



PART 11 WELDING



PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS

PART 11 WELDING

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PRINCIPLES FOR THE CLASSIFICATION AND CONSTRUCTION OF STEEL SHIPS

PART 11 WELDING

Chapter 1 GENERAL

1.1 General

1.1.1 Application

1. Welding works, etc., hereinafter referred to as “weldings”, to be used in hull construction, equipment, machinery, etc. are to be in accordance with the requirements of this Part unless specified in other Part.
2. The requirements of this Part are applied to the welding’s where the manufacturer is to adhere to the requirements specified below.
 - (1) To ensure the quality of the welding’s under the appropriate facilities and control system, by achieving the process control throughout the welding works.
 - (2) Where deviation from the controls occurs and/or inferior quality of products is identified, the manufacturer is to investigate the substantial cause, to report the result of investigation to the Surveyor and to take corrective measures.
3. Welding not specified in this Part may be used when it is specially approved with respect to the design and the works by the Society.

1.2 Tests before Welding Works

1.2.1 Execution of Tests

1. The welding procedure, the welder s qualifications and the welding consumables specified in this Part are to be subjected to the required tests in the presence of the Surveyor and to be approved by the Society before welding works.
2. The tests of welding not specified in this Part are to be carried out in accordance with the test specification or the test standard which is approved by the Society.
3. Where appropriate certifications for the welding procedure, the welders qualifications, the welding consumables, etc. are accepted by the Society, the tests thereof may be dispensed with by the Society s discretion.

1.3 Welding Works

1.3.1 Execution of Welding Control

The manufacturer is to comply with the requirements specified in [Chapter 2](#) of this Part regarding the control of the welding works of hull construction, etc. mainly.

1.3.2 Confirmation of Welding Work Condition

1. For the effectiveness of the control of the welding works to be carried out by the manufacturer, the Society is to confirm the condition during welding works at an appropriate interval accepted by the Surveyor, when deemed necessary. In this case, the manufacturer is to give the convenience to the Surveyor and to permit the Surveyor to enter all relevant areas of the yard.
2. If it is deemed to be necessary in preceding -1, the Surveyor may require the manufacturer to take corrective measures for the control of practice.

1.4 Inspection and Quality for Weld

1.4.1 Implementation of Inspection

1. Inspection of weld is to be carried out in the presence of the Surveyor during or after welding works specified in [2.1.4, Part 1B](#) of the Rules.
2. Where the quality and the control system of weld are deemed appropriate by the Society, the presence of the Surveyor may be reduced.

1.4.2 Quality and Repair

1. The quality of weld is to be assured in accordance with the requirements provided below.
 - (1) Inspection during welding works Inspection items during welding works, which are designated by the Surveyor taking account of the result of confirmation of welding work conditions specified in [1.3.2](#), are to be observed in good order.
 - (2) Visual inspection of weld
Visual inspection of weld is to be carried out. The weld is to be free from weld cracks, excess weld metal or excessive convexity and surface harmful imperfections, such as undercuts, overlaps, etc., and excessive misalignment and deformation. The size of fillet welds is to comply with the requirements specified in [1.2.3, Part 2](#).
 - (3) Non-destructive inspection of weld
Non-destructive inspection of weld which is separately specified by the Society is to be carried out. The weld is to be free from weld cracks and internal harmful imperfections such as lack of fusion and penetration, etc.



2. The welding defects found in the inspection specified in preceding -1 are to be restored, or repaired in accordance with repairing procedures deemed appropriate by the Society under the Surveyor's direction.
3. For the quality confirmation independently during or after welding works, including non-destructive inspection, restorations or repairs of the welding defects admitted by the manufacturer is to be complied with the requirement specified in -2. These records are to be submitted under the request of the surveyor.

1.4.3 Standard of Quality

When the Surveyor judges that the quality of weld remarkably falls short of the standard, the Society may be require the manufacturer to improve the quality of weld based upon the result of inspection.

Chapter 2 WELDING WORKS

2.1 General

2.1.1 Application

1. The requirements of this Chapter are mainly applied to the welding works of hull construction, etc. where the manufacturer is to adhere to the requirements provided below.

- (1) To arrange the material having proper certification in advance, in accordance with approved plan of hull construction, etc. by the Society.
- (2) To ensure the process and accuracy in accordance with appropriate quality.
- (3) To engage the welders having proper qualification, and to carry out control of their qualification, maintaining their skills and training to them.

2. In addition to the mentioned above in preceding -1, the manufacturer is to control the practice of weld in accordance with the requirements specified in this chapter.

3. The requirements specified in this chapter are to be applied to welding works of rolled steels for hull, rolled steels for low temperature service and high strength quenched and tempered rolled steels for structures as base metal.

Welding works for the other materials are to be deemed appropriate by the Society.

2.2 Work Scheme

2.2.1 Welding Application Plan

The manufacturer is to submit the welding application plan, including the following items, to the Society every ship for approval prior to welding works. Midship section plan (showing grades of materials, thickness, dimension, etc.) may be used as the plan.

- (1) Kinds of main structural members for hull within 0.6L amidships, which are intended for on-site welding
- (2) Kinds of welding procedure which is applied to the welding in preceding (1) and its welding position, including the number and the date of approval of the welding procedure
- (3) Others items considered necessary by the Society

2.2.2 Welding Procedure and related specification

1. Welding procedure and related specification are to be approved by the Society in accordance with the requirements specified in [Chapter 4](#) of this Part.

2. At least the following welding conditions are to be included in the welding procedure specification specified in preceding -1.

- (1) Welding procedure
- (2) Base metal (grade of steel and maximum thickness)

- (3) Welding consumables (grade, shielded gas, backing, etc.)
- (4) Kind of welding (butt or fillet)
- (5) Welding position
- (6) Details of edge preparations according to the thickness of base metal (including standard tolerances for edge preparation condition, i.e. groove angle, root gap, and misalignment), number of electrodes and arrangement, leg length or throat thickness, layer or pass sequence and welding parameter (amperage, voltage, welding speed, heat input, current).
- (7) Preheating and interpass temperature
- (8) Post weld heat treatment
- (9) Other conditions necessary for the welding procedure

3. The welding procedure and related specification, in addition to the requirements in preceding -2, are to be including repair procedure of the welding defects which comprise the following provisions.

- (1) Kind of the welding defects
- (2) The way of chipping, grinding, etc. for the welding defects
- (3) Edge preparations after the removal of the welding defects
- (4) Quality verification scheme for the portion of the welding defects removed, including non-destructive inspection
- (5) Procedures of the welding, including the welding procedure, the welding consumables, the welders qualifications, preheating, post weld heat treatment, etc.
- (6) Quality verification scheme of the repair part, including non-destructive inspection

2.3 Welding Preparation

2.3.1 Material Control

In welding works, the manufacturer is to adhere to the requirements provided below.

- (1) To establish the means which can clearly identify the kinds of steels and welding consumables in order to prevent from misuse.
- (2) To remove harmful imperfections from the surface of steel and the processed portion such as gas cut.
- (3) Heat processing such as the line heating, etc. of steels is to comply with the standard which is accepted to be appropriate by the Society, unless specifically approved.
- (4) Welding consumables are to be stored and controlled appropriately, and to be dried adequately where considered necessary.
- (5) The manufacturer is to properly instruct welders about the use of welding consumables.

2.3.2 Edge Preparation, etc.

1. The grooves are to be processed correctly and uniformly, and cracks or flaws in the grooves are to be removed.

Moisture, grease, rust, etc. are to be removed from groove and its adjacent. Painting of welding portion is not to give harmful effect to the quality of weld.

2. The special attention is to be paid to the edge preparation of intersection of weld lines, grooves made by on-site cutting, etc.

2.3.3 Fitting Process, etc.

1. The shape, size and root gap of the grooves are to comply with the standard specified in welding procedure specification of [2.2.2](#) corresponding to welding procedure to be applied. No excessive gap is accepted between the base plates in *T* joints and lap joints.

2. The ends of important welded joints are to be fitted with the end tabs or to have proper oversized edge, which are to be cut off after welding.

3. Jigs used for welding joints are to be so fitted as not to give excessive restraint. After welding, the jigs are to be removed in general, and any defect of the base metal caused by removing the jigs is to be repaired properly by welding, grinding, etc.

4. The welding joints are to be free from excessive gaps, misalignments, deformations, etc. Where the fitting is done improperly, it is to be restored properly.

5. Excessive loads are not to be used for the rectifying of poor fitting part such as large deformation.

2.4 Welding Process

2.4.1 Selection of Welding Consumables

1. The welding consumables used for rolled steels for hull, rolled steels for low temperature service and high strength quenched and tempered rolled steel plates for structures are to be selected in accordance with the requirements provided below.

(1) The selection of welding consumables is to be in accordance with the requirements provided in [Table 2.1](#).

(2) For the requirement specified in preceding (1), welded joints of different grades of steel may be used as the followings.

(a) Welding consumables for lower grade of steel may be used for welded joints of different grades of steel of the same specified strength.

(b) Welding consumables required for the steel of lower specified strength may be used for welded joints of different specified strength, provided that the adequate measures to prevent cracks are taken.

(c) Low hydrogen electrodes are to be used for the welding of the high tensile steels or for the welding of the high tensile steel and mild steel. Where the high tensile steels with thermo-mechanical control process are used as base metal, non-low hydrogen electrodes may be used as the welding consumables provided that it is deemed to be appropriate by the Society.

Table 2.1 Selection of Welding Consumables (rolled steel plate)

Kind and Grade of Steel to be welded		Grade of applicable welding consumables ⁽¹⁾⁽⁴⁾
Rolled Steel for Hull	KA	1, 2, 3, 51, 52, 53, 54, 52Y40, 53Y40, 54Y40, L1, L2, L3
	KB, KD	2, 3, 52, 53, 54, 52Y40, 53Y40, 54Y40, L1, L2, L3
	KE	3, 53, 54, 53Y40, 54Y40, L1, L2, L3
	KA32, KA36	51, 52, 53, 54, 52Y40, 53Y40, 54Y40, L2 ⁽²⁾ , L3, 2Y42, 3Y42, 4Y42, 5Y42
	KD32, KD36	52, 53, 54, 52Y40, 53Y40, 54Y40, L2 ⁽²⁾ , L3, 2Y42, 3Y42, 4Y42, 5Y42
	KE32, KE36	53, 54, 53Y40, 54Y40, L2 ⁽²⁾ , L3, 2Y42, 3Y42, 4Y42, 5Y42
	KF32, KF36	54, 54Y40, L2 ⁽²⁾ , L3, 4Y42, 5Y42
	KA40, KD40	52Y40, 53Y40, 54Y40, 3Y42, 4Y42, 5Y42, 2Y46, 3Y46, 4Y46, 5Y46
	KE40	53Y40, 54Y40, 3Y42, 4Y42, 5Y42, 3Y46, 4Y46, 5Y46
	KF40	54Y40, 4Y42, 5Y42, 4Y46, 5Y46
Rolled Steel for Low Temperature Service	KL24A	L1, L2, L3, 54, 54Y40
	KL24B, KL27, KL33	L2, L3, 5Y42 ⁽³⁾
	KL37	L3, 5Y42
	KL9N53, KL9N60	L91, L92
High Strength Quenched and Tempered rolled Steel plates for Structures	KA420	2Y42, 3Y42, 4Y42, 5Y42, 2Y46, 3Y46, 4Y46, 5Y46, 2Y50, 3Y50, 4Y50, 5Y50
	KD420	3Y42, 4Y42, 5Y42, 3Y46, 4Y46, 5Y46, 3Y50, 4Y50, 5Y50
	KE420	4Y42, 5Y42, 3Y46, 5Y46, 4Y50, 5Y50
	KF420	5Y42, 5Y46, 5Y50
	KA460	2Y46, 3Y46, 4Y46, 5Y46, 2Y50, 3Y50, 4Y50, 5Y50
	KD460	3Y46, 4Y46, 5Y46, 3Y50, 4Y50, 5Y50
	KE460	4Y46, 5Y46, 4Y50, 5Y50
	KF460	5Y46, 5Y50
	KA500	2Y50, 3Y50, 4Y50, 5Y50, 2Y55, 3Y55, 4Y55, 5Y55
	KD500	3Y50, 4Y50, 5Y50, 3Y55, 4Y55, 5Y55
	KE500	4Y50, 5Y50, 4Y55, 5Y55
	KF500	5Y50, 5Y55
	KA550	2Y55, 3Y55, 4Y55, 5Y55, 2Y62, 3Y62, 4Y62, 5Y62
	KD550	3Y55, 4Y55, 5Y55, 3Y62, 4Y62, 5Y62
	KE550	4Y55, 5Y55, 4Y62, 5Y62
	KF550	5Y55, 5Y62
	KA620	2Y62, 3Y62, 4Y62, 5Y62, 2Y69, 3Y69, 4Y69, 5Y69
	KD620	3Y62, 4Y62, 5Y62, 3Y69, 4Y69, 5Y69
	KE620	4Y62, 5Y62, 4Y69, 5Y69
	KF620	5Y62, 5Y69
	KA690	2Y69, 3Y69, 4Y69, 5Y69
	KD690	3Y69, 4Y69, 5Y69
	KE690	4Y69, 5Y69
	KF690	5Y69



