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for pressure vessels**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry and the Minister of Health, Labour and Welfare through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by the High Pressure Gas Safety Institute of Japan (KHK)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS B 8285**:2003 is replaced with this Standard.

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Welding procedure qualification test for pressure vessels

1 Scope

This Japanese Industrial Standard specifies the welding procedure qualification test for pressure vessels.

This Standard is also applicable to boilers.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall be applied and the revisions (including amendments) made thereafter shall not be applied. For those without the indication of the year, the most recent edition (including amendments) shall be applied.

JIS G 3101 *Rolled steels for general structure*

JIS G 3103 *Carbon steel and molybdenum alloy steel plates for boilers and pressure vessels*

JIS G 3106 *Rolled steels for welded structure*

JIS G 3115 *Steel plates for pressure vessels for intermediate temperature service*

JIS G 3116 *Steel sheet, plates and strip for gas cylinders*

JIS G 3118 *Carbon steel plates for pressure vessels for intermediate and moderate temperature services*

JIS G 3119 *Manganese-molybdenum and manganese-molybdenum-nickel alloy steel plates for boilers and pressure vessels*

JIS G 3120 *Manganese-molybdenum and manganese-molybdenum-nickel alloy steel plates quenched and tempered for pressure vessels*

JIS G 3124 *High strength steel plates for pressure vessel for intermediate and moderate temperature service*

JIS G 3126 *Carbon steel plates for pressure vessels for low temperature service*

JIS G 3127 *Nickel steel plates for pressure vessels for low temperature services*

JIS G 3128 *High yield strength steel plates for welded structure*

JIS G 3201 *Carbon steel forgings for general use*

JIS G 3202 *Carbon steel forgings for pressure vessels*

JIS G 3203 *Alloy steel forgings for pressure vessels for high-temperature service*

JIS G 3204 *Quenched and tempered alloy steel forgings for pressure vessels*

JIS G 3205 *Carbon and alloy steel forgings for pressure vessels for low-temperature service*

JIS G 3206 *High strength chromium-molybdenum alloy steel forgings for pressure vessels under high-temperature service*

- JIS G 3214 *Stainless steel forgings for pressure vessels*
- JIS G 3452 *Carbon steel pipes for ordinary piping*
- JIS G 3454 *Carbon steel pipes for pressure service*
- JIS G 3455 *Carbon steel pipes for high pressure service*
- JIS G 3456 *Carbon steel pipes for high temperature service*
- JIS G 3457 *Arc welded carbon steel pipes*
- JIS G 3458 *Alloy steel pipes*
- JIS G 3459 *Stainless steel pipes*
- JIS G 3460 *Steel pipes for low temperature service*
- JIS G 3461 *Carbon steel boiler and heat exchanger tubes*
- JIS G 3462 *Alloy steel tubes for boiler and heat exchanger*
- JIS G 3463 *Stainless steel boiler and heat exchanger tubes*
- JIS G 3464 *Steel heat exchanger tubes for low temperature service*
- JIS G 3467 *Steel tubes for fired heater*
- JIS G 3468 *Large diameter welded stainless steel pipes*
- JIS G 4051 *Carbon steels for machine structural use*
- JIS G 4109 *Chromium-molybdenum alloy steel plates for boilers and pressure vessels*
- JIS G 4110 *High strength chromium-molybdenum and chromium-molybdenum-vanadium alloy steel plates for pressure vessels under high-temperature service*
- JIS G 4303 *Stainless steel bars*
- JIS G 4304 *Hot-rolled stainless steel plate, sheet and strip*
- JIS G 4305 *Cold-rolled stainless steel plate, sheet and strip*
- JIS G 4311 *Heat-resisting steel bars*
- JIS G 4312 *Heat-resisting steel plates and sheets*
- JIS G 4901 *Corrosion-resisting and heat-resisting superalloy bars*
- JIS G 4902 *Corrosion-resisting and heat-resisting superalloy plates and sheets*
- JIS G 4903 *Seamless nickel-chromium-iron alloy pipes*
- JIS G 4904 *Seamless nickel-chromium-iron alloy heat exchanger tubes*
- JIS G 5101 *Carbon steel castings*
- JIS G 5102 *Steel castings for welded structure*
- JIS G 5111 *High tensile strength carbon steel castings and low alloy steel castings for structural purposes*
- JIS G 5121 *Corrosion-resistant cast steels for general applications*
- JIS G 5151 *Steel castings for high temperature and high pressure service*
- JIS G 5152 *Steel castings for low temperature and high pressure service*

