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JAPANESE INDUSTRIAL STANDARD

Method of qualification test for welding procedure

JIS Z 3040—1995

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JAPANESE INDUSTRIAL STANDARD

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Method of qualification test for
welding procedure

Z 3040-1995

1. Scope This Japanese Industrial Standard specifies the general test methods for preliminary verification of the suitability of the welding procedure for welding structures being welded.

Remarks: The cited standards of this Standard are indicated in Attached Table 6.

2. Definitions For the main terms used in this Standard, the definitions in JIS Z 3001 apply.

3. Classification of qualification test for welding procedure The qualification test for the welding procedure (hereafter referred to as "qualification test") shall be classified, with respect to the practically employed welding methods, based on the combination of the respective items specified in the following.

3.1 Welding methods One category of the welding method shall be individual type of welding methods given in Table 1 or their combination.

When two or more welding methods are employed, and the welding methods are used in combination under the conditions where the qualification tests have already been carried out, it may be regarded as one category.

Table 1. Classification of welding methods

Classification of welding method	Type	Classification of welding operation
A	Shielded 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
F	Self-shielded arc welding	Semi-automatic and automatic
S	Other weldings, e.g., gas welding, electroslag welding, electrogas arc welding, plasma arc welding and electron beam welding each type of welding shall be one category respectively.	Manual, semi-automatic and automatic

Remarks: Robotic welding shall be involved in the automatic welding.

Informative reference: Classification of the welding operation is not the classification of the welding procedure, but shall be entered on the report of the results of practice or the like.

3.2 Weld joint Classification of the type of the weld joint shall consist of the butt joint, fillet weld joint and branch connection for tubes. T joint and corner joint shall be represented by the butt joint with the same throat thickness.

The fillet weld joint and the branch connection of tubes which are equivalent to the butt joint according to the qualification test previously carried out may be deemed as one class thereof.

3.3 Kinds of base metal The classification⁽¹⁾ of the kinds of the base metal shall be determined according to Attached Table 1, and base metals other than those shall be classified according to their respective kinds.

The following cases may be deemed as one class, respectively.

- (1) When no impact tests are required, and the welding of the same P-number is applied.
- (2) For the classes of base metal P-3, P-4 and P-5 (only for those metals of standard alloy contents including 3 % or less of chromium) when verification has been previously made among the same base metals, and when the welding is carried out with the base metal of P-number which is smaller than the respective P-numbers where the qualification tests were carried out.
- (3) The classes of base metals P-9A and P-9B may be represented by P-9B.
- (4) The classes of base metals P-22 and P-25 may be represented by P-25.

Note (1) The classification of the kind of base metal shall be expressed as follows:

P-P number - group number

(Examples) P-1-1 (when group number is given)

P-6 (When group number is not given)

3.4 Thickness of base metal, throat thickness of fillet welding and outside diameter of tubes

3.4.1 Butt joint The thickness of the base metal in the case of butt joint shall be classified as given in Table 2 according to the thickness of the specimen.

Table 2. Classification of thickness of base metal

Unit: mm

Thickness of specimen (t)	Division of base metal (T)	
	One side single pass welding or two sided single pass welding	Multi-layer welding
3 and under	0.8 t to 1.1 t incl.	t to 2 t incl.
Over 3 up to and incl. 12		3 to 2 t incl.
Over 12 up to and incl. 100		0.5 t to 2 t incl. (maximum T is 150)
Over 100		0.5 t to 1.5 t incl.

3.4.2 Fillet weld joint The throat thickness of the fillet weld in the case of fillet weld joint shall be classified according to the throat thickness of the specimen as given in Table 3.

The thickness of base metal is not regarded as a change of classification.