Notes:

- 1 The symbols of welding consumables listed above show the materials which are specified in [Table 6.1](#), [Table 6.12](#), [Table 6.21](#), [Table 6.29](#) and [Table 6.58](#), and have same mark at the end. (For example, “3” shows *KMW3*, *KAW3*, *KSW3* and *KEW3*, “L3” shows *KMWL3*, *KAWL3* and *KSWL3*, “3 Y42” shows *KMW3 Y42*, *KAW3 Y42* and *KSW3 Y42*.)
- 2 Welding consumables of “L2” is applicable to steel grade of *KA32*, *KD32*, *KE32* or *KF32* only.
- 3 Welding consumables of “5Y42” is applicable to steel grade of *KL33* only.

2.4.2 Consideration for Welding Environment

1. The welding is to be carried out under the conditions of protection against moisture, wind and snow.
2. The welding is to be carried out under the environment which is well considered so that the works may be carried out without any difficulty.

2.4.3 Preheating, etc.

1. Application of preheating, short bead, etc. are to be carried out in accordance with the standard which is deemed to be appropriate by the Society, unless specifically approved.
2. Arc strikes on high tensile steels and mild steels except *KA*, *KB* and *KD* are to be avoided. Where arc strikes are made by mistake, those are to be removed by grinding or to be repaired by welding with short bead having an appropriate length.
3. The tack welding is to be carried out taking account of especially preheating, selection of welding consumables, weld length, etc.
4. In case of welding under excessive restraint or for extremely thick steel plate, cast steel or forged steel, special precautions are to be taken, such as preheating of the material, use of low hydrogen electrodes, etc. For cast steel or forged steel, the material is to be of the one which has the suffix *W* at the end of its grade symbol specified in [Part 10](#).

2.4.4 Welding Sequence

1. Welding sequence and direction of welding are to be so determined as to prevent harmful imperfection such as cracks in welded joints and excessive deformations.
2. The joints which may cause greater contraction by welding are to be welded prior to the joints which may cause smaller contraction in principle.

2.4.5 Execution of Welding

1. The welding is to be carried out in accordance with the welding procedure specifications specified in [2.2.2](#).

Special precaution is to be paid to the both ends of the weld, the intersections, etc.

2. The welding is to be carried out by the welder having the appropriate qualification according to the application of the welding.
3. Butt welded joints are to be back chipped to remove the defects in root of welds before applying the back side welding, except in case of one side welding or other processes approved by the Society.
4. In the intersections of butt welded joints, the edge preparation is to be done to preceding welding.
5. The end portion of fillet welding under high stress concentration area is to be continuous round. The crater filling may be acceptable to the other end portion.

2.5 Inspection and Quality for Welding

2.5.1 Inspection and Quality

Inspection and quality for welding are to be in accordance with the requirements specified in [1.4](#).

Chapter 3 TEST SPECIMENS AND MECHANICAL TESTING PROCEDURES

3.1 General

3.1.1 Application

1. Test specimens and mechanical testing procedures for various tests in this Part are to comply with the requirements in this Chapter, unless expressly provided in and after the next Chapter.
2. Where specimens or mechanical testing procedures differing from those prescribed in this Part are used, they are to be approved by the Society.
3. The test specimens are to be selected according to respective requirements in this Chapter.

3.2 Test Specimens

3.2.1 Selection of Test Specimens

1. Except where otherwise specified or agreed with the Surveyor, test specimens are not to be detached from the test assembly until having been stamped by the Surveyor.
2. If test specimens are cut from test assemblies by flame cutting or shearing, a reasonable margin is required to enable sufficient material to be removed from the cut edges during final machining.
3. The preparation of test specimens is to be done in such a manner that test specimens are not subjected to any significant cold straining or heating.
4. If any test specimen shows defective machining or defects having no relation to the substantial nature, it may be discarded and substituted by another test specimen.

3.2.2 Tensile Test Specimens

1. Tensile test specimens are to be of size and dimensions given [Table 3.1](#), and the both ends of the test specimen may be machined to such a shape as to fit the holder of the testing machine.
2. The upper and lower surfaces of weld are to be filed, ground or machined flush with the surface of plate.
3. Reinforcements and back straps are to be machined flush with base metal.

3.2.3 Bend Test Specimens

1. Bend test specimens are to be of size and dimensions given in [Table 3.2](#) according to the kind of test assemblies.
2. Where the thickness of test assemblies is greater than the thickness of the bend test specimen prescribed in [Table 3.2](#), the face bend or root bend specimen may be machined on its compression side to the specified thickness.
3. Reinforcements and back straps are to be machined flush with base metal.



3.2.4 Impact Test Specimens

1. Three impact test specimens are considered to be one set.
2. Impact test specimens are to be *U4* specimens specified in [2.2.4, Part 10](#) and to be of size and dimensions given in [Fig. 2.1](#), [Tables 2.5](#) and [2.6](#).

3.2.5 Confirmation for Test Specimens

The size and dimensions of test specimens are to be carefully inspected and verified by suitable means before testing.

3.3 Mechanical Testing Procedures

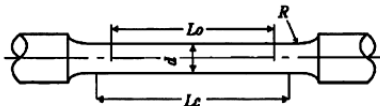
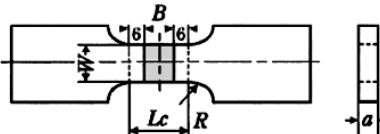
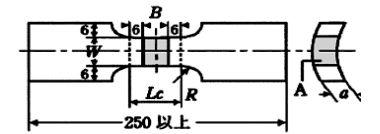
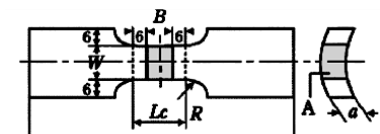
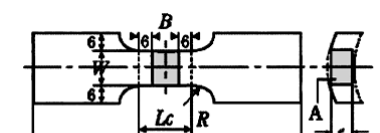
3.3.1 Tensile Test and Impact Test

Tensile tests and impact tests are to be carried out in accordance with the procedures prescribed in [2.3, Part 10](#).

3.3.2 Bend Test

1. Unless otherwise specified, bend tests may be either a guided bend test or a roller bend test.
2. Guided bend test jigs are to be as shown in [Figs. 3.1](#) and [3.2](#).
3. Roller bend test jigs are to be as shown in [Fig. 3.3](#).

Table 3.1 Size and Dimension of Tensile Test Specimens (mm)


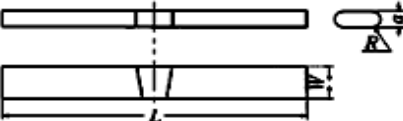
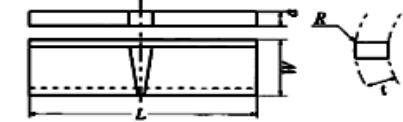

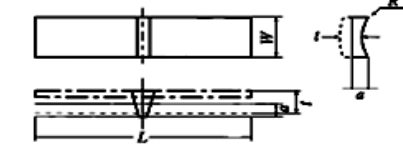
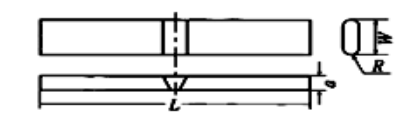
Kind	Size of specimens		Dimensions ⁽¹⁾	Intended for
U1A	Deposited tensile test specimens		As a rule $d=10$ $L_0=50$ $L_c=60$ $R \geq 10$	Deposited metal tensile test (Longitudinal tensile test)
1B			$d=6.0$ $L_0=24$ $L_c=32$ $R \geq 6$	Deposited metal test: $t=12$ (Welding consumables for stainless steel)
1C			$d=12.5$ $L_0=50$ $L_c=60$ $R \geq 15$	Deposited metal test: $19 \leq t \leq 25$
U2A	Butt weld tensile test specimen		$a=t^{(2)}$ $W=30$ $L_c=B+12$ $R \geq 50$	Butt weld tensile test for place
U2B			$a=t^{(2)}$ $W=12(t \leq 2)$ $L_c=B+60$ $R \geq 25$	
2C			$a=t$ $W=20$ $L_c=B+12$ $R \geq 50$ The sectional area of A shall be considered to be $W \times a$	Butt weld test for pipe: $t < 9$
2D			$a=t^{(2)}$ $W=20$ $L_c=B+12$ $R \geq 50$ The sectional area of A shall be finished to be rectangular. However, the machinery allowance shall be minimum.	Butt weld test for pipe: $t \geq 9$



Notes:

- 1 The following designations are used.
 d : diameter, a : thickness, W : width, L_0 : gauge length, L_C : parallel part length
 R : transition radius, B : breadth of weld, t' : thickness of test assembly
 t' : thickness of hobbled test assembly.
- 2 When the thickness of the test piece is so large that it exceeds the capacity of the testing machine, the test piece may be divided to be tested.





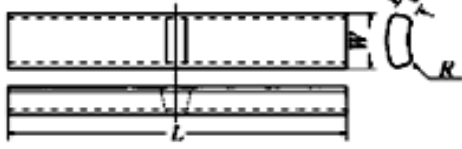
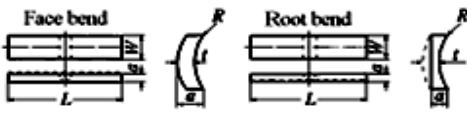
Table 3.2(a) Size and Dimension of Bend Test Specimens⁽¹⁾

Kind	Used for	Size of specimen		Dimensions	Intended for
UB-1	Welding procedure qualification test	Face and root bend specimen		$a = t$ $W = 30$ $L \geq 200$ $R = 1 \sim 2$	Test assemblise for butt weld test for plate:
UB-2		Side bend specimen		$a = 10$ $W = t^{(2)}$ $L \geq 200$ $R = 1 \sim 2$	Test assemblise for butt weld test for plate: $t \geq 12$
B-3				$a = 10$ $W = t^{(2)}$ $L = 200$ $R \leq 1.5$	Test assemblise for butt weld test for plate: $t \geq 20$
B-4		Face and root bend specimen		$a = t$ $W = 19$ $L = 200$ $R \leq 1.5$ For the tube whose D is 34.0 to 60.5 shall be 1 (For the tube having D of 34.0 and under, the width obtained by dividing the tube longitudinally into four equal parts shall be the width of the test piece.	Test assemblies for butt weld test for pipe: $t \leq 10$
B-5				$a = 10$ $W = 40$ $L = 200$ $R \leq 1.5$ For the tube having an D of 11.43 and under, W shall be 19	Test assemblies for butt weld test for pipe: $10 \leq t \leq 20$
UB-6	Approval test and annual inspection for welding consumables	Face and root bend specimen		$a = t$ $W = 30$ $L \geq 200$ $R = 1 \sim 2$ Where the thickness of test assemblies exceeds 25 mm, the thickness of test specimen may be reduced to 25 mm with its surface machined on one side only (compression side)	Butt weld test

Notes:

- The following designations are used:
 a : thickness, W : width, R : edge radius, D : external tube diameter
 t : thickness of test assembly, B : breadth of weld, L : length
- Where the thickness of the side bend specimen exceeds 40mm, the test specimen may be divided to be tested.

