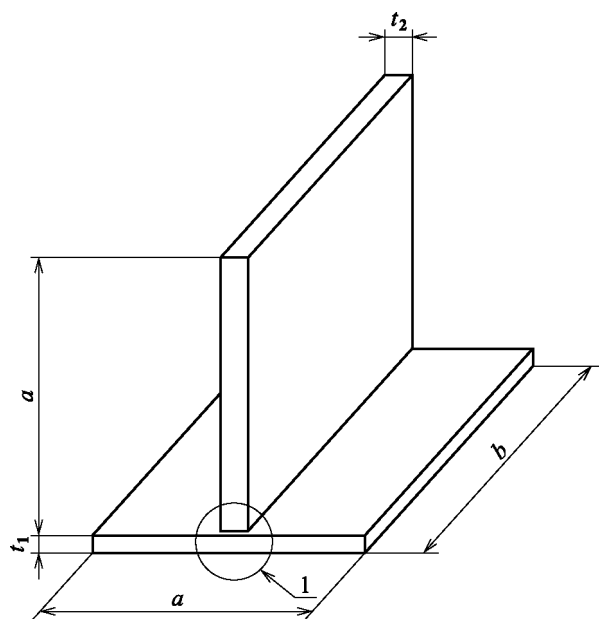
1: joint preparation and fit-up as detailed in the pWPS

a : minimum dimension 150 mm

D : outside pipe diameter

t : material thickness

Figure 2 Test piece for a butt joint in pipe with full penetration



Key

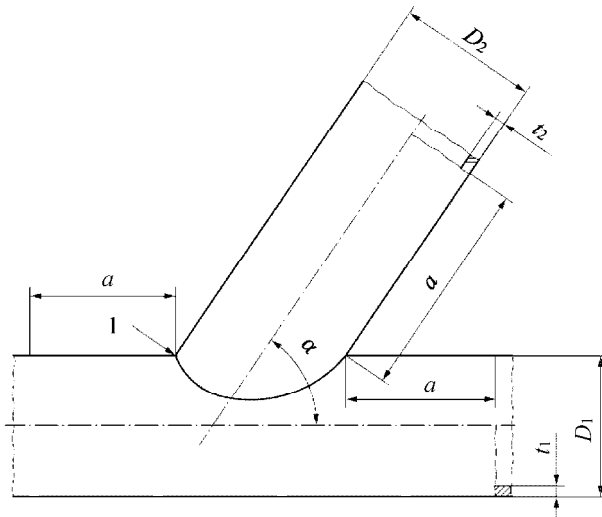
1: joint preparation and fit-up as detailed in the pWPS

a : minimum dimension 150 mm

b : minimum dimension 350 mm

t_1, t_2 : material thickness

Figure 3 Test piece for a T-joint



Key

- 1: joint preparation and fit-up as detailed in the pWPS
- α : branch angle
- a : minimum dimension 150 mm
- D_1 : outside diameter of main pipe
- D_2 : outside diameter of branch pipe
- t_1 : main pipe material thickness
- t_2 : branch pipe material thickness

Figure 4 Test piece for a branch connection

7 Examination and testing

7.1 Type and extent of testing

Type and the extent of testing shall be according to either of the following levels.

- a) **Level 1** Type and the extent of testing shall be in accordance with the requirements of Table 1. If impact testing, hardness testing or non-destructive testing (hereafter referred to as NDT) is required by an application standard or specification, they shall be carried out and assessed in accordance with the requirements of Level 2, unless otherwise specified by the application standard or specification.
- b) **Level 2** Type and the extent of testing shall be in accordance with the requirements of Table 2.

An application standard may specify additional tests, e.g., :

- longitudinal weld tensile test;
- all weld metal bend test;
- corrosion test;
- chemical analysis;
- microscopic examination;

- delta ferrite examination of austenitic stainless steel;
- hardness test;
- cruciform test;
- impact test;
- NDT.

NOTE Specific service, material or manufacturing conditions may require more comprehensive testing than is specified by this Standard in order to gain more information and to avoid repeating the welding procedure test at a later date just to obtain additional test data.

Table 1 For Level 1 : Examination and testing of the test pieces

Test piece	Type of test	Extent of testing	Footnote
Butt joint with full penetration See Figure 1 and Figure 2	Visual testing	100 %	a)
	Transverse tensile test	2 specimens	
	Transverse bend test	4 specimens	
T-joint See Figure 3	Visual testing	100 %	b)
	Macroscopic examination	2 specimens	
Note a) For bend test, see 7.4.2 .			
Note b) Where mechanical properties are required by an application standard, it shall be tested accordingly. If an additional test piece is needed, the dimensions should be sufficient enough to allow testing of the mechanical properties. For this additional test piece, the welding parameter range, parent material group, filler metal and heat treatment are required to be the same.			