Table 3. Classification of throat thickness of fillet welding

Unit: mm

Throat thickness of test weld (l)	Classification of throat thickness of fillet welding (L)
10 and under	0.75 l to 1.5 l incl.
Over 10	10 and over

3.4.3 Branch connection of tubes The branch connection of tubes shall be classified as follows:

- (1) The outside diameter of tubes shall be classified according to the outside diameter of the specimens as specified in Table 4.

Table 4. Classification of outside diameter of branch connection of tubes

Unit: mm

Outside diameter of specimens (D)	Classification of outside diameter
165.2 or under	0.5 D to 2 D incl.
Over 165.2	0.5 D and over

- (2) Classification of the intersection angle of the branch connection shall be α to 90°C incl. for the intersection angle α of the specimen.

3.5 Welding consumables

3.5.1 Covered electrode Covered electrodes shall be classified as given in Attached Table 2. Other covered electrodes than those specified in Attached Table 2 shall be classified according to the combination of the kind of the electrode and the composition thereof. When two or more kinds of covered electrodes are used, the combination thereof shall be regarded as category.

However, change of electrodes from F-1-(2) to F-1-(3) or vice versa shall not be regarded as change of kind.

3.5.2 Welding wire and filler metal for MIG or MAG welding Solid wire, flux cored wire and filler metal for MIG or MAG welding, shall be classified as given in Attached Table 3. However, the solid wire shall be classified into another category of the flux cored wire.

Other welding wires and filler metals than those given in Attached Table 3 shall be classified according to the combination of the kind and the composition thereof.

3.5.3 Welding wire for submerged arc welding Solid wires for submerged arc welding (including strip electrode) shall be classified as given in Attached Table 4. Other solid wires than those given in Attached Table 4 shall be classified according to the combination of the kind and the composition thereof.

3.5.4 Welding flux for submerged arc welding Welding flux for submerged arc welding shall be classified as given in Attached Table 5.

Other solid wires than those given in Attached Table 5 shall be classified according to the combination of the kind and the composition thereof.

3.5.5 Fusible insert The filler metal such as fusible insert shall be classified according to the cases either it is used or not used. When the filler metal such as fusible insert is used, it shall be classified according to the combination of the kind and the composition thereof.

3.6 Shielding gas Shielding gases shall be classified by their kinds. When two or more kinds of gases are mixed, classification shall be made according to their combination including the mixing ratio thereof.

3.7 Protection by gas from backside As to gas protection from the backside, it shall be classified according to the case either it is used or not used such protection.

The change from "without protection by gas from backside" to "with protection by gas from backside" is not regarded as a change of classification.

3.8 Backing As to backing, it shall be classified according to the case either it is used or not used the backing. In the cases where backings are used they shall be classified according to the kind of the backing materials.

The change from "without backing" to "with backing", or from "with backing" to "two sided welding" is not regarded as a change of classification.

3.9 Electrode As to the electrode, it shall be classified according to the number of the electrodes.

3.10 Kind of power source The kind of power source shall be classified according to a.c. or d.c.

3.11 Preheating As to preheating, it shall be classified according to the application of preheating or not.

Where the preheating is conducted, it shall be subclassified according to the lower limit of the temperature being used. When the temperature falls within a range of 50°C lower than the lower limit of the previous qualification test, it shall be regarded as the same category as mentioned beforehand.

Change from "without preheating" to "with preheating" is not regarded as a change of classification.

3.12 Welding heat input The welding heat input shall be classified according to the upper limit of the heat input.

The heat input shall be calculated as follows:

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

where, H : heat input (J/cm)

E : voltage (V)

I : current (A)

V : speed (cm/min)

3.13 Post weld heat treatment Post weld heat treatment shall be classified according to the case either it is applied or not. When the heat treatment is carried out, classification shall be made according to the combination of the holding temperature and the minimum holding time.

3.14 Additional classification where impact test is required The impact test, where required, shall be as follows:

- (1) The temperature of the impact test shall be classified by the lower limit.
- (2) The welding position shall be classified by each welding position.