Table 3.2(b) Size and Dimension of Bend Test Specimens⁽¹⁾

Kind	Used for	Size of Specimen	Dimensions	Intended for
B-7	Approval test and annual inspections for welding consumables	Face and root bend specimen 	$a = 10$ $W = 40$ $L \geq 200$ $R \leq 1.5$	Butt weld test (welding consumable for 9% Ni steel)
UB-8		Side bend specimen 	$a = 10$ $W = t$ $L \geq 200$ $R = 1 \sim 2$	Butt weld test (welding consumables for electroslag and electro gas and two-run technique MIG welding for aluminum alloy)
B-10	Welders qualification test	Face and root bend specimen 	$a = 3.2$ $W = 40$ $L = 150$ $R \leq a/6$	Test assemblies for butt weld test for plate: $t = 3.2$
B-11			$a = 9$ $W = 40$ $L = 250$ $R \leq 1.5$	Test assemblies for butt weld test for plate: $t = 9$
B-12		Side bend specimen 	$a = 9$ $W = t$ $L = 250$ $R \leq 1.5$	Test assemblies for butt weld test for plate: $t \geq 25$
B-13		Face and root bend specimen 	$a = t$ $W = 15$ $L = 250$ $R \leq 1.5$	Test assemblies for butt weld test for pipe: $a \leq t \leq 5.3$
B-14		Side Bend specimen 	$a = 9$ $W = 40$ $L = 250$ $R \leq 1.5$	Test assemblies for butt weld test for pipe: $9 \leq t \leq 15$
B-15			$a = 9$ $W = t$ $L = 250$ $R \leq 1.5$	Test assemblies for butt weld test for pipe: $t \geq 20$

Notes:

- 1 The following designations are used:
 a : thickness, W : width, R : edge radius, D : external tube diameter
 t : thickness of test assembly, B : breadth of weld, L : length
- 2 Where the thickness of the side bend specimen exceeds 40mm, the test specimen may be divided to be tested.

Fig. 3.1 Guided Bend Test Jig (Unit: mm) (For bend test specimen of 9 mm in thickness)

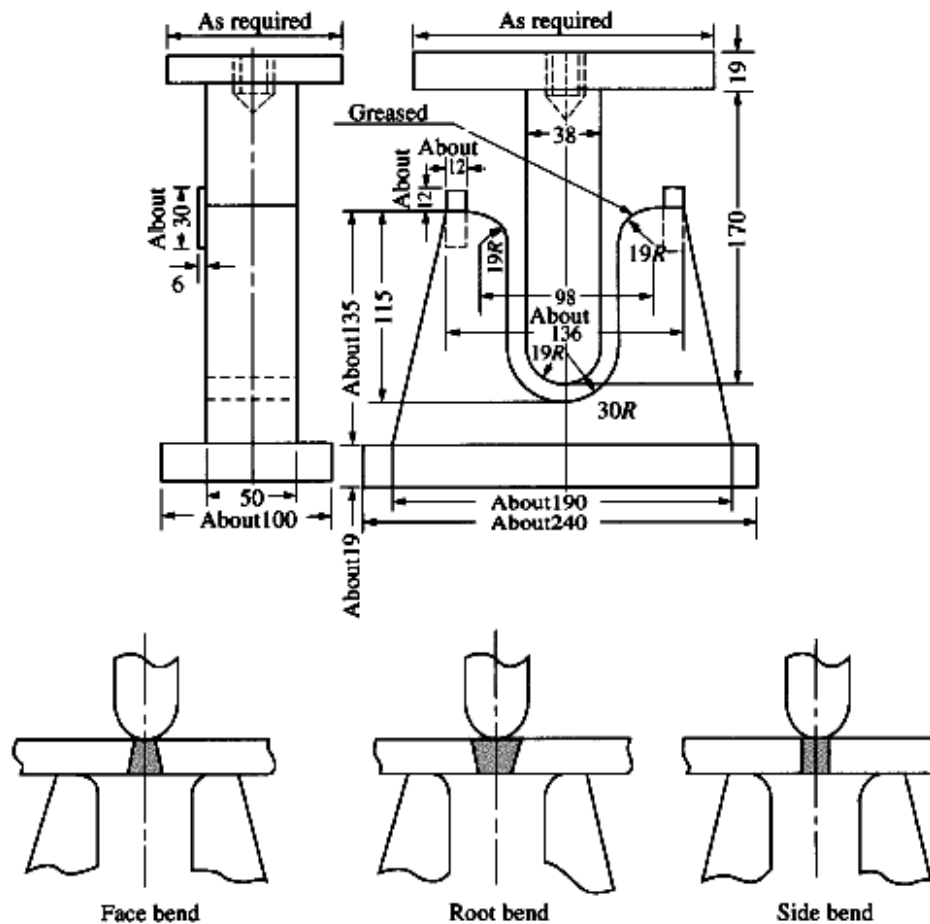


Fig. 3.2, 3.3

Fig. 3.2 Guided Bend Test Jig (Unit: mm)
(For bend test specimen of 3.2 mm in thickness)

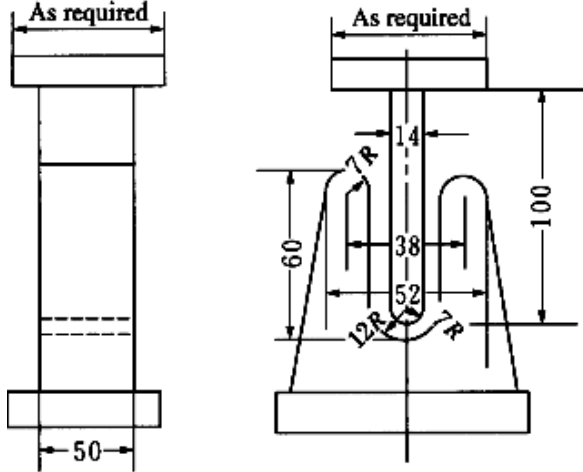
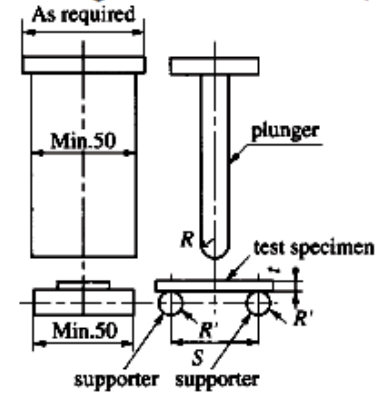


Fig. 3.3 Jigs for Roller Bend Test (Unit: mm)



Note:

- t :thickness of test specimen
- R :radius of plunger
- R' :radius of supporting roller (not specified)
- S :span between supports $\{2(R + R' + t + 2)\}$

Chapter 4 WELDING PROCEDURE AND RELATED SPECIFICATIONS

4.1 General

4.1.1 Application

1. The requirements in this Chapter are to be applied to the approval of welding procedure and related specifications mainly for hull construction, etc., unless specified in another chapter.
2. The requirements of this chapter correspondingly apply to the welding procedure and related specifications for the approval of steel castings and steel forgings which is to be weldable quality used for hull structures. However, the impact test may be omitted, upon the approval by the Society.
3. The welding procedure and related specifications approved by the Society are valid for welding works in all shops and sites belonging to the yard under the same facility and control system.
4. The welding procedures differing from the requirements specified in this Chapter are to be in accordance with the requirements specified in [1.1.1-3](#).

4.1.2 Approval of Welding Procedure and Related Specifications

1. The manufacturer is to obtain the approval of the welding procedures in the following cases specified in (1) through (3).
 - (1) Where the welding procedures are first adopted for welding works specified in [Chapter 2](#).
 - (2) Where the items described in the approved welding procedure specifications are altered.
 - (3) Where considered necessary by the Surveyor.
2. The specifications which corresponds to the welding procedure provided in preceding -1 are to be collected as the welding procedure specification and to be approved by the Society. The specifications are to include the items specified in [2.2.2-2](#) and -3.

4.1.3 Execution of Tests

1. For the approval of welding procedure and related specifications, the tests specified in [4.2](#) or [4.3](#) are to be carried out based on the representing conditions, such as the edge preparation, welding parameter, etc., described in the welding procedure specification, with satisfactory results. However, for quenched and tempered high tensile rolled steel for structure, the tests are to be carried out every heat treatment.
2. Part of or all requirements for the tests provided in preceding -1 may be dispensed in the case which deemed appropriate by the Society, subject to the approval of the welding procedure specifications.
3. The addition of tests or test conditions other than those specified in this Chapter for the welding procedure qualification (e.g. design of strength, thickness and temperature, and welding heat input) may be required, where deemed necessary by the Society.
4. The changes of backing material for one-side welding are to be deemed appropriate by the Society.

5. For qualification tests for stainless clad steels, the requirements specified in [4.2](#) and [4.3](#) are to be complied with. However the impact test may be dispensed with where other welding procedure qualification on the stainless clad steel base metal has been approved under the same welding condition.
6. Welding procedure used by dissimilar process (combination welding) may be carried out with separate welding procedure tests for each weld process.

4.1.4 Range of Approval

1. The scope of approval of the welding procedure and related specifications of rolled steels for hull and quenched and tempered high tensile rolled steel for structure are in accordance with the following (1) through (5), on the condition that other welding conditions are same. However, the range of approval differing from the requirements specified in this Chapter may be accepted that it is deemed appropriate by the Society.

- (1) Kind of weld joints

Kind of weld joints is in accordance with in [Table 4.1](#). Where the welding procedures for butt welding are approval, the kinds of weld joints include the fillet weld joints, corresponding to the welding position applied for the butt weld joint.

- (2) Thickness

The range of the thickness is in accordance with in [Table 4.2](#).

- (3) Leg length of fillet welding

The range of the leg length of fillet welding is in accordance with in [Table 4.3](#).

- (4) Kinds of base metal

- (a) Rolled steels for hull

- i) Within the same strength level, the welding procedures are considered applicable to lower toughness grade (material with higher specified impact test temperature).
 - ii) In addition to the requirement in **i)**, within the same and below toughness grades, the welding procedures are considered applicable to the one and two lower strength levels (material with the one and two lower specified yield strength).

- (b) Quenched and tempered high tensile rolled steel for structure

- i) Within the same strength level, the welding procedures are considered applicable to lower toughness grade.
 - ii) In addition to the requirement in **i)**, within the same and below toughness grades, the welding procedures are considered applicable to the one lower strength levels.

- (c) Notwithstanding the requirement given in **(a)** and **(b)**, for the large heat input welding specified in [Note \(5\) of Table 4.2](#), the welding procedures are considered applicable to that toughness grade tested and one strength level below.

- (5) Kinds of welding consumables

The welding consumables are to be not bland but grade (including all suffixes), except the large heat input specified [Note \(5\) of Table 4.2](#).

2. The restriction of welding procedure condition (e.g. heat input welding and preheating) in actual work is to be deemed appropriate by the Society.
3. Where deemed necessary by the Society for welding procedure, restrictions on the heat treatment of base metals, carbon equivalent or cold cracking susceptibility and the locations of application of the welding procedure may be imposed.
4. The range of approval of materials other than the rolled steels for hull and quenched and tempered high tensile rolled steel for structure are to be deemed appropriate by the Society.