- JIS G 5201 *Centrifugally cast steel pipes for welded structure*
- JIS G 5202 *Centrifugally cast steel pipes for high temperature and high pressure service*
- JIS H 3100 *Copper and copper alloy sheets, plates and strips*
- JIS H 3250 *Copper and copper alloy rods and bars*
- JIS H 3300 *Copper and copper alloy seamless pipes and tubes*
- JIS H 3320 *Copper and copper alloy welded pipes and tubes*
- JIS H 4000 *Aluminium and aluminium alloy sheets, strips and plates*
- JIS H 4040 *Aluminium and aluminium alloy rods, bars and wires*
- JIS H 4080 *Aluminium and aluminium alloys extruded tubes and cold-drawn tubes*
- JIS H 4090 *Aluminium and aluminium alloy welded pipes and tubes*
- JIS H 4100 *Aluminium and aluminium alloy extruded shape*
- JIS H 4140 *Aluminium and aluminium alloy forgings*
- JIS H 4551 *Nickel and nickel alloy plate, sheet and strip*
- JIS H 4552 *Nickel and nickel alloy seamless pipes and tubes*
- JIS H 4553 *Nickel and nickel alloy bars*
- JIS H 4600 *Titanium and titanium alloys—Sheets, plates and strips*
- JIS H 4630 *Titanium and titanium alloys—Seamless pipes*
- JIS H 4631 *Titanium and titanium alloy tubes for heat exchangers*
- JIS H 4635 *Titanium and titanium alloy welded pipes*
- JIS H 4650 *Titanium and titanium alloys—Rods and bars*
- JIS H 4751 *Zirconium alloy tubes*
- JIS Z 2242 *Method for Charpy pendulum impact test of metallic materials*
- JIS Z 2343-1 *Non-destructive testing—Penetrant testing—Part 1: General principles—Method for liquid penetrant testing and classification of the penetrant indication*
- JIS Z 2343-2 *Non-destructive testing—Penetrant testing—Part 2: Testing of penetrant materials*
- JIS Z 2343-3 *Non-destructive testing—Penetrant testing—Part 3: Reference test blocks*
- JIS Z 2343-4 *Non-destructive testing—Penetrant testing—Part 4: Equipment*
- JIS Z 3001-1 *Welding and allied processes—Vocabulary—Part 1: General*
- JIS Z 3001-2 *Welding and allied processes—Vocabulary—Part 2: Welding processes*
- JIS Z 3043 *Method of welding procedure qualification test for stainless-clad steel*
- JIS Z 3044 *Method of welding procedure qualification test for nickel and nickel alloy clad steels*
- JIS Z 3121 *Methods of tensile test for butt welded joints*