The change from "the vertical position by the upward welding" to "other welding positions" is not regarded as a change of welding position.

- (3) The interpass temperature shall be classified by the upper limit of the temperature. When the temperature falls within a range of 50°C higher than the upper limit of the previous qualification test, it shall be regarded as the same category as mentioned beforehand.

- (4) As to the number of layers, it shall be classified into the multilayer and single layer welding applied on one side.

The change from "single layer" to "multilayer" is not regarded as a change of classification.

4. Qualification tests

4.1 Preparation of specimen The conditions for qualification tests shall be selected according to the combination of classes and types of qualification items specified 3., and then the specimen shall be prepared as follows:

4.1.1 Butt welded joint Butt welded joints shall be prepared as follows:

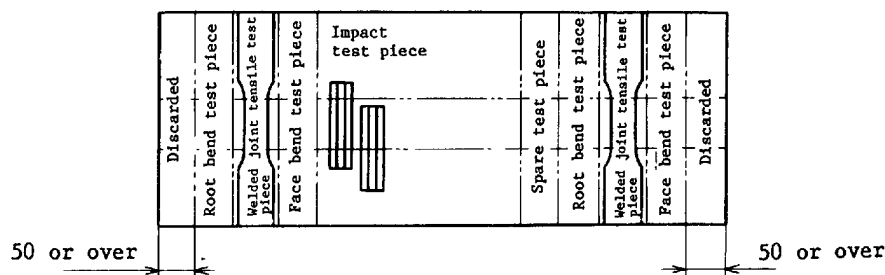
- (1) Where the specimen is a plate, it shall be prepared by flat-position welding according to Fig. 1. When the impact test is carried out or the flat-position welding is recognized as unsuitable, the practical welding position shall be applied. However, where the specimen consists of different base metals or values for the specimen and for the weld metal differ, the specimens and test pieces shall be taken to carry out the longitudinal bend test as specified in JIS Z 3122 in lieu of the bend test. In this case, the specimens for the welded joint tensile test and those for the longitudinal bend test or the like may be prepared separately to take the test pieces.

The full width of the specimens for longitudinal bend test, etc. shall be 150 mm or over.

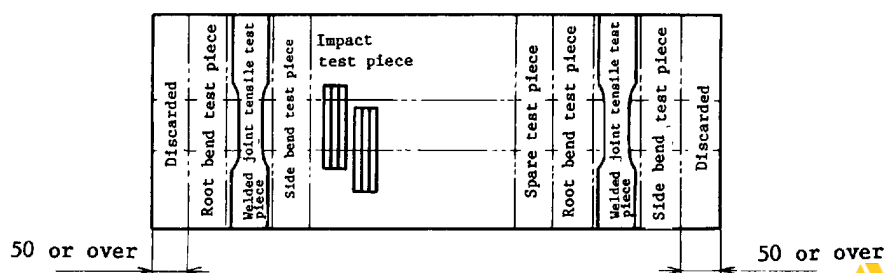
Fig. 1. Method of taking specimens and test pieces
(in the case of plate)