Table 4.1 Range of approval for type of weld joint

Type of welded joint for test assembly				Range of approval
Butt Welding	One side	With backing	A	A, C
		Without backing	B	A, B, C, D
	Both side	With gouging	C	C
		Without gouging	D	C, D
Fillet Welding			E	E

Table 4.2 Approved Range of Thickness⁽¹⁾

Thickness of test assemblies $t(mm)^{(2),(3),(4)}$	Approved range of thickness (mm)			
	Butt welding			Fillet welding
	Multi-run technique	Single-run technique or Two-run technique	Large heat input welding process	
$t \leq 100$	$0.5t$ to $2t^{(6),(7)}$ (100 max)	$0.7t$ to $1.1t^{(6),(7)}$ (100 max)	$0.7t$ to t	$0.5t$ to $2t^{(6),(7)}$ (100 max)

Notes:

- 1 Welding procedure used by dissimilar process (combination welding) is to be correspondingly applied to [Table 4.2](#). In this case, thickness or throat thickness of each welding method is to be t .
- 2 For unequal plate thickness of butt welds the lesser thickness is ruling dimension.
- 3 For fillet welds, the range of approval shall be applied to the web thickness and flange thickness of test piece.
- 4 If T-joint welds are applied to full penetration, the requirements are correspondingly applied to the requirements of butt welding.
- 5 Large heat input welding means the welding with a welding heat input of not less than $50kJ/cm$.
- 6 For the vertical-down welding, the test piece thickness t is always taken as the upper limit of the range of application.
- 7 For test assembly thickness not more than $12mm$, the specified minimum content is not applicable.

Table 4.3 Applicable leg length of fillet welding

Approved range of leg length (<i>mm</i>)	
Single-run technique	Multi-run technique
$0.75f$ to $1.5f^{(1)(2)}$	$0.5f$ to $2f^{(1)(2)}$

Notes:

- 1 f : leg length of test piece
- 2 Where welding in vertical downward position is applied, the approved range of thickness is to be f .

4.2 Tests for Butt Welded Joints

4.2.1 Application

The requirements in [4.2](#) apply to the butt welded joints of materials prescribed shown in [Table. 4.4](#) or equivalent materials by a manual, semi-automatic welding or automatic welding method.

4.2.2 Kinds of Test

The kinds of butt welded joint test and number of specimens are to be in accordance with the requirements specified given in [Table 4.4](#).

4.2.3 Test Assemblies

1. Test assemblies are to be prepared with the same or equivalent material as used in the actual work.
2. The dimensions and types of test assembly are to be as indicated in (A), (B), (C), (D), (E) and (F) of [Fig. 4.1](#)
3. Test assemblies are to be welded in the same welding positions as the actual work.
4. Test assemblies for pipes over 300mm in diameter at the actual work may be those for the plates.
5. For butt welded joints of rolled steel plates for low temperature service and quenched and tempered high tensile rolled steels for structure, the test assemblies are to be generally so prepared that the rolling direction is parallel to the direction of welding.
6. In general, the thickness of test assemblies for welding procedure qualification test is to be equal to the thickness of the thickest material to be adopted in the actual work.
7. The tack welds of test piece are to be the same procedure as actual work.

Table 4.4 Kinds of Butt Welded Joint Test and Number of Specimens

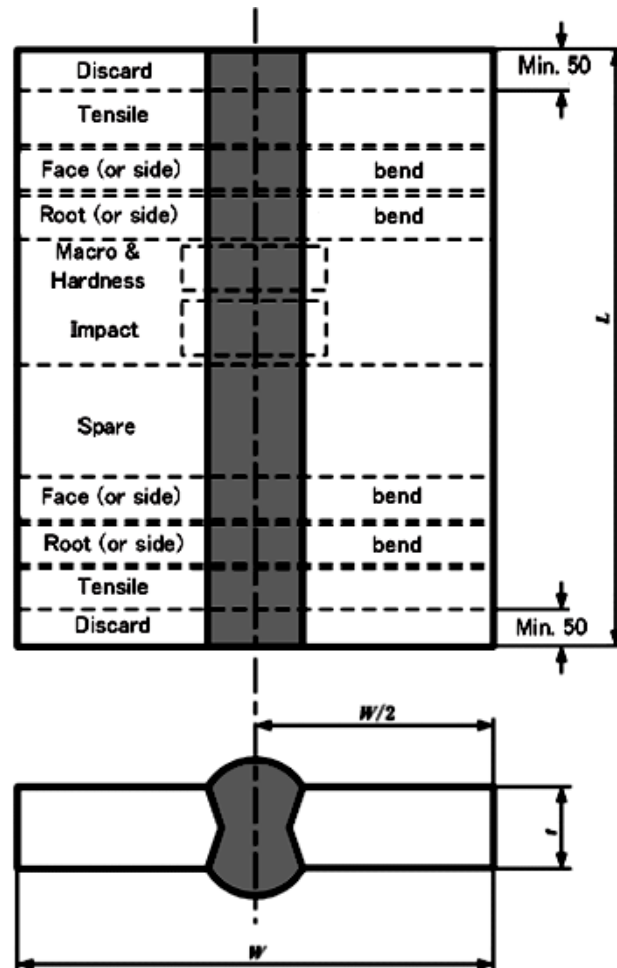
Kind and grade of test assembly			Kinds of test and number of specimens ⁽¹⁾							
			Visual inspection	Tensile test	Bend test	Impact test (sets) ⁽²⁾	Macro-Structure inspection	Hardness test	Non-destructive inspection ⁽³⁾	
Rolled steel for hull	KA, KB, KD, KE KA32,KD32,KE32, KF32, KA36, KD36, KE36, KF36, KA40, KD40, KE40, KF40		Whole length of welding joints	2	4 ⁽⁵⁾	3~8<a,b,c,d,e> ⁽⁷⁾	1	1 ⁽¹⁰⁾	Whole length of welding joints	
Rolled steels for lower temperature service	KL24A, KL24B, KL27, KL33,KL37, KL2N30,KL3N32, KL5N43			4 ⁽⁴⁾	2 ⁽⁶⁾	5<A,B,C,D,E> ⁽⁸⁾		—		
	KL9N53, KL9N60									
Steel pipes for low temperature service	KLPA, KLPB, KLPC, KLP2, KLP3, KLP9			4	4	3~8<a,b,c,d,e> ⁽⁷⁾		1		
Quenched and tempered high tensile rolled steel for structure	KA420, KD420, KE420, KF420, KA460, KD460, KE460, KF460, KA500, KD500, KE500, KF500, KA550, KD550, KE550, KF550, KA620, KD620, KE620, KF620, KA690, KD690, KE690, KF690									
Rolled stainless steels	KSUS304,KSUS304L, KSUS304N1, KSUS304N2, KSUS304LN, KSUS309S, KSUS310S, KSUS316, KSUS316L, KSUS316N, KSUS316LN, KSUS317, KSUS317L, KSUS317LN, KSUS321, KSUS329J1, KSUS329J3L, KSUS329J4L, KSUS347									
Stainless steel pipes	K304TP, K304LTP, K309STP, K310STP, K316TP, K316LTP, K317TP, K317LTP, K321TP, K329J1TP, K329J3LTP, K329J4LTP, K347TP			4	4 ⁽⁵⁾	(9)		1		—
Aluminium alloys ⁽¹¹⁾	5000 Series	5754P, 5086P, 5086S ⁽¹²⁾ , 5083P, 5083S ⁽¹²⁾ , 5383P, 5383S ⁽¹²⁾ , 5059P, 5059S ⁽¹²⁾ , 5456P								
	6000 Series	6005AS ⁽¹³⁾ , 6061P, 6061S ⁽¹³⁾ , 6082S ⁽¹³⁾								

Notes:

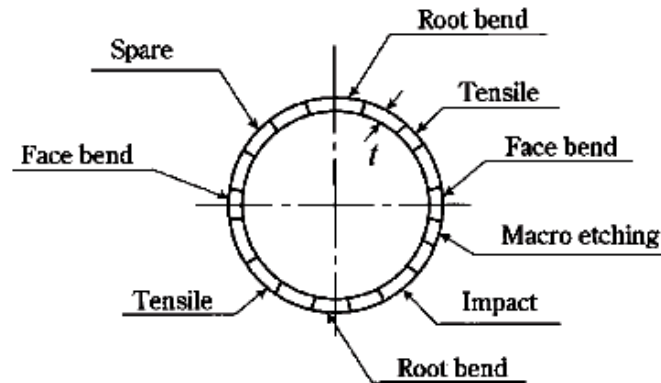
1 Where found necessary by the Society, deposited metal tensile test, microscopic test and tests other than those may be required.

- 2 In this Table, the mark in < > specifies position of notch given in [Fig. 4.2](#) through [Fig. 4.4](#).
- 3 Internal inspections by radiographic examination or ultrasonic examination and surface inspections by magnetic particle examination or liquid penetrant examination are to be carried out.
- 4 Two specimens are to be taken longitudinally and transversely respectively. (See [Fig. 4.1\(D\)](#))
- 5 Two specimens are to be taken from root bend and face bend respectively. (See [Fig. 4.1\(A\)](#), [\(E\)](#) and [\(F\)](#)).
- 6 The specimens are to be taken longitudinally. (See [Fig. 4.1\(D\)](#)).
- 7 The specimens are to be taken in accordance with [Fig. 4.2](#) and [4.3](#).
- 8 The position of notch for the specimen is to be shown in [Fig. 4.4](#).
- 9 Where found necessary by the Society, impact tests up to steels specially used for may be required.
- 10 For KA36, KD36, KE36, KF36, KA40, KD40, KE40 and KF40, the tests are to be carried out.
- 11 All temper conditions indicated with grades are to be included (See [Table 8.3](#)).
- 12 Rolled products which have the same grade and temper condition may be used.
- 13 Other rolled aluminium alloys of 6000 series with tensile strength 260 N/mm^2 and above may be used.

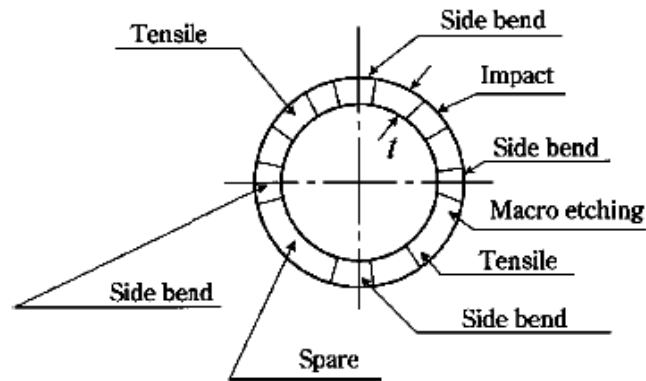
Fig 4.1(a) Welding Procedure Qualification Test assemblies (Unit: mm)



(A) Test Assembly for Plates (materials indicated in (D), (E) and (F) are excluded)



(B) Test Assembly for Pipes up to 20mm in Thickness



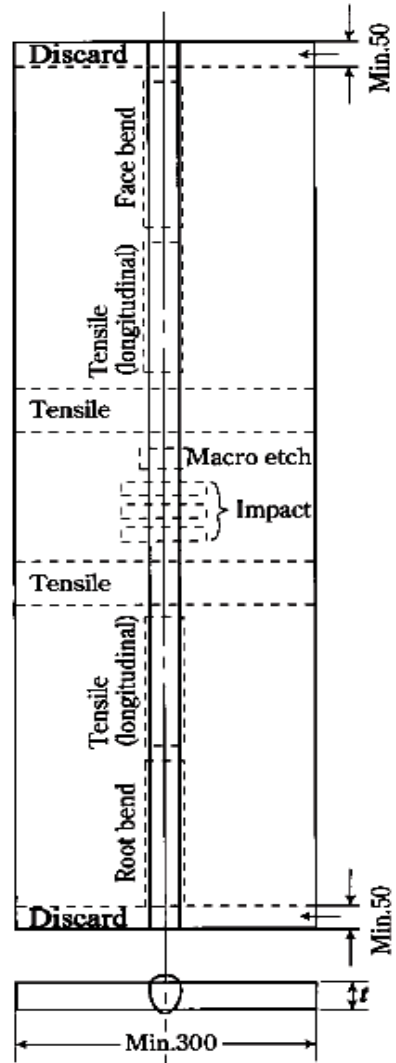
(C) Test Assembly for Pipes over 20mm in Thickness