- JIS Z 3122 *Methods of bend test for butt welded joint*
- JIS Z 3211:2000 *Covered electrodes for mild steel*
- JIS Z 3212:2000 *Covered electrodes for high tensile strength steel*
- JIS Z 3221:2003 *Stainless steel covered electrodes*
- JIS Z 3223:2000 *Molybdenum steel and chromium molybdenum steel covered electrodes*
- JIS Z 3224:1999 *Nickel and Nickel-alloy covered electrodes*
- JIS Z 3225:1999 *Covered electrodes for 9 % nickel steel*
- JIS Z 3231:1999 *Copper and copper alloy covered electrodes*
- JIS Z 3232:2000 *Aluminium and aluminium alloy welding rods and wires*
- JIS Z 3241:1999 *Covered electrodes for low temperature service steel*
- JIS Z 3312:1999 *MAG welding solid wires for mild steel and high strength steel*
- JIS Z 3313:1999 *Flux cored wires for gas shielded and self-shielded metal arc welding of mild steel, high strength steel and low temperature service steel*
- JIS Z 3316:2001 *TIG welding rods and solid wires for mild steel and low alloy steel*
- JIS Z 3317:1999 *MAG welding solid wires for molybdenum steel and chromium molybdenum steel*
- JIS Z 3318:1999 *MAG welding flux cored wires for molybdenum steel and chromium molybdenum steel*
- JIS Z 3321:2003 *Stainless steel, welding rods and solid wires*
- JIS Z 3323:2003 *Stainless steel flux cored wires*
- JIS Z 3324:1999 *Stainless steel solid wires and fluxes for submerged arc welding*
- JIS Z 3325:2000 *MAG welding solid wires for low temperature service steel*
- JIS Z 3331:2002 *Titanium and titanium alloy welding rods and solid wires*
- JIS Z 3332:1999 *Filler rods and solid wires for TIG welding of 9 % nickel steel*
- JIS Z 3333:1999 *Submerged arc welding solid wires and fluxes for 9 % nickel steel*
- JIS Z 3334:1999 *Nickel and nickel alloy filler rods and solid wires for arc welding*
- JIS Z 3341:1999 *Copper and copper alloy rods and solid wires for inert gas shielded arc welding*
- JIS Z 3351:1999 *Submerged arc welding solid wires for carbon steel and low alloy steel*
- JIS Z 3352:1988 *Submerged arc welding fluxes for carbon steel and low alloy steel*

3 Terms and definitions

For the purposes of this Standard, the terms and definitions given in **JIS Z 3001-1** and **JIS Z 3001-2** apply.

4 Classification of welding procedures

Classification of the welding procedures is made according to the combination of respective items as the following **a)** to **k)** regarding the welding method practically applied.

- a) **Welding method** Welding methods are classified according to the types of the welding method as given in table 1 or the combination thereof.

Table 1 Classification of welding methods

Classification of welding methods	Type	Classification of welding operations
A	Metal-arc welding	Manual
U	Submerged arc welding	Automatic
T	TIG welding	Manual, semi-automatic and automatic
M	MIG or MAG welding	Semi-automatic and automatic
P	Plasma arc welding	Semi-automatic and automatic
S	Other welding ^{a)}	Manual, semi-automatic and automatic
NOTE : Classification of welding operations is not the classification of the welding procedure; however it may be indicated in the reports on the implementation results or the like.		
Note ^{a)} The classification is on respective types of other welding.		

- b) **Type of parent material** Classification of the types of parent material to be qualified (hereafter referred to as “parent material”) shall be the combination of the P number and the group number in the case where the P number and the group number in table A.1 are assigned, while being made by the type of the parent material for others in the case where not indicated in table A.1.

When the parent materials of two or more classifications are welded, that combination shall be defined as one classification.

- c) **Thickness of parent material** Classification of the thicknesses of parent material to be qualified and the thicknesses of test specimen shall be as given in table 2.

Table 2 Classification of thickness of parent material to be qualified and thickness of test specimen

Unit: mm

Thickness of test specimen (t)	Classification of thickness of parent material to be qualified (T)
Under 1.5	t or over to and incl. $2t$
1.5 or over to and excl. 10	1.5 or over to and incl. $2t$
10 or over to and excl. 150	5 or over to and incl. $2t$ (200 in maximum)
— When the thickness of test specimen is 150 mm or more, $1.33t$ shall be the upper limit of T. — The upper limit of T shall be $1.1t$ in the case where the test is carried out under the following conditions. a) When any of passes exceed 13 mm in thickness. b) In the case of the short circuiting transfer welding where t does not exceed 13 mm. c) When one-side 1 pass welding is carried out. d) When the heat treatment temperature after welding exceeds the A_{c3} transformation temperature. — When the impact test is required, the lower limit of T shall be the smaller one of either t or 16 mm. When t does not exceed 5 mm, $0.5t$ shall be used. — The thickness shall be the nominal thickness.	

d) **Welding consumables**

- 1) **Covered electrode** Classification of the covered electrodes shall be as given in table B.1. For other covered electrodes than those in this table, the classification shall be made according to the combination of respective types and compositions thereof.