Unit: mm

(a) For plates less than 19 mm in thickness

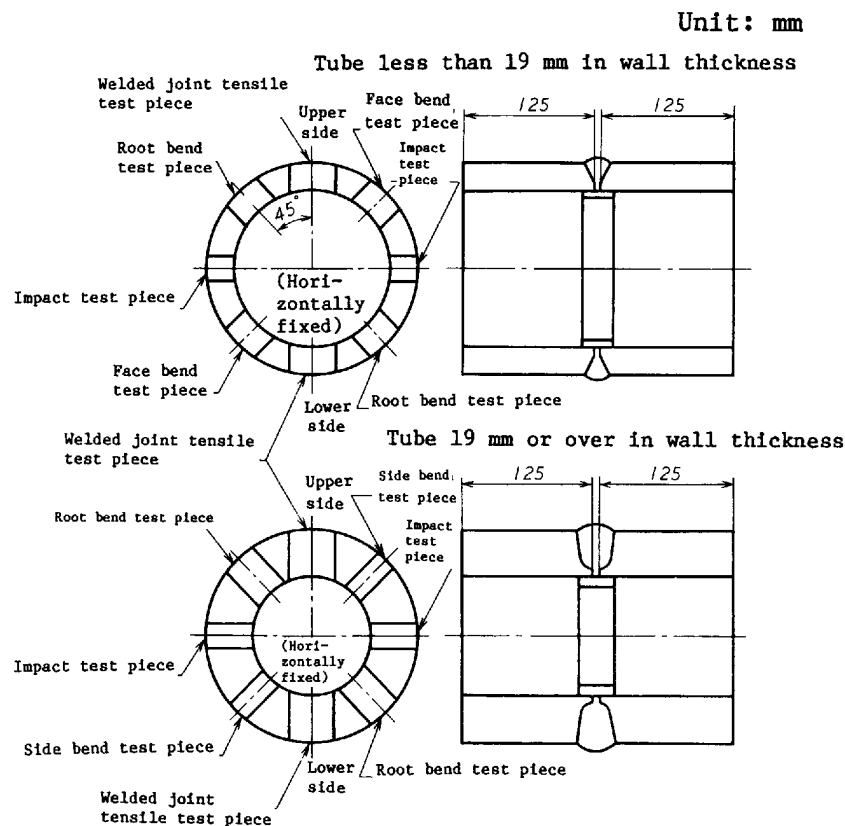


(b) For plates 19 mm or over in thickness



- Remarks 1. The length and width of the specimen shall be sufficiently large to provide the respective test pieces.
2. The shapes of the groove of the joint shall be suitable ones for respective welding method.
3. In the case of both side welding, the words "root bend test piece" shown in Fig. 1 shall be read as "face bend test piece".
4. The impact test shall be carried out when specially designated, and the number of the impact test pieces and the location to take the test piece shall be as given in Table 5.
5. The location to take respective test pieces is illustrated as an example, but not designated specially.
- (2) Where the specimen is a tube, it shall be prepared by horizontal rotation or horizontal fixed-position welding according to Fig. 2. If the diameter of a tube is so small that the test pieces are infeasible to prepare according to Fig. 2, they may be prepared in accordance with the test method specified in JIS Z 3121 and JIS Z 3122.

Fig. 2. Method of taking specimen and test piece (in the case of tube)



Remarks 1. The impact test shall be carried out when specially designated, and the number of the impact test pieces and the location to take the test piece shall be as given in Table 5.

2. When the specimen is welded in the horizontally fixed condition, the location to take the test pieces shall be as shown in the figure, and the horizontally fixed plane shall be shown therein.

4.1.2 Fillet weld joint Fillet weld joint shall be prepared as follows:

- (1) Where the specimen is a plate, it shall be prepared by horizontal fillet welding according to Fig. 3. When horizontal fillet welding is recognized as unsuitable, practical welding position shall be applied.
- (2) Where the specimen is a tube, it shall be prepared by either of horizontal rotation or horizontal fixed-position welding according to Fig. 4.

Fig. 3. Method of taking specimen and test piece for fillet weld joint (In the case of plate)