Notes:

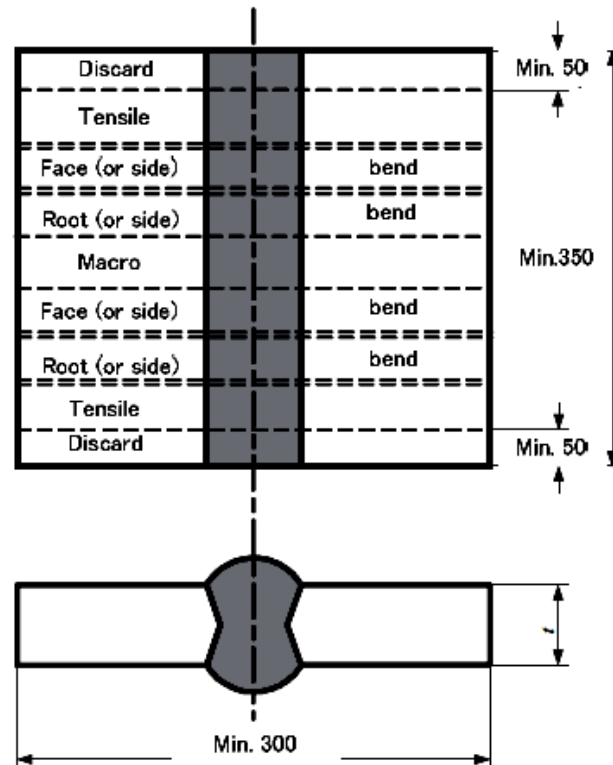
- 1 In [Fig. \(A\)](#), width (W) and length (L) of test specimens are as follows.
Manual welding and semi-automatic welding: $W \geq 300mm$, $L \geq 350mm$
Automatic welding: $W \geq 400mm$, $L \geq 1000mm$
- 2 The root and face bends may be substituted by 4 side bends for $t \geq 12mm$.

Fig 4.1(b) Welding Procedure Qualification Test assemblies (Unit: mm)

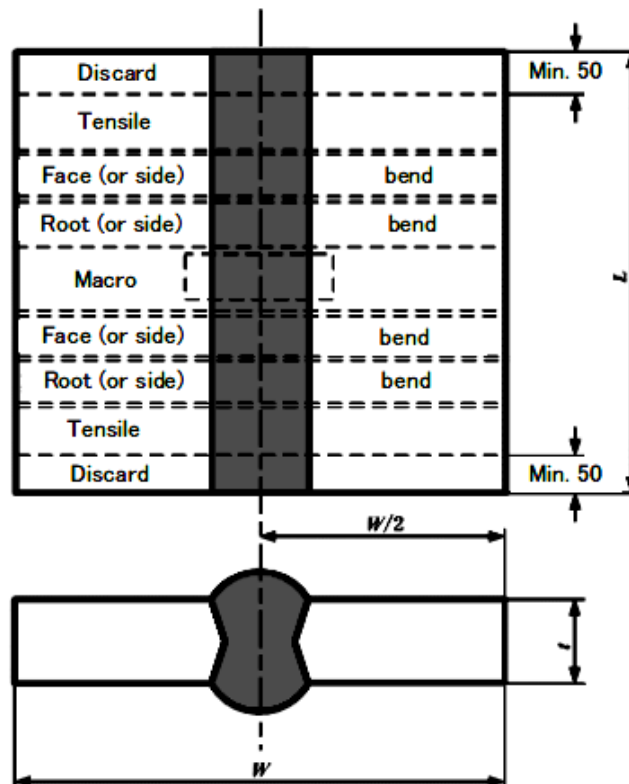
(D) Test Assembly for RL9N53 or RL9N60



(E) Test Assembly for Plates of Rolled Stainless Steel



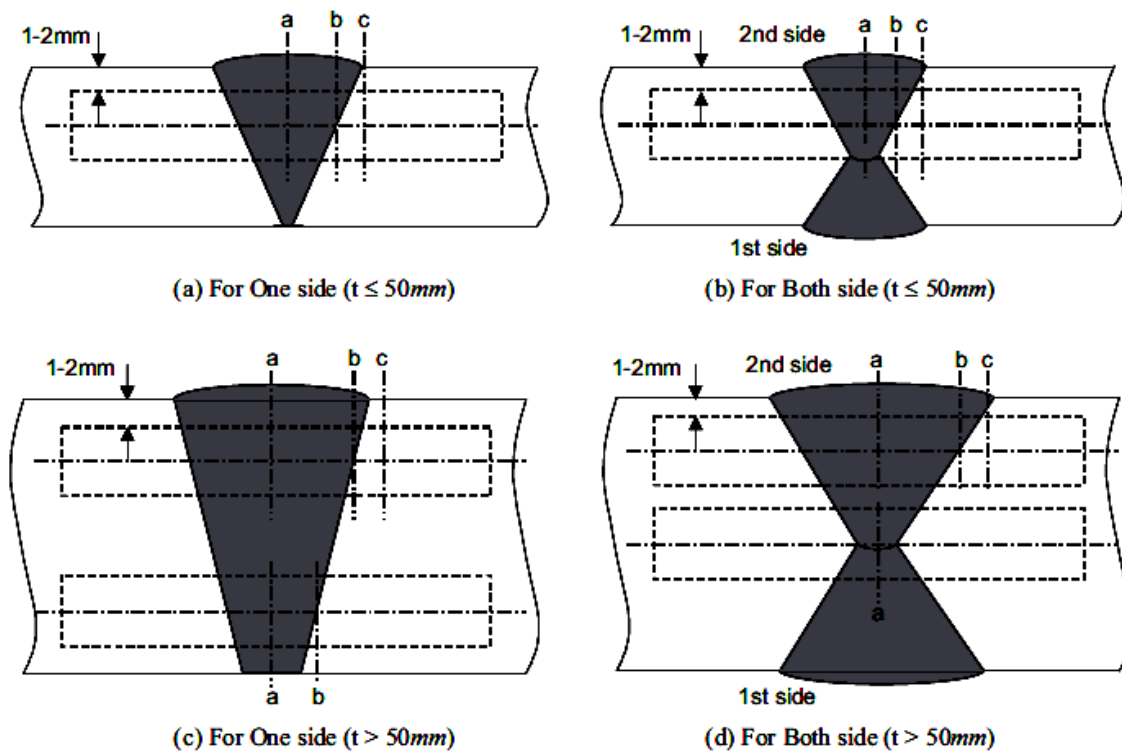
(F) Test Assembly for Plates of Aluminium Alloy



Notes:

- 1 In **Fig. (F)**, width (W) and length (L) of test assembly are as follows.
Manual welding and semi-automatic welding: $W \geq 300mm$, $L \geq 350mm$
Automatic welding: $W \geq 400mm$, $L \geq 1000mm$
- 2 The root and face bends may be substituted by 4 side bends for $t \geq 12mm$.
- 3 For butt joint of dissimilar alloy material, longitudinal bend tests may be required by the Society.

Fig 4.2 Position of Notch for Impact Test Specimen for rolled steels for hull and quenched and tempered high tensile rolled steel for structure (Where welding heat input is not greater than $50kJ/cm$, Unit: mm)



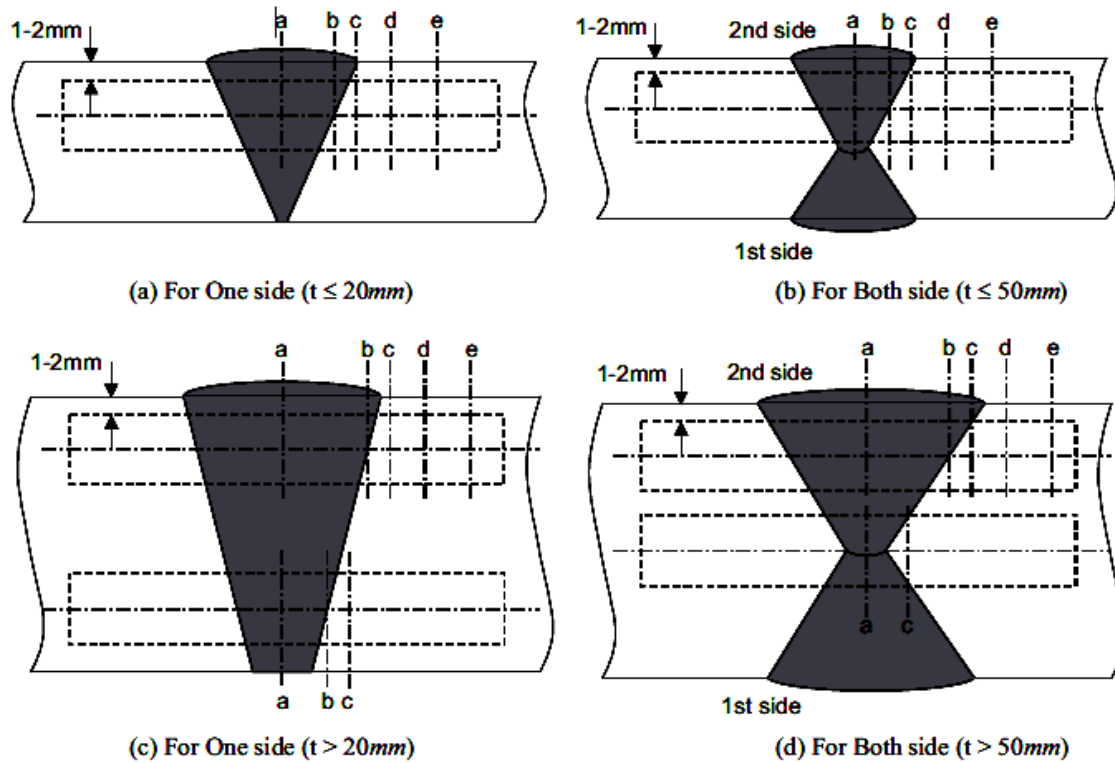
Notch location:

- a: Center of weld "WM"
- b: On fusion line "FL"
- c: In HAZ, 2mm from fusion line

Note:

For one side single run welding over 20 mm notch location "a" shall be added on root side.