Table 2 For Level 2 : Examination and testing of the test pieces

Test piece	Type of test	Extent of testing	Footnote
Butt joint with full penetration See Figure 1 and Figure 2	Visual testing	100 %	—
	Radiographic or ultrasonic testing	100 %	a)
	Surface crack detection	100 %	b)
	Transverse tensile test	2 specimens	—
	Transverse bend test	4 specimens	c)
	Impact test	2 sets	d)
	Hardness test	required	e)
T-joint with full penetration See Figure 3 Branch connection with full penetration See Figure 4 ^{d)}	Macroscopic examination	1 specimen	—
	Visual testing	100 %	—
	Surface crack detection	100 %	b)
	Ultrasonic or radiographic testing	100 %	a), g)
	Hardness test	required	e)
T-joint and branch connection See Figure 3 and Figure 4 ^{d)}	Macroscopic examination	2 specimens	—
	Visual testing	100 %	—
	Surface crack detection	100 %	b)
	Hardness test	required	e)
	Macroscopic examination	2 specimens	—
	Visual testing	100 %	—
	Surface crack detection	100 %	b)
	Hardness test	required	e)
Note ^{a)} Ultrasonic testing shall not be used for $t < 8$ mm and not for material groups 8, 10, 41 to 48 (see Table 5 and Table 6). Note ^{b)} Accessible weld surfaces: penetrant testing or magnetic particle testing. For non-magnetic materials, penetrant testing. Note ^{c)} For bend tests, see 7.4.2. Note ^{d)} One set in the weld metal and one set in the heat-affected zone for materials ≥ 12 mm thick and having specified impact properties required by technical delivery conditions and/or if appropriate according to the service conditions. Application standards may require impact testing below 12 mm thick. The testing temperature shall be chosen by the manufacturer with regard to the application or application standards. For additional tests, see 7.4.4. Note ^{e)} Not required for parent metals: sub-group 1.1, groups 8 and 41 to 48 and dissimilar joints between these groups, except for dissimilar joints between sub-group 1.1 and group 8 (see Table 5 and Table 6). Note ^{f)} Where mechanical properties are required by an application standard, it shall be tested accordingly. If an additional test piece is needed, the dimensions should be sufficient enough to allow testing of the mechanical properties. For this additional test piece, the welding parameter range, parent material group, filler metal and heat treatment are required to be the same. Note ^{g)} For outside diameter ≤ 50 mm, no ultrasonic testing is required, but radiographic testing is required provided that the joint configuration will provide valid results. For outside diameter > 50 mm and where it is not technically possible to carry out ultrasonic testing, a radiographic testing shall be carried out provided that the joint configuration will provide valid results.			

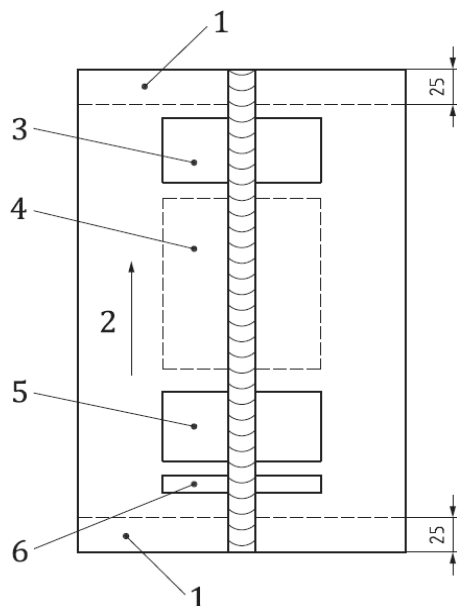
7.2 Location and taking of test specimens

Test specimens shall be taken in accordance with Figure 5 to Figure 8.

For location of hardness and impact specimens, 8.4.2 shall be considered.

It is acceptable to take the test specimens from locations avoiding areas which have imperfections within the acceptance limits for the NDT method(s) used.