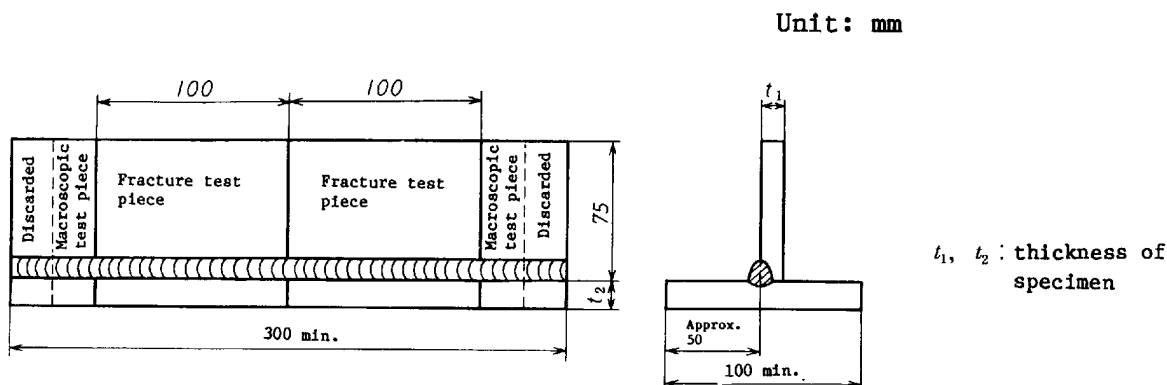
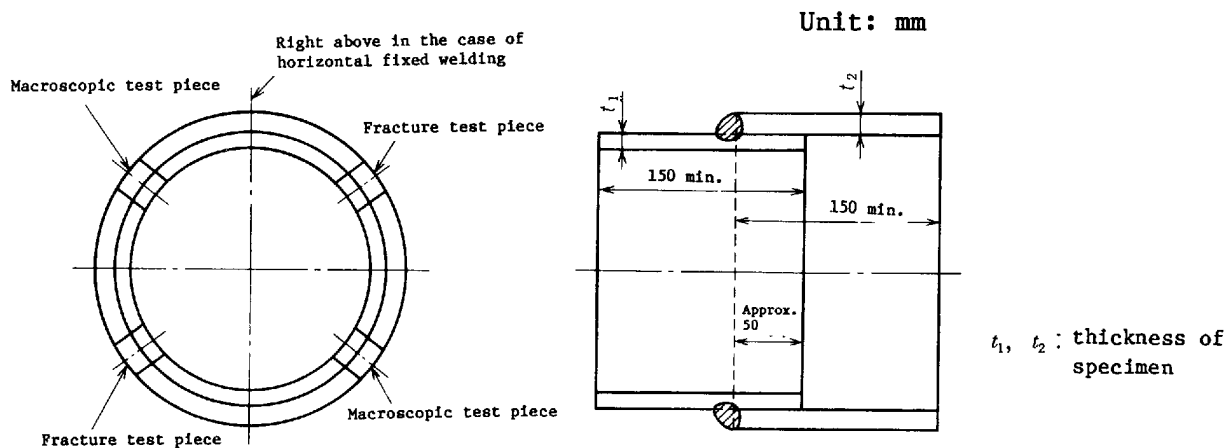
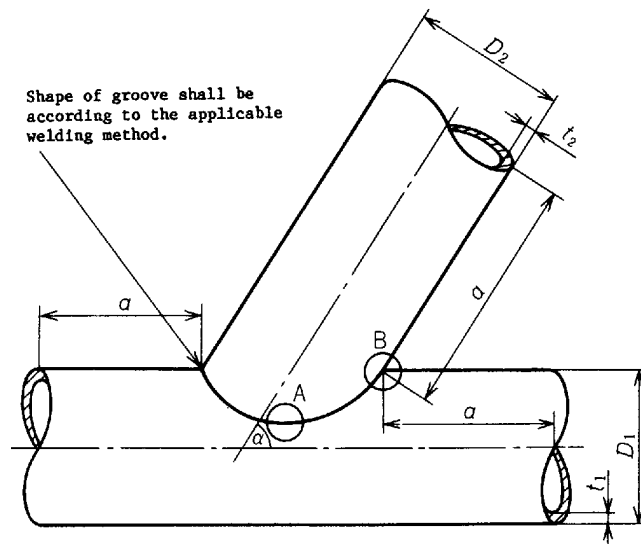


Fig. 4. Method of taking specimen and test piece for fillet weld joint (In the case of tube)



4.1.3 Branch connection of tubes Branch connection of tubes shall be prepared according to Fig. 5.

Fig. 5. Method of taking specimen and test piece



a : 150 mm min.