When the covered electrodes of two or more classifications are used together, the combination thereof shall be defined as one classification.

- 2) **Welding wire and filler material**

- 2.1) **MIG or MAG welding wire and filler material** Classification of the MIG or MAG welding wires and the filler materials shall be as given in table B.2. However, the solid wire and the flux-cored wire shall be classified separately. For other welding wires and filler materials than those in this table, the classification shall be made according to the combination of respective types and compositions thereof.
- 2.2) **Submerged arc welding wire** Classification of the submerged arc welding wires (including strip electrodes) shall be as given in table B.3. For other welding wires than those in this table, the classification shall be made according to the combination of respective types and compositions thereof.
- 3) **Submerged arc welding flux** Classification of the submerged arc welding fluxes shall be as given in table B.4. For other fluxes than those in this table, the classification shall be made according to the combination of respective types and compositions thereof.

- 4) **Fusible insert** Classification of filler materials such as the fusible insert shall be made according to the use or the non-use of filler materials.

When the filler material such as the fusible insert is used, the classification shall be made according to the combination of respective types and compositions thereof.

- e) **Shielding gas** Classification of the shielding gas shall be with or without it.

When the shielding gas is used, the classification shall be made according to the types of shielding gases. When two or more shielding gases are used together, the classification shall be made according to the combination of respective types and the mixing ratio thereof.

- f) **Gas protection from back** Classification of the gas protection shall be with or without it.

- g) **Backing** Classification of the backing shall be with or without it.

When the backing is used, the classification shall be made according to the types of material thereof.

- h) **Electrode** Classification of the electrodes shall be made according to the number of electrodes.

- i) **Preheating** Classification of the preheating shall be with or without it.

When the preheating is carried out, the classification shall be made according to the lower limit of the preheating temperature.

- j) **Post weld heat treatment** Classification of the post weld heat treatment shall be with or without it.

When the post weld heat treatment is carried out, the classification shall be made according to the combination of the retention temperature and the minimum retention time.

- k) **Impact test** The impact test, if required, shall be as follows.

- 1) Test temperature shall be classified according to the lower limit thereof.
- 2) Welding position shall be classified according to respective welding positions.
- 3) Interpass temperature shall be classified according to the upper limit thereof.
- 4) Number of layers shall be classified into to the multi-layer or the single-layer on one side.
- 5) Energy input per unit length on welding shall be classified according to the upper limit of heat input.

The heat input shall be calculated according to the following formula.

$$H = \frac{60EI}{V}$$

where, H : heat input (J/cm)
 E : voltage (V)

I : current (A)

V : welding speed (cm/min)

5 Qualification tests

5.1 Preparation of test specimen

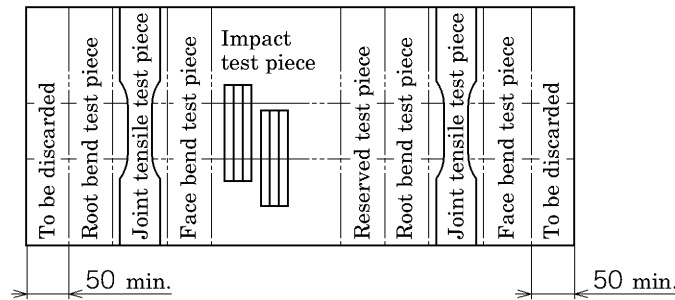
The test specimen shall be prepared by the following methods according to the classification of welding procedures of clause 4.