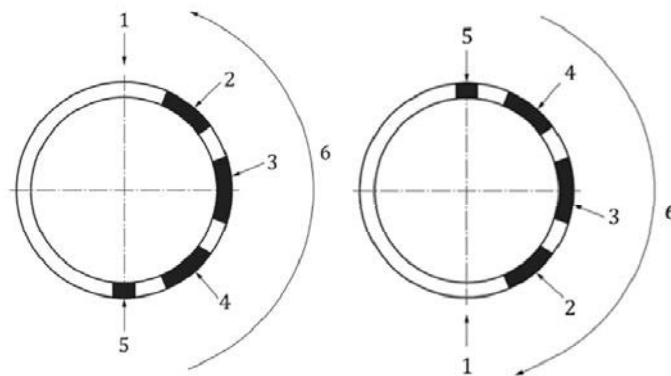
Unit: mm



Key

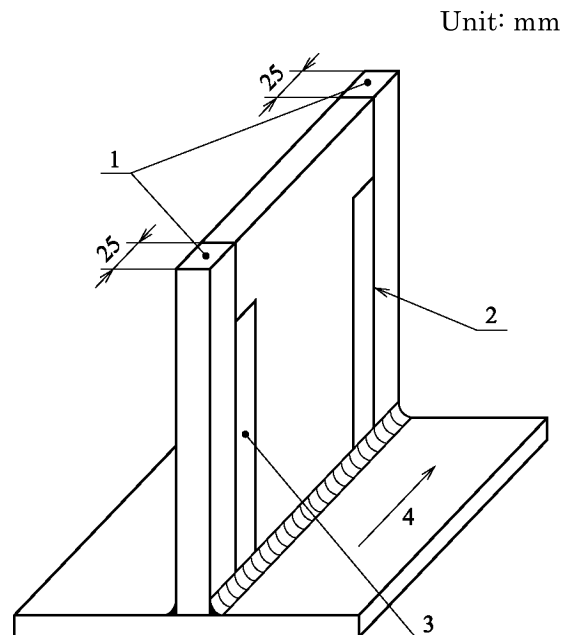
- | | |
|--------------------------------|----------------------------|
| 1 : discard 25 mm | 5 : area 3 |
| 2 : welding directions | — 1 tensile test specimen |
| 3 : area 1 | — bend test specimens |
| — 1 tensile test specimen | 6 : area 4 |
| — bend test specimens | — 1 macro test specimen |
| 4 : area 2 | — 1 hardness test specimen |
| — impact test specimens and | |
| — additional test specimens if | |
| required | |

Figure 5 Location of test specimens for a butt joint in plate



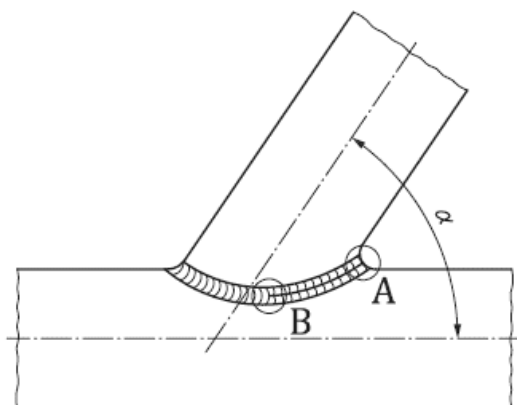
- Key
- | | |
|---|---|
| 1 : end of weld | 4 : area 3 |
| 2 : area 1 | — 1 tensile test specimen |
| — 1 tensile test specimen | — bend test specimens |
| — bend test specimens | 5 : start of weld : |
| 3 : area 2 | — 1 macro test specimen |
| — impact test specimens | — 1 hardness test specimen (taken from the start of weld) |
| — additional test specimens if required | 6 : welding direction |

Figure 6 Location of test specimens for a butt joint in pipe



- Key
- | |
|--------------------------------------|
| 1 : discard 25 mm |
| 2 : macro test specimen |
| 3 : macro and hardness test specimen |
| 4 : welding direction |

Figure 7 Location of test specimens in a T-joint



Key
A : macro and hardness test specimen to be taken
B : macro test specimen to be taken
 α : branch angle

Figure 8 Location of test specimens for a branch connection on pipe

7.3 NDT

All NDT in accordance with 7.1 shall be carried out and accepted on the test pieces prior to cutting of the test specimens. The discard (see Figure 5 and Figure 7) shall not be considered for NDT. Any post-weld heat-treatment (hereafter referred to as PWHT) that is specified shall be completed prior to NDT.

For materials that are susceptible to hydrogen induced cracking and where no post-heating or no PWHT is specified, NDT shall be delayed.

Depending upon joint geometry, materials and the requirements for work, the NDT shall be carried out as required in Table 1 and Table 2 in accordance with JIS Z 3090 (visual testing), JIS Z 3104, JIS Z 3106, ISO 17636-1 or JIS Z 3110 (radiographic testing), JIS Z 3060 or ISO 17640 (ultrasonic testing), JIS Z 2343-1 (penetrant testing) and JIS Z 2320-1 or ISO 17638 (magnetic particle testing). Acceptance levels shall be in accordance with 7.5.