D_1 : outside diameter (mm) of main tube

t_1 : wall thickness (mm) of main tube

D_2 : outside diameter (mm) of branch tube

t_2 : wall thickness (mm) of branch tube

A, B : location to take macroscopic test pieces

α : intersection angle ($^\circ$) of branch tube

4.2 Test piece and test method

4.2.1 Category of test and number of test pieces Category of test and number of test pieces shall be as given in Table 5.

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Table 5. Category of test and number of test pieces

Specimen		Category of test	Number of test pieces
Butt joint	Under 19 mm in thickness	Welded joint tensile test	2
		Face bend test	
		Root bend test	
		Impact test	3 respectively ⁽²⁾
	19 mm or over in thickness (both side welding)	Welded joint tensile test	2
		Face bend test	
		Side bend test	
		Impact test	3 respectively ⁽²⁾
	19 mm or over in thickness (One side welding)	Welded joint tensile test	2
		Root bend test	
		Side bend test	
		Impact test	3 respectively ⁽²⁾
Fillet weld joint		Macroscopic test	2
		Fracture test	
Branch connection of tube		Macroscopic test	

Note ⁽²⁾ The impact test shall be carried out when specially designated, and three impact test pieces shall be taken respectively from the weld metal portion and the heat-affected zone. When different types of base metals are used, each three test pieces shall be taken from the heat-affected zone and weld metal portion respectively.

The bond portion of the double bevel groove joint may be added upon agreement between the purchaser and supplier.

The impact test may be omitted in the case where the specimen is under 12 mm in thickness.

Remarks: Non-destructive tests such as radiographic testing, the testing on hardness distribution of the weld, the chemical analysis for the weld metal or the like may be applied upon agreement between the purchaser and supplier.

4.2.2 Method of taking test piece The methods of taking the test pieces shall comply with those shown in Fig. 1 or Fig. 2 in the case of butt joint, those shown in Fig. 3 or Fig. 4 in the case of fillet weld joint and those shown in Fig. 5 in the case of the connection of tubes.

The sampling position for the impact test piece shall be in accordance with the Grade 1 test specified in JIS Z 3128.

4.2.3 Shape and dimensions of test piece and test method The shape and dimensions of the test piece and the test method shall be as follows:

- (1) **Tensile test** The shape and dimensions of the test piece and the test method for the welded joint tensile test shall be in accordance with JIS Z 3121.
- (2) **Bend test** The shape and dimensions of the test piece and the test method for the bend test shall be in accordance with JIS Z 3122.

The bending radius for each classification of the base metal shall be as given in Table 6 in the case where the test piece is 10 mm in thickness. However, the bending radius shall apply the value in parentheses when the thickness (t) of the test piece is under 10 mm.

Table 6. Bending radius of test piece

Classification of base metal	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 ($2t$)
P-11A, P-11B, P-25 ⁽³⁾	33 ($\frac{10}{3}t$)
P-51	40 ($4t$)
P-27 ⁽³⁾ , P-52, P-61, P-62	50 ($5t$)
P-23 ⁽³⁾ , P-2X ⁽⁴⁾ , P-35	80 ($8t$)

Notes ⁽³⁾ The case of welding of different kinds of materials is included.

⁽⁴⁾ P-2X expresses that P-21, P-22, P-25 and P-27 are welded by using Y-23.