In the case of the welded joint of plates and tubes, the test specimen shall be the butt welded joint.

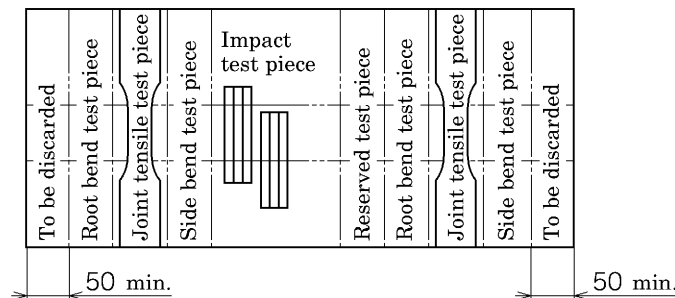
- a) **Welded joint of plate** The sampling method of the test specimen and the test piece shall be as given in figure 1. The welding position of test specimen shall be the flat position. However, this does not apply to the case where the flat position welding is unsuitable for the welding which requires the impact test, etc.

When the test specimen has different values in elongation between the different parent materials or between the test specimen and the weld metal, the test specimen and the test pieces shall be taken by interpreting the face bend test, root bend test and side bend test as the longitudinal bend test specified in **JIS Z 3122**. In this case, the test pieces may be taken from the test specimens separately prepared for the joint tensile test and for the longitudinal bend test, etc. The full width of the test specimen for sampling of the longitudinal bend test piece, etc. shall be 150 mm or more.

Unit: mm



a) Test specimen of less than 19 mm in thickness



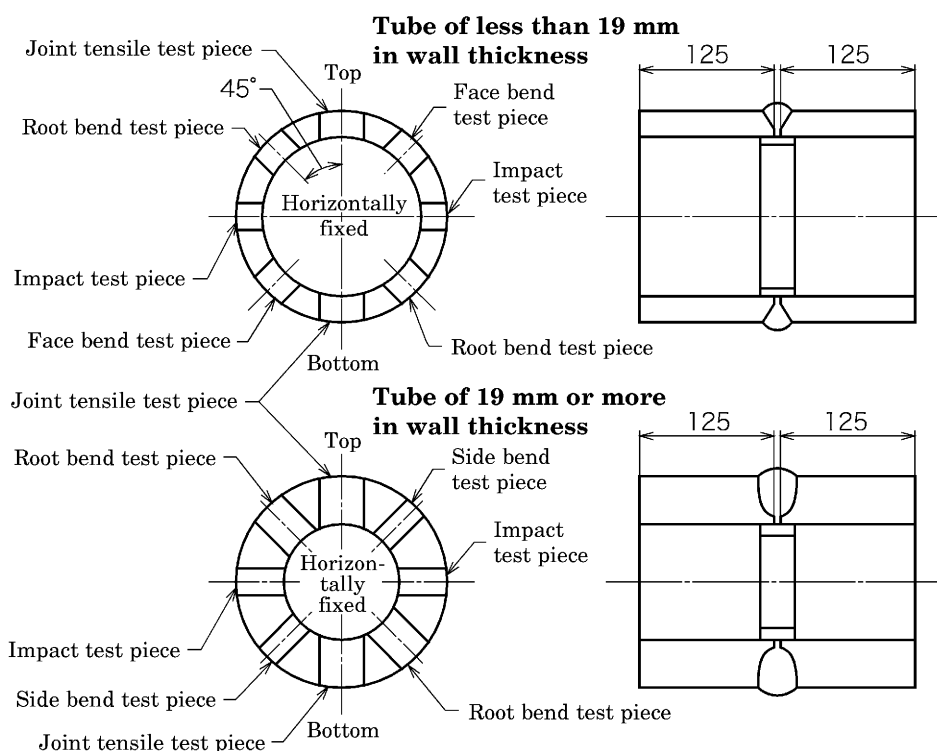
b) Test specimen of 19 mm or more in thickness