7.4 Destructive testing

7.4.1 Transverse tensile test

Specimens and testing for transverse tensile testing for butt joint shall be in accordance with JIS Z 3121. The test shall represent the whole thickness except as necessary to obtain parallel sides on the specimens. Tensile testing shall ensure all welding processes used and the associated essential variables are tested.

For pipes >50 mm outside diameter, the excess weld metal shall be removed on both faces to give the test specimen a thickness equal to the wall thickness of the pipe.

For pipes ≤ 50 mm outside diameter, for which the transverse tensile test is performed on the full pipe, the excess weld metal may be left undressed on the inside sur-

face of the pipe.

The tensile strength of the test specimen shall not be less than the corresponding specified minimum value for the parent metal unless otherwise specified prior to testing.

For dissimilar parent metal joints, the tensile strength shall not be less than the minimum value specified for the parent material having the lowest tensile strength.

NOTE The transverse tensile test is permitted to be performed on the full pipe with an outside diameter of less than 50 mm in JIS Z 3121, but of 50 mm or less in this Standard.

7.4.2 Bend test

Specimens and testing for bend testing for butt joints shall be in accordance with JIS Z 3122 and shall be as follows.

For thicknesses <12 mm, two root and two face bend test specimens shall be tested. For thicknesses ≥12 mm, four side bend specimens may be used instead of root and face bend test specimens.

For dissimilar metal joints or heterogeneous butt joints in plates, one root and one face longitudinal bend test specimen may be used instead of four transverse bend test specimens (two root and two face bend test specimens).

During testing, the test specimens shall not reveal any imperfection >3 mm in any direction. Imperfections appearing at the corners of a test specimen during testing shall be ignored in the evaluation.

7.4.3 Macroscopic examination

The test specimen shall be prepared and etched in accordance with **ISO 17639** on one side to clearly reveal the fusion line, the heat-affected zone and the build-up of the runs.

The test specimen shall include unaffected parent metal and shall be recorded by at least one photograph of macro cross-section per procedure test.

The acceptance levels shall be in accordance with **7.5**.

7.4.4 Impact testing

Test specimens and testing for impact tests shall be in accordance with this Standard for location of specimens and temperature of testing, and with JIS Z 3128 for dimensions and testing. The striker radius of 2 mm according to JIS Z 2242 shall be used, unless otherwise specified.

For weld metal, test specimen Type VWT (V : Charpy V-notch - W : notch in weld metal - T : notch through the thickness) and for heat-affected zone specimen Type VHT (V : Charpy V-notch - H : notch in heat-affected zone - T : notch through the thickness) shall be used. From each specified location, each set shall be comprised of three specimens.

Specimens shall be sampled from a maximum of 2 mm below the upper surface of the

parent metal and transverse to the weld.

In the heat-affected zone, the mid-point of the notch shall be at 1 mm to 2 mm from the fusion line. In the weld metal, the mid-point of the notch shall be at the weld centreline.

For butt joints where the material thickness is $t > 50$ mm, two additional sets of specimens shall be taken from the root area, one set taken in the weld and one set taken from the heat-affected zone.

For joints between materials with the same material specification and designation, the absorbed energy shall be in accordance with the appropriate parent material standard unless modified by the application standards.

For dissimilar metal joints, impact tests shall be carried out on specimens from the heat-affected zone in each parent metal and the absorbed energy shall be in accordance with the appropriate parent material standard.

The average value of the three specimens shall meet the specified requirements. For each notch location, one individual value may be below the minimum average value specified, provided that it is not less than 70 % of that value.

Where more than one welding process or type of covering and fluxes are qualified in a single test piece, additional impact test specimens shall be taken from the weld metal and heat-affected zone that include each process and type of covering and fluxes.

7.4.5 Hardness testing

Vickers hardness testing with a load of HV10 shall be performed in accordance with **ISO 9015-1**. Hardness measurements shall be taken in the weld, the heat-affected zones and the parent metal in order to evaluate the range of hardness values across the welded joint.

For weld thicknesses less than or equal to 5 mm, only one row of indentations shall be made at a depth of up to 2 mm below the upper surface of the welded joint.

For weld thicknesses over 5 mm, one row of indentation from each side shall be made at a depth of up to 2 mm from the surface.

For double sided welds, one additional row of indentations shall be made through the root area. Examples of typical indentation patterns are given in **ISO 9015-1**.

Where more than one welding process is used, each welding process has to be tested by at least one row of indentation.

For each row of indentation at least three individual indentations shall be made in each of the following areas :

- the weld;
- both heat-affected zones;
- both parent metals.

For the heat-affected zone, the first indentation shall be placed as close to the fusion