- Remarks 1. Thickness of the test piece may be reduced when the bending radius is not less than $5t$. However, the lower limit value shall be 3.2 mm.
2. The bending radius may be obtained by the following formula when the classification of the base metal is not designated, or when the base metal is in the category of the bending radius of $(2t)$ and also the specified value of elongation of the base metal or of the welding consumable is under 20 %.

$$R = \frac{t(200 - \epsilon)}{4\epsilon}$$

where, R : bending radius (mm)

t : thickness of test piece (mm)

ϵ : specified value of elongation (%)

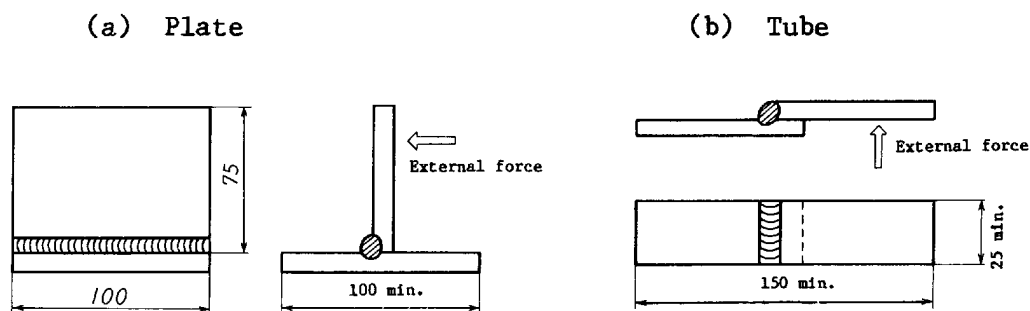
- (3) Impact test The impact test shall be carried out in accordance with JIS Z 2242, and the test piece shall be No. 4 test piece (the notch shall be prepared along the through-thickness direction) in JIS Z 2202.

The temperature of the impact test shall be agreed between the purchaser and manufacturer.

- (4) Macroscopic test The macroscopic test shall be carried out to investigate the presence of defects in the test pieces indicating macrostructure of cross section of the weld shown in Figs. 3, 4 and 5.
- (5) Fracture test The fracture test shall be carried out in accordance with Fig. 6 (a) in the case of plate specimens or Fig. 6 (b) in the case of tubular specimens to investigate the presence of defects on the fracture throughout the whole length of the weld zone after fracturing by applying external force to bend so that the root side of the weld becomes the tensile side.

Fig. 6. Fracture test method for fillet weld joint

Unit: mm



5. Evaluation of results of qualification test Evaluation criteria for the results of qualification tests are given in the Annex.

6. Records The following records on the results of the qualification tests for the welding procedure shall be prepared.

- (1) List of qualification items
- (2) Copy of certificates of test results for base metals and welding consumables
- (3) Records of welding (welding equipment, welding consumables, welding conditions or the like)
- (4) Records of heat treatment

Results of non-destructive tests, the hardness distribution of weld zone, and the chemical analysis of weld metal in the case of alloy or alloy steel shall be included as necessary.

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Attached Table 1. Classification of base metal

Classification of base metal		Standard alloy content		Symbol of kinds (examples)		Shape
P number	Group number					
1	1	Carbon steel	C series	SS 330 (JIS G 3101) SS 400 (JIS G 3101) SM 400A (JIS G 3106) SN 400A (JIS G 3136)		Steel plate
			C-Mn series	SG 255 (JIS G 3116)		
			C-Si series	SB 410 (JIS G 3103) SB 450 (JIS G 3103)		
			C-Mn-Si Series	SM 400B.C (JIS G 3106) SN 400B (JIS G 3136) SPV 235 (JIS G 3115) SG 295 (JIS G 3116) SGV 410 (JIS G 3118) SGV 450 (JIS G 3118) SLA 235A.B (JIS G 3126) SLA 325A.B (JIS G 3126)		
			C series	SGP (JIS G 3452) STPG 370 (JIS G 3454) STS 370 (JIS G 3455) STPY 400 (JIS G 3457) STB 340 (JIS G 3461)		Steel tube
			C-Mn series	STPG 410 (JIS G 3454) STS 410 (JIS G 3455) STPL 380 (JIS G 3460) STBL 380 (JIS G 3464) STF 410 (JIS G 3467)		
			C-Si series	STPT 370 (JIS G 3456) STPT 410 (JIS G 3456) STB 410 (JIS G 3461)		
			C-Mn series	S 10C (JIS G 4051) S 12C (JIS G 4051) S 15C (JIS G 4051) S 17C (JIS G 4051) S 20C (JIS G 4051) S 22C (JIS G 4051) S 25C (JIS G 4051) S 28C (JIS G 4051) S 30C (JIS G 4051)		Steel bar
			C-Si series	SF 340A (JIS G 3201) SF 390A (JIS G 3201) SF 440A (JIS G 3201) SFVC 1 (JIS G 3202)		
						Forged steel