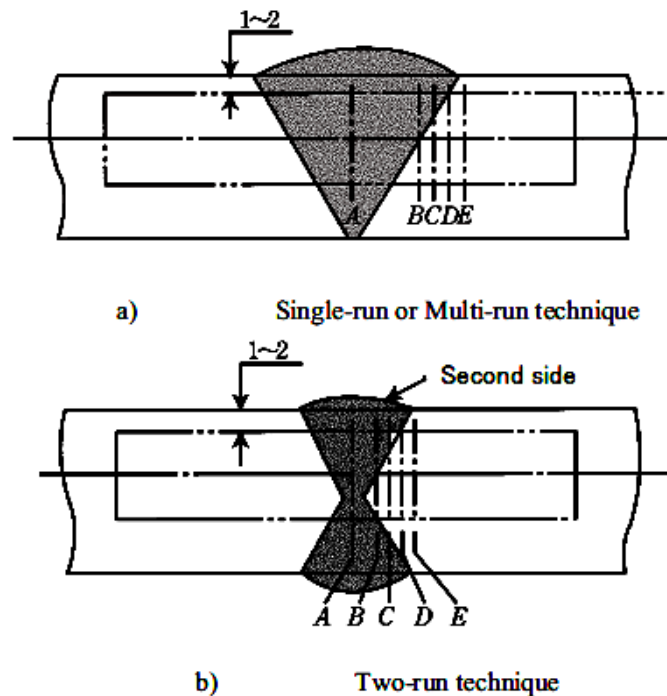
Fig 4.3 Position of Notch for Impact Test Specimen for rolled steels for hull and quenched and tempered high tensile rolled steel for structure (Where welding heat input is greater than $50kJ/cm$, Unit: mm)



Notch location:

- a: Center of weld "WM"
- b: On fusion line "FL"
- c: In HAZ, 2mm from fusion line
- d: In HAZ, 5mm from fusion line
- e: In HAZ, 10mm from fusion line

Fig 4.4 Positions of Notch for Impact Test Specimens for Rolled Steel for Low Temperature Service and Steel Pipes for Low Temperature Service (Unit: mm)



Notch location:

- a: Center of weld “WM”
- b: On fusion line “FL”
- c: In HAZ, 2mm from fusion line
- d: In HAZ, 5mm from fusion line
- e: In HAZ, 10mm from fusion line

4.2.4 Finished Inspection

Welded surface is to be regular and uniform and is to be free from injurious defects, such as cracks, undercuts, overlaps, etc.

4.2.5 Tensile Tests

1. Tensile tests are to be carried out with the U2A, U2B, 2C and 2D shown in [Table 3.1](#). However, where other test specimens are used, they are to be approved by the Society. The ultimate tensile strength is not to be less than the minimum ultimate tensile strength specified for the base metal except for those specified in [Table 4.5](#).
2. The number of tensile test specimens taken from each test assembly is to be as shown in [Table 4.4](#).
3. As for the requirements for tensile tests of welded joints of steels of different specified strength, those for joints of steels of lower specified strength are to be applied.

Table 4.5 Tensile Test Requirements for Butt Welded Joint

Kind of test assembly	Grade of test assembly	Tensile test	
		Tensile strength (N/mm^2)	0.2% proof stress (N/mm^2)
Rolled steels for low temperature service	KL9N53, KL9N60	590 min ⁽¹⁾	315 min
		630 min ⁽²⁾	—
Steels pipes for low temperature service	KLP9	630 min	—
Aluminium alloys ⁽³⁾	5086P-H112 ⁽⁴⁾ 5086P-H116	240 min	—
	5083P-H116 5083P-H321	275 min	—
	6061P-T6 6005AS-T5 ⁽⁵⁾ , 6005AS-T6 ⁽⁵⁾ 6001S-T6 ⁽⁵⁾ 6082S-T5 ⁽⁵⁾ , 6082S-T6 ⁽⁵⁾	170 min	—

Notes:

- 1 For test specimens in longitudinal direction
- 2 For test specimen in transverse direction
- 3 Grades of aluminium alloys have indication grade showing the temper condition.
- 4 For test assembly thickness not more than 12.5mm
- 5 See [Notes \(13\)](#) of [Table 4.4](#).

4.2.6 Bend Tests

1. Bend tests are to be carried out with the face bend and root bend or side bend test specimen shown in UB-1, UB-2, B-3, B-4, or B-5 of [Table 3.2](#), and the test specimens are to be bent by the jig shown in [Table 4.6](#). There is to be no crack or any other defect greater than 3mm in length in any direction on the surface of bent specimen.
2. The number of bend test specimens taken from each test assembly is to be as shown in [Table 4.4](#).

Table 4.6 Bend Test Requirements for Butt Welded Joint

Kind of test assembly	Grade of test assembly	Maximum radius of plunger (mm) ⁽¹⁾	Belding angle (degree)
Steels pipes for low temperature service	<i>KLP9</i>	$\frac{10}{3}a$	180
High strength quenched and tempered rolled steel plates for structure	<i>KA420, KD420, KE420, KF420, KA460, KD460, KE460, KF460, KA500, KD500, KE500, KF500</i>	$\frac{5}{2}a$	
	<i>KA550, KD550, KE550, KF550, KA620, KD620, KE620, KF620, KA690, KD690, KE690, KF690</i>	$3a$	
Aluminium alloys ⁽²⁾	<i>5754P, 5086P, 5086S⁽³⁾, 5083P, 5083S⁽³⁾, 5383P, 5383S⁽³⁾, 5059P, 5059S⁽³⁾, 5456P, 6005AS⁽⁴⁾, 6061P, 6061S⁽⁴⁾, 6082S⁽⁴⁾</i>	$\left(\frac{100 \times a}{A} - a\right) \times 0.5$	
Other materials		$2a$	

Notes:

- 1 a : thickness of the test specimen in [Table 3.2\(a\)](#) (mm)
- 2 A : minimum elongation specified in [Table 8.3, Part 10](#) (%) and in the case of a combination of different alloys, the lowest individual value is to be used.
- 3 See [Notes \(11\)](#) of [Table 4.4](#).
- 4 See [Notes \(12\)](#) of [Table 4.4](#).
- 5 See [Notes \(13\)](#) of [Table 4.4](#).

4.2.7 Impact Tests

1. Impact test specimens are to be *U4* specimens shown in [Table 2.5, Part 10](#) and to be taken from the position shown in [Fig. 4.2](#) to [Fig. 4.4](#).

Where *U4* impact test specimens cannot be taken because of the convenience of material, the requirements in sub-paragraphs [2.2.4-4](#) and [2.3.2-2 in Part 10](#) of the Rules is to be applied.

2. The number of specimens taken from each test assembly and the position of notch for the specimen are to be as shown in [Table 4.4](#) and [Fig. 4.2](#) to [Fig. 4.4](#). The longitudinal direction of the notch of the test specimen is to be in the direction of the thickness of test material.

3. The testing temperature and the minimum mean absorbed energy of three specimens are to be as specified in [Table 4.7](#) to [Table 4.9](#) and the percent brittle fracture of the specimens is to be measured.

4. The test specimens are to be taken from the automatically welded part, for the combined joint welded by automatic welding and manual or semi-automatic welding. It may be required to take another set of test specimens from the manually or semi-automatically welded part, where deemed necessary by the Society.

5. For the butt joints where higher grade of steel is welded to lower grade of steel, the impact test is to be carried out in accordance with the requirements for the impact tests of butt joints of the lower grade of steel.
6. As for the requirements for impact tests of welded joints of steels of different specified strength, those for joints of steels of lower specified strength are to be applied.

Table 4.7 Impact Test Requirements for Butt Weld Joint

(Rolled Steel for Hull, where thickness is not greater than 50mm) ⁽¹⁾

Grade of steel	Testing temperature (°C)	Value of minimum average absorbed energy (J) ⁽²⁾		
		For manually or semi-automatically weld joints		For automatically welded joints
		Downhand, Horizontal, Overhead	Vertical upward, Vertical downward	
KA ⁽³⁾	20	47	34	34
KB ⁽³⁾ , KD	0			
KE	-20			
KA32, KA36	20			
KD32, KD36	0			
KE32, KE36	-20			
KF32, KF36	-40			
KA40	20		39	39
KD40	0			
KE40	-20			
KF40	-40			

Notes:

- 1 For thickness above 50mm, impact test requirements are to be in accordance with **4.1.3-3** and to be agreed by the Society.
- 2 A set of test specimens is considered to have failed if the value of absorbed energy of more than two test specimens is less than the specified value of minimum mean absorbed energy or if the value of any one of the test specimens is less than 70% of the specified value of minimum mean absorbed energy.
- 3 Steels average absorbed energy on fusion line and in heat affected zone is to be minimum 27J.

Table 4.8 Impact Test Requirements for Butt Welded Joint (Rolled Steels for Lower Temperature Service)

Grade of steel	Testing temperature (°C)	$A^{(1)}$	$B, C, D, E^{(1)}$	
		Value of minimum mean absorbed energy ⁽³⁾ (J)	Value of minimum mean absorbed energy ⁽³⁾ (J)	
			$L^{(2)}$	$T^{(2)}$
KL24A	-40	27	41	27
KL24B	-50			
KL27	-60			
KL33	-60			
KL37	-60			
KL2N30	-70			
KL3N32	-95			
KL5N43	-110			
KL9N53	-196			
KL9N60	-196			
KLPA	-40		27	—
KLPB	-50			
KLPC	-60			
KLP2	-70			
KLP3	-95		34	
KLP9	-196		41	

Notes:

- 1 Position of notch as shown in [Fig. 4.4](#).
- 2 L (or T) indicates that the direction of welding is transverse (or parallel) to the rolling direction of test materials.
- 3 A set of test specimens is considered to have failed if the value of absorbed energy of more than two test specimens is less than the specified value of minimum mean absorbed energy or if the value of any one of the test specimens is less than 70% of the specified value of minimum mean absorbed energy.
- 4 Where requirements in *IGC Code IMO* apply, the impact test temperature is to be as given as follows:
 - (a) Impact test temperature for KL24A through KL5N43 is to be the lower of the temperatures given in [Table 3.17](#) specified in [3.4.5-2, Part 10](#) of the Rules.
 - (b) Impact test temperature for KLPA through KLPC is to be either 5°C below the design temperature or -20°C whichever is less.

Table 4.9 Impact Test Requirements for Butt Weld Joint
(Quenched and Tempered High Tensile Rolled Steels for Marine Construction)

Grade of steel	Testing temperature (°C)	Value of minimum mean absorbed energy (J) ⁽¹⁾		
		$a^{(2)}$	$B, c, d, e^{(2)}$	
			$L^{(3)}$	$T^{(3)}$
KA420	0	47	42	28
KD420	-20			
KE420	-40			
KF420	-60			
KA460	0		46	31
KD460	-20			
KE460	-40			
KF460	-60			
KA500	0	50	50	33
KD500	-20			
KE500	-40			
KF500	-60			
KA550	0	55	55	37
KD550	-20			
KE550	-40			
KF550	-60			
KA620	0	62	62	41
KD620	-20			
KE620	-40			
KF620	-60			
KA690	0	69	69	46
KD690	-20			
KE690	-40			
KF690	-60			

Notes:

- 1 A set of test specimens is considered to have failed if the value of absorbed energy of more than two test specimens is less than the specified value of minimum mean absorbed energy or if the value of any one of the test specimens is less than 70% of the specified value of minimum mean absorbed energy.
- 2 Position of notch as shown in [Fig 4.2](#) and [Fig 4.3](#).
- 3 L (or T) indicates that the direction of welding is transverse (or parallel) to the rolling.

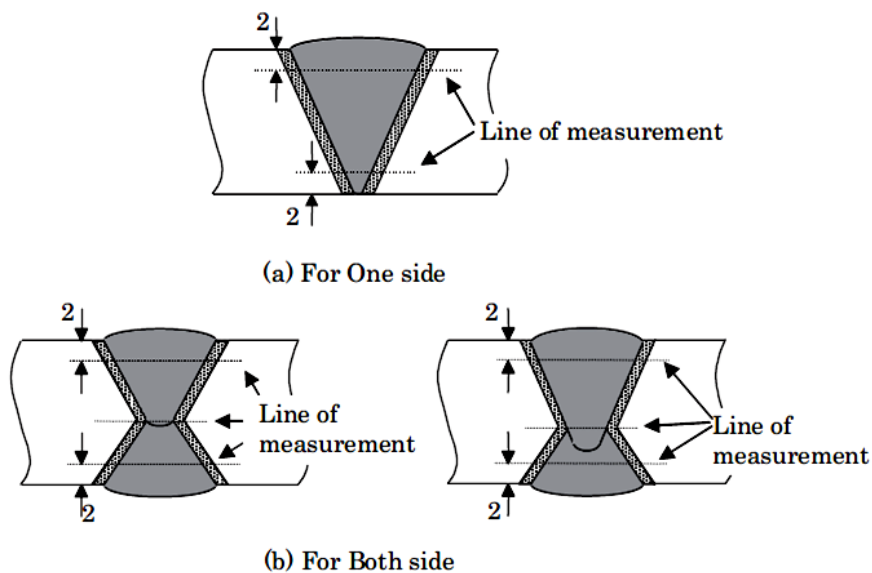
4.2.8 Macro-structure Inspection

1. The transverse section of test specimens taken from the welded joint is to be etched and examined, and is to show that there are no crack, poor penetration, lack of fusion and other injurious defects.
2. Macro examination shall include about 10 mm unaffected base metal.