- The length and the width of test specimen shall be large enough for sampling test pieces.
- The shape of groove of joint shall be made suitable for the welding method.
- In the case of double-side welding of 19 mm or more in thickness, the “root bend test piece” in figure 1 b) shall be read as the “face bend test piece”.
- The impact test shall be carried out, if required. The number of impact test pieces shall be three from each of the heat-affected zone and the weld metal. However, where different parent materials are used, the number of impact test pieces shall be three from the heat affected zones of respective parent materials and three from the weld metal (see table 3).
- The cutting-off of test piece shall be mechanical cutting or thermal cutting. In the case of thermal cutting, the margin of cutting shall be 3 mm or more.
- The sampling position of each test piece is only exemplification.

Figure 1 Sampling method of test specimens and test pieces (for plate)

- b) **Welded joint of tube** When the test specimen is a tube, the sampling method of test specimens and test pieces shall be as given in figure 2. The welding position of test specimen shall be the horizontal rotary welding or the horizontal fixed welding. However, when the diameter of test specimen is so small that figure 2 is not conformed, the test method specified in **JIS Z 3121** and **JIS Z 3122** shall apply.

Unit: mm



- When the thickness of test specimen is less than 19 mm and the root pass is carried out without backing, the “face bend test piece” shall be read as the “root bend test piece”.
- The number of impact test pieces shall be three from each of the heat-affected zone and the weld metal. However, where different parent materials are used, the number of impact test pieces shall be three from the heat affected zones of respective parent materials and three from the weld metal (see table 3).
- The cutting-off of test piece shall be mechanical cutting or thermal cutting. In the case of thermal cutting, the margin of cutting shall be 3 mm or more.
- In the case where the test specimen is welded in horizontal fixed position, the horizontal plane shall be as the diagram given.

Figure 2 Sampling method of test specimens and test pieces (for tube)

5.2 Test pieces and test methods

5.2.1 Type and number of test pieces

The type and number of test pieces shall be as given in table 3.

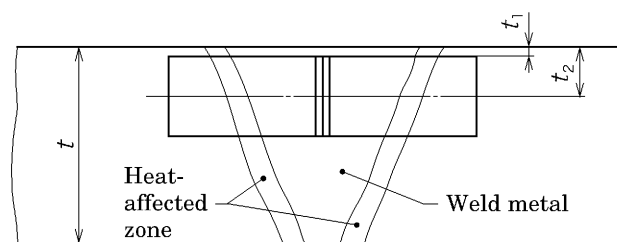
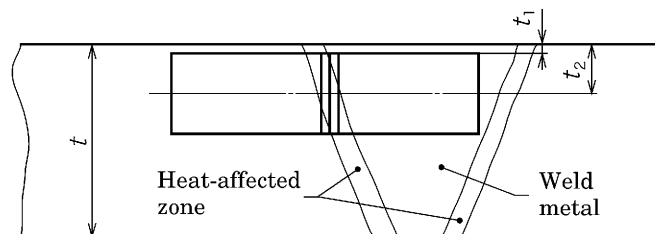
Table 3 Type and number of test pieces

Thickness of test specimen (t) (mm)		Type and number of test pieces				
		Joint tensile test	Face bend test	Root bend test	Side bend test	Impact test ^{a)}
Under 19		2	2	2	—	3
19 or over	Double-side welding	2	2	—	2	3
	One-side welding	2	—	2	2	3

Note ^{a)} The impact test shall be carried out, if required. The number of impact test pieces shall be three from each of the heat-affected zone and the weld metal. However, where different parent materials are used, the number of impact test pieces shall be three from the heat affected zones of respective parent materials and three from the weld metal.

5.2.2 Sampling method of test pieces

The test pieces shall be sampled as given in figure 1 or figure 2. The sampling position of the impact test pieces shall be as given in figure 3.