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Attached Table 1. (continued)

Classification of base metal		Standard alloy content	Symbol of kinds (examples)	Shape
P number	Group number			
1	1	Carbon steel	C-Mn-Si series SFL 1 (JIS G 3205)	Forged steel
			C series SC 360 (JIS G 5101) SC 410 (JIS G 5101) SC 450 (JIS G 5101)	Cast steel
			C-Si series SCW 410 (JIS G 5102) SCW 450 (JIS G 5102) SCPL 1 (JIS G 5152)	
			C-Mn-Si series SCPH 1 (JIS G 5151)	
	2	Carbon steel having the specified minimum tensile strength of 490 N/mm ²	C-Mn-Si series SB 480 (JIS G 3103) SM490A to C (JIS G 3106) SM520B.C (JIS G 3106) SM490YA.YB (JIS G 3106) SN490B (JIS G 3136) SPV 315 (JIS G 3115) SPV 355 (JIS G 3115) SPV 410 (JIS G 3115) SG 325 (JIS G 3116) SG 365 (JIS G 3116) SGV 480 (JIS G 3118) SLA 360 (JIS G 3126) SLA 410 (JIS G 3126)	Steel plate
			C-Mn series STS 480 (JIS G 3455)	Steel tube
			C-Si series STPT 480 (JIS G 3456)	
			C-Mn-Si series STB 510 (JIS G 3461)	
			C-Mn series S 33C (JIS G 4051) S 35C (JIS G 4051)	Steel bar
			C-Si series SF 490A (JIS G 3201) SFVC 2A (JIS G 3202) SFVC 2B (JIS G 3202)	Forged steel
			C-Mn-Si Series SFL 2 (JIS G 3205)	

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Attached Table 1. (continued)

Classification of base metal		Standard alloy content	Symbol of kinds (examples)	Shape
P number	Group number			
1	2	Carbon steel having the specified minimum tensile strength of 490 N/mm ²	C series SC 480 (JIS G 5101)	Cast steel
			C-Mn-Si series SCW 480 (JIS G 5102) SCPH 2 (JIS G 5151)	
	3	Carbon steel having the specified minimum tensile strength of 590 N/mm ²	C-Mn-Si series SM 570 (JIS G 3106) SPV 450 (JIS G 3115) SPV 490 (JIS G 3115)	Steel plate
			C-Mn-Si-Cr series SCW 550 (JIS G 5102) SCW 620 (JIS G 5102)	Cast steel
3	1	Heat resisting low alloy steel	C-1/2 Mo series SB 450M (JIS G 3103)	Steel plate
			1/2 Cr-1/2 Mo series SCMV 1-1 (JIS G 4109)	
			C-1/2 Mo series STPA 12 (JIS G 3458) STBA 12 (JIS G 3462) STBA 13 (JIS G 3462)	Steel tube
			1/2 Cr-1/2 Mo series STPA 20 (JIS G 3458) STBA 20 (JIS G 3462)	
			C-1/2 Mo series STFA 12 (JIS G 3467)	Steel tube for fired heater
			SCPH 11 (JIS G 5151) SCPL 11 (JIS G 5152)	Cast steel