4.2.9 Hardness test

1. Vickers hardness is to be measured at the position shown in [Fig 4.5](#). The kinds of specimens for Vickers hardness are to be in accordance with the requirements specified given in [Table 4.10](#).
2. The number of specimens for hardness test is to be in accordance with the requirements specified given in [Table 4.4](#).

Fig. 4.5 Hardness test (Unit: mm)



Notes:

- 1 For each row of indentations there shall be a minimum of 3 individual indentations in the weld metal, the heat affected zones (both side) and the base metal (both sides).
- 2 Measuring intervals are to be 1mm on the basis of the bond.
- 3 Measuring load is to be 10kg Vickers.

Table 4.10 Requirements of hardness test

kinds of specimen	Vickers hardness (<i>HV10</i>)
Rolled steels for hull ⁽¹⁾	350 max
Quenched and tempered high tensile rolled steel of structure	420 max

Note:

- 1 For *KA36*, *KD36*, *KE36*, *KF36*, *KA40*, *KD40*, *KE40* and *KF40*, the tests are to be carried out.

4.2.10 Non-destructive Inspection

1. Internal inspections by radiographic examination or ultrasonic examination, and surface inspections by magnetic particle examination or liquid penetrant examination are to be carried for whole length of the welding. The result of non-destructive inspection is to show that there are no crack, poor penetration, lack of fusion and other injurious defects.
2. In case any post-weld heat treatment is required or specified, non-destructive inspection test is to be performed after heat treatment.
3. Quenched and tempered high tensile rolled steel for structure shall be delayed for minimum of 48 hours, unless heat treatment has been carried out.

4.2.11 Retests

1. Where visual inspection, macro-structure inspection or non-destructive inspection fails to meet the requirements, the new test specimens welded under the same welding conditions, are to be subject to retest and all of these test specimens are to pass the test.
2. Where the tensile test or the bend test fails to meet the requirements, twice as many test specimens as the number of failed test specimens are to be selected from either the first test material or test materials welded under the same welding conditions, and all of these test specimens are to pass the test.
3. Where results of the impact test fail to satisfy the requirements and in cases other than those given in the following (1) and (2), retests may be carried out on a set of test specimens selected from the same test material as the one from which the failed test specimens were selected. In this case, the test specimens are considered to have passed the tests if the average value of absorbed energy of a total of six test specimens, including the values of the failed specimens, is not less than the value of the specified minimum mean absorbed energy and, furthermore, if the number of test specimens among the said test specimens which are of lower energy than the specified value of minimum mean absorbed energy, and the number of test specimens

which are of 70% lower energy than the specified value of minimum mean absorbed energy are not more than two and one respectively.

- (1) Where all test specimens fail to reach the specified value of minimum mean absorbed energy
- (2) Where two of the test specimens fail to reach 70% of the specified value of minimum mean absorbed energy
4. If there is a single hardness value above the maximum values allowed, additional hardness tests shall be carried out (on the reverse of the specimen or after sufficient grinding of the test surface).
5. Where the test specimens fail to meet the requirements specified in either of preceding -1 through -4, new test specimens are to be welded by changing the welding condition, and to be retest and pass all test items as specified.

4.3 Tests for Fillet Weld Joints

4.3.1 Application

The requirements in [4.3](#) apply to the fillet joints of materials prescribed in shown in [Table 4.4](#) or equivalent materials welded by a manual, semi-automatic or automatic welding method.

4.3.2 Kinds of Test

Fillet weld joints are to be subjected to finished inspection, macro-structure inspection, hardness test, fracture and non-destructive inspection test. Additional tests may be required if found necessary by the Society.

4.3.3 Test Assemblies and Welding

1. Test assembly is to be prepared with the same or equivalent material used in the actual work.
2. The dimensions and type of test assembly are to be as indicated in [Fig. 4.6](#).
3. Test assembly is to be welded in the same welding position as the actual work.
4. The assembly is to be welded on one side only, except in case deemed necessary by the Surveyor.
5. For manual and semi-automatic welding, a stop/restart should be included in middle of the test assemblies in longitudinal direction.
6. The tack welds of test piece are to be the same procedure as actual work.

4.3.4 Finished Inspection

Welded surface is to be regular and uniform and is to be free from injurious defects, such as cracks, undercuts, overlaps, etc.

4.3.5 Macro-structure Inspection

1. In macro etched specimens showing the transverse section of fillet weld joint, weld joints are to be free from excessive difference between upper and lower fillet lengths, cracks and other injurious defects.

2. Macro examination shall include about 10mm unaffected base metal.

4.3.6 Hardness test

1. Vickers hardness is to be measured at the position shown in [Fig 4.7](#). The kinds of specimens for Vickers hardness are to be in accordance with the requirements specified given in [Table 4.10](#).
2. The number of specimens for hardness test are to be in accordance with the requirements specified given in [Table 4.4](#).

4.3.7 Fracture Tests

The remaining test assemblies after the macro-structure specimen has been removed are to be broken by pressing as shown in [Fig. 4.6](#), without cracks, poor penetrations, blow holes and injurious defects in the fractured surface. Where, however, the sum of lengths having blow holes (include poor penetrations), except at both ends of the specimen, is not greater than 10% of the total welded length, the test may be regarded as satisfactory.

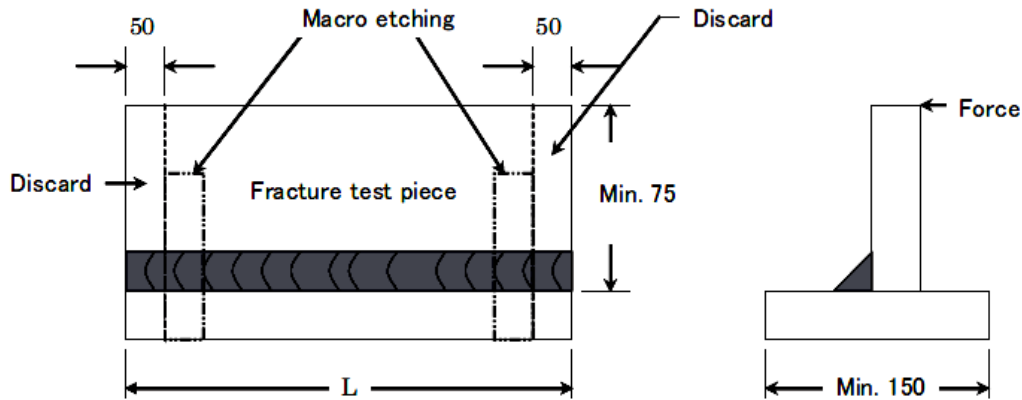
4.3.8 Non-Destructive Inspection

1. Surface inspections by magnetic particle examination or liquid penetrant examination are to be carried for whole length of the welding. The result of non-destructive inspection is to show that there are no crack and other injurious defects.
2. In case any post-weld heat treatment is required or specified, non-destructive inspection test is to be performed after heat treatment.
3. Quenched and tempered high tensile rolled steel for structure shall be delayed for minimum of 48 hours, unless heat treatment has been carried out.

4.3.9 Retests

1. Where visual inspection, macro-structure inspection, fracture test or non-destructive inspection test fails, the new test specimens welded under the same welding conditions, are to be subject to retest, and all of these test specimens are to pass the test items specified.
2. Where the hardness test fails, the retest may be correspondingly applied to the requirement in [4.2.11-4](#).

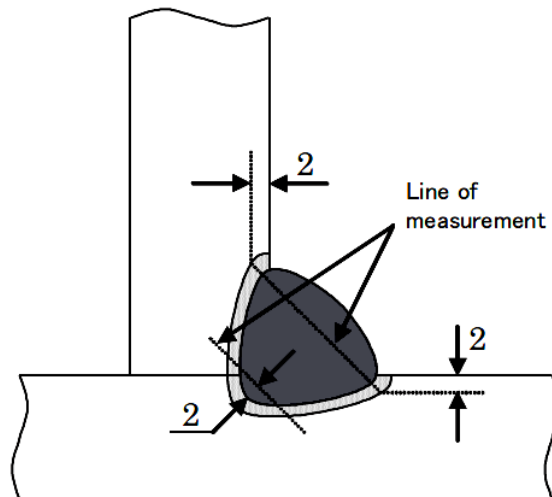
Fig. 4.6 Test Assembly for Fillet Weld Joints (Unit: mm)



Note:

- 1 The length of test specimen, L is not less than 350mm for manual welding and semi-automatic welding (including gravity welding) and not less than $1,000\text{ mm}$ for automatic welding.

Fig. 4.7 Hardness test (Unit: mm)



Notes:

- 1 For each row of indentations there shall be a minimum of 3 individual indentations in the weld metal, the heat affected zones (both side) and the base metal (both sides).
- 2 Measuring intervals are to be 1mm on the basis of the bond.
- 3 Measuring load is to be 10kg Vickers.

Chapter 5 WELDERS AND THEIR QUALIFICATION TESTS

5.1 General

5.1.1 Welders

1 Each welder intended to engage in the welding work specified in this Part is to pass the qualification tests required according to the applicable welding process and welding consumables to be welded and to be furnished with the Qualification Certificate issued by the Society. Each welder intended to engage in the automatic welding operation is to be of a well experienced welder for the specific welding work concerned.

2 This Chapter specifies the qualification test requirements for manual, semi-automatic and *TIG* (tungsten inert gas) welding. The term “semi-automatic welding” means that the welding is carried out manually by a welding operator holding a gun through which only the wire is fed automatically.

3 This Chapter specifies the qualification test requirements for the welding work of mild steels, stainless steels and aluminium alloy materials.

4 The qualification test requirements for each welder intended to engage in the welding work of the special materials and welding work not specified in this Chapter are to be in accordance with the specific approval given by the Society.

5.1.2 Welder Qualification Certificates

Qualification Certificates are to be issued to the welders who have passed the qualification test by the Society. The certificate is to be shown to the Surveyor at any time if required.

5.1.3 Period of Validity

The period of validity for the qualified welder is full three years from the qualified date.

5.1.4 Continuation of Qualification

Welders qualified by the Society are, for continuation of their qualification, to have the qualification renewal tests prior to the due date. Where they have passed the tests, the new qualification certificates with the validity of three years will be issued. In this case, the renewal tests are to be in accordance with the specific approval given by the Society.

5.1.5 Retests

1. Where any test specimen fails to meet the specified dimensional requirements by poor machining, a replacement test assembly is to be prepared for testing.

2. For the welder who fails to meet the requirements in part of the tests, the retests as to the failed tests may be made on duplicate test specimens taken from the test assemblies welded within one month from the date of the failure.

3. The welder who fails to meet the requirements in all parts of the tests or in the retest prescribed in -2 is not to take the next test within one month from the date of the failure.

5.1.6 Welding and Procedure

1. Test assemblies may be welded with either alternating current or direct current.
2. The test assemblies are not to be changed their up-and-down or right-and-left position throughout the welding operation. The welding in vertical position is to be done upward procedure.
3. The welding is to be carried out only on one side and the back welding is not to be carried out unless specified otherwise.
4. In general, the test assemblies for plates are to be so restrained or prestrained that the warping due to the welding does not exceed an angular distortion of 5 *degrees*.
5. The test assemblies are not to be subjected to peening or heat treatment throughout the period before, during and after the welding.