**a) Weld metal****b) Heat affected zone**

The meaning of symbols in diagram shall be as follows.

t : thickness of parent material

t_1 : distance between surface of parent material and surface of test piece

t_2 : distance between surface of parent material and axis of test piece

- t_2 is taken as $0.25 t$. However, when the axis of test piece cannot be taken in this position, it shall be taken so that t_1 is within 2 mm.
- The notch of the test piece for the heat affected zone shall be determined so that it comes at the centre of width of heat-affected zone.

Figure 3 Sampling position of impact test pieces

5.2.3 Shape and dimensions of test pieces and test methods

The shape and dimensions of test pieces and the test methods shall be as follows.

a) **Shape and dimensions of joint tensile test piece and joint tensile test method**

- 1) The shape and dimensions of the joint tensile test piece shall be in accordance with **JIS Z 3121**.
- 2) The joint tensile test method shall be in accordance with **JIS Z 3121**. When the capacity of the test equipment is not sufficient to test the test piece with its original thickness, the test piece may be cut and divided to the required thickness by a thin saw before being supplied for test. In this case, the joint tensile test shall be carried out for all of the divided test pieces.

b) **Shape and dimensions of bend test piece and bend test method**

- 1) The shape and dimensions of the bend test piece shall be in accordance with **JIS Z 3122**.
- 2) The bend test method shall be in accordance with either the guide bend test method or the roller bend test method specified in **JIS Z 3122**, except that the bending radius shall be as given in table 4 according to the P number of the parent material.

Table 4 Bending radius of test piece

P-number of parent material	Bending radius (mm)
P-1, P-3, P-4, P-5, P-6, P-7, P-8A, P-8B, P-9A, P-9B, P-21, P-22, P-31, P-32, P-34, P-42, P-43, P-45	20 (2 <i>t</i>)
P-11A, P-11B, P-25 ^{a)}	33 ($\frac{10}{3}$ <i>t</i>)
P-51	40 (4 <i>t</i>)
P-27 ^{a)} , P-52, P-61, P-62	50 (5 <i>t</i>)
P-23 ^{a)} , P-2X ^{b)} , P-35	80 (8 <i>t</i>)
— The parenthesized bending radius values shall apply to the test piece whose thickness <i>t</i> is less than 10 mm. — When the bending radius is 5 <i>t</i> or larger, the thickness of the test piece may be made smaller, but not below 3.2 mm. — When P number of parent material is not specified, or when the specified value of elongation of the parent material or welding consumables is less than 20 % in the classification of bending radius 2 <i>t</i>, the bending radius may be obtained according to the following formula. $R = \frac{t(100 - \varepsilon)}{2\varepsilon}$ where, <i>R</i> : bending radius (mm) <i>t</i> : thickness of test piece (mm) <i>ε</i> : specified valued of elongation (%) Notes ^{a)} The case of joints of different material is included. ^{b)} P-2X shows P-21, P-22, P-25 and P-27 where welding is made by using the classification Y-23 of wire, etc.	

c) Impact test piece and impact test method

- 1) The shape of impact test piece, when the nominal thickness of material is not less than 12 mm, shall be the V-notch test piece specified in **JIS Z 2242**. However, when the test piece of 10 mm in width cannot be taken due to the shape or the thickness of material, the width of test piece shall be one of the maximum width among the sub-sized test pieces of 7.5 mm, 5 mm and 2.5 mm capable of being taken, or the full thickness of material (the unevenness on surface may be removed.).
- 2) The V-notch of test piece shall be made in the thickness direction of material.
- 3) The impact test method shall be in accordance with **JIS Z 2242**.
- 4) The test temperature of the impact test shall be in accordance with the specification¹⁾ separately determined or the agreement between the parties concerned with delivery.

Note ¹⁾ The specification separately determined means applicable laws and regulations, or the specifications determined in other standards.

6 Criteria for evaluation of qualification test results

The criteria for evaluation of qualification test results shall be as given in Annex C.

7 Others

The qualification test methods for special shapes, etc. shall be as given in Annex D for the following **a)** to **c)**.

- a) Overlaying
- b) Welding of clad steel
- c) Welding of tube to flat tubesheet