5.2 Qualifications

5.2.1 Kinds, Grades and Classes of Qualification

1. The kinds of qualification are to be classified as given in [Table 5.1](#) according to the welding procedure used in actual welding work.
2. The grades of qualification are to be classified as given in [Table 5.2](#) according to the thickness of materials used in actual welding work.
3. The Classes of welding positions for each Grade are to be classified as given in [Table 5.3](#).
4. Welder of Class Z referred to in -3 above is regarded to be qualified for all the classes of *F*, *V*, *H* and *O* within the same Grade.
5. Any welder who intends to be qualified for Class *V*, Class *H*, Class *O* and Class *P* of each Grade and each Kind is to have qualification of Class *F* of the corresponding Kind and Grade.
6. Welder of any Class of any Grade of Kind *N* may be regarded as the welder of the same Class of the same Grade of Kind *A*.
7. Welder of Grade 3 may be regarded as the welder of Grade 2 and Grade 1, and welder of Grade 2 may be similarly regarded as the welder of Grade 1 within the same Class and Kind.

Table 5.1 Kinds of Welder Qualification

Symbol	Welding process in actual work
<i>A</i>	Both side welding including back chipping and back welding
<i>N</i>	One side welding without backing

Table 5.2 Grades of Welder Qualification and Applicable Plate Thickness

Grade	Thickness (<i>mm</i>) of materials used in actual welding work
Grade 1	5 or below
Grade 2	19 or below
Grade 3	No restriction

Table 5.3 Classes of Welding Positions for Each Grade of Qualification

Qualification						
Grade	Class					
	Plates					Pipes
	Welding in flat position (Class <i>F</i>)	Welding in vertical position (Class <i>V</i>)	Welding in horizontal position (Class <i>H</i>)	Welding in overhead position (Class <i>O</i>)	Welding in all position (Class <i>Z</i>)	Welding of fixed pipe (Class <i>P</i>)
Grade 1	1 <i>F</i>	1 <i>V</i>	1 <i>H</i>	1 <i>O</i>	1 <i>Z</i>	1 <i>P</i>
Grade 2	2 <i>F</i>	2 <i>V</i>	2 <i>H</i>	2 <i>O</i>	2 <i>Z</i>	2 <i>P</i>
Grade 3	3 <i>F</i>	3 <i>V</i>	3 <i>H</i>	3 <i>O</i>	3 <i>Z</i>	3 <i>P</i>

5.3 Testing Procedure

5.3.1 Kinds and Procedure of Test

1. Welding process, testing assemblies, welding positions and testing procedures for each qualification test are to be as indicated in [Table 5.4](#), [Table 5.5](#) and [Table 5.6](#).
2. The welding positions for butt joints and pipes are indicated in [Fig. 5.1](#) and [Fig 5.2](#) respectively.

Table 5.4 Welding procedures for Qualification Test

Kind	Welding	Backing of test assembly
<i>A</i>	Arc welding	With backing
<i>N</i>		Without backing

Table 5.5 Thickness of Test Assembly, Welding Position and Testing Procedure for Qualification Test (Plates)

Grade	Thickness of test assembly (mm)	Welding in position					Testing procedure
		Class <i>F</i>	Class <i>V</i>	Class <i>H</i>	Class <i>O</i>	Class <i>Z</i>	
Grade 1	3.2	Welding in flat position	Welding in vertical position	Welding in horizontal position	Welding in overhead position	Welding in all position	Face bend test and root bend test
Grade 2	9	Welding in flat position	Welding in vertical position	Welding in horizontal position	Welding in overhead position	Welding in all position	Face bend test and root bend test
Grade 3	25 or over	Welding in flat position	Welding in vertical position	Welding in horizontal position	Welding in overhead position	Welding in all position	Side bend test

Table 5.6 Test Assembly and Testing Procedure for Class P (Fixed Pipe)

Test			
Grade	Test assembly of fixed pipe material		Testing procedure
	Mild steel & stainless steel	Aluminium alloy	
Grade 1	Thickness : 4.0 ~ 5.3mm Outside dia.: 100 ~ 120mm	Thickness : 4.0 ~ 5.3mm Outside dia.: 100 ~ 150mm	Root bend test (Face bend and root bend test for aluminium alloy)
Grade 2	Thickness : 9 ~ 11mm Outside dia.: 150 ~ 170mm	Thickness : 12 ~ 15mm Outside dia.: 150 ~ 200mm	Face bend and root bend test
Grade 3	Thickness : .20mm and over Outside dia.: 200 ~ 300mm	Thickness : .20mm and over Outside dia.: 200 ~ 300mm	Side bend test

Fig. 5.1 Welding Positions of Plates

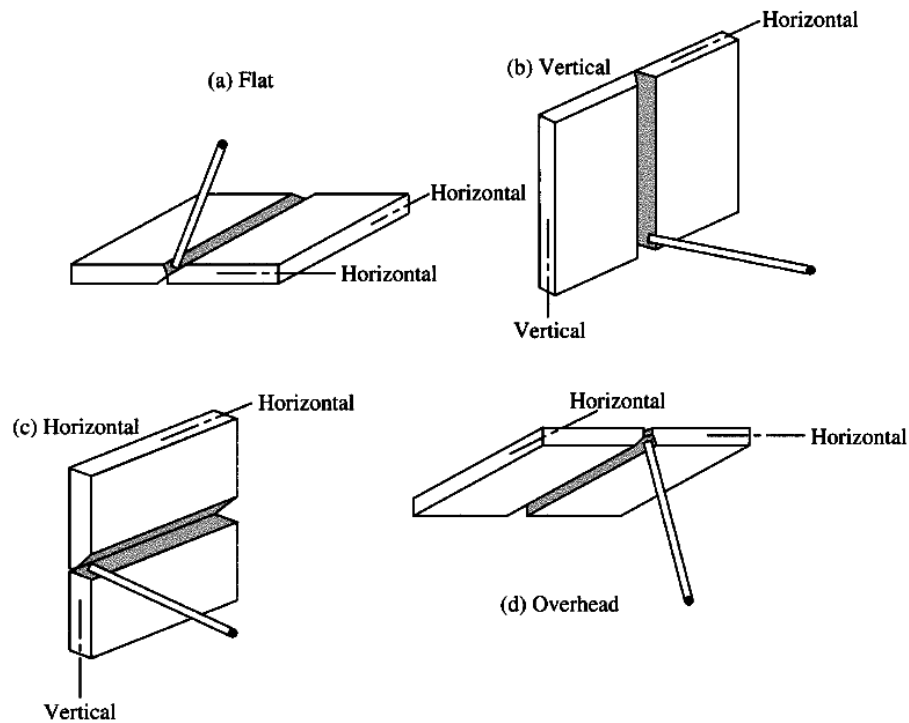
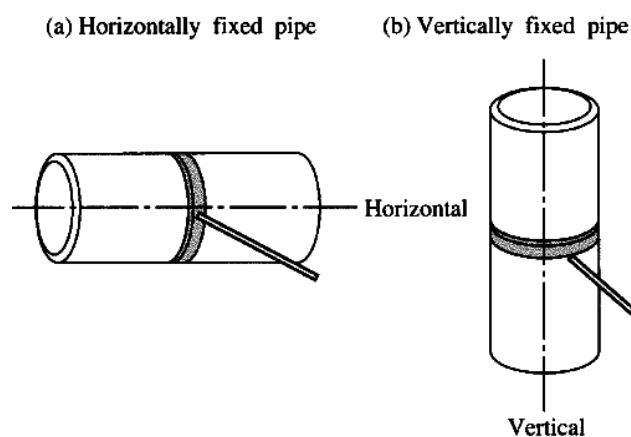


Fig. 5.2 Welding Positions for Pipes



5.3.2 Testing Materials and Welding Consumables

1. Testing materials and welding consumables for mild steels are to conform to one of the following requirements or to be of equivalent quality approved by the Society.

(1) Test assemblies for plates

Rolled steel plate for hull (KA through KE)

Rolled steel plate for boiler (KP42 or KP46)

- (2) Test assemblies for pipes
Steel pipes of Grades 1 to 3 for pressure piping (*KSTPG38* through *KSTPT49* prescribed in [Table 4.10](#), [Part 10](#).) Pipe fabricated with the plates specified in (1)
- (3) Welding consumables to be used for testing are to be of the consumables for mild steels approved by the Society.
2. Testing materials and welding consumables for stainless steels are to conform to one of the following requirements or to be of equivalent quality approved by the Society.
 - (1) Test assemblies for plates
Rolled stainless steel plates specified in [Part 10](#).
 - (2) Test assemblies for pipes
Stainless steel pipes specified in [Part 10](#)
Pipes fabricated with the rolled stainless steel plates specified in (1)
 - (3) Welding consumables to be used for testing are to be of the consumables for stainless steels approved by the Society.
3. Testing materials and welding consumables for aluminium alloy are to conform to one of the following requirements or to be of equivalent quality approved by the Society.
 - (1) Test assemblies for plates
5083P-O specified in [Part 10](#)
 - (2) Test assemblies for pipes
Pipes fabricated with the rolled materials specified in (1)
 - (3) Welding consumables to be used for testing are to be of the consumables for aluminium alloy approved by the Society.

5.3.3 Test Assemblies for Each Kind and Grade

1. The dimensions and types of test assemblies for plates of Grade 1 are to be as indicated in [Fig. 5.3](#).
2. The dimensions and types of test assemblies for plates of Grade 2 are to be as indicated in [Fig. 5.4](#).
3. The dimensions and types of test assemblies for plates of Grade 3 are to be as indicated in [Fig. 5.5](#).
4. The dimensions and types of test assemblies for pipes of Grade 1 are to be as indicated in [Fig. 5.6](#). The test assemblies are to be properly fixed as indicated in [Fig. 5.2 \(a\)](#), and welding is to be carried out between *A*, *B* and *C* as shown in [Fig. 5.6 \(a\)](#), where *A* and *C* are to be right above and just under the horizontal axis. Subsequently, the test assemblies are to be vertically fixed as indicated in [Fig. 5.2 \(b\)](#), and welding is to be carried out between *A*, *D* and *C*, as shown in [Fig. 5.6 \(a\)](#).
5. The dimensions and types of test assemblies for pipes of Grade 2 are to be as indicated in [Fig. 5.7](#). The test assemblies are to be properly fixed as indicated in [Fig. 5.2 \(a\)](#), and welding is to be carried out between *AB* and *AD* as shown in [Fig. 5.7 \(a\)](#), where *A* is to be just under the horizontal axis. Subsequently, the test assemblies are to be vertically fixed as indicated in [Fig. 5.2 \(b\)](#), and welding is to be carried out between *B*, *C* and *D*, as shown in [Fig. 5.7 \(a\)](#). Welding may be started either from *B* or from *D*.

6. The dimensions and types of test assemblies for pipes of Grade 3 are to be as indicated in [Fig. 5.8](#). The welding process is to be the same as for test assemblies specified in -5 above.

5.3.4 Test Specimens

The test specimens are to be finished to size and dimensions as shown in [Table 3.2](#).

- (1) Face bend and root bend test specimens from plate test assemblies for each Class of Grades 1 and 2 are to be of the type *B-10* and *B-11*, and side bend test specimens from plate test assemblies for each Class of Grade 3 are to be of the type *B-12*.
- (2) Face bend and root bend test specimens from pipe test assemblies for each Class of Grades 1 and 2 are to be of the type *B-13* and type *B-14* respectively, and side bend tests specimens from pipe test assemblies for each Class of Grade 3 are to be of the type *B-15*.

5.3.5 Test Procedure for Each Test Specimen

1. The test is to be of bend test either by guided bend test or roller bend test. The test specimens are to be bent through 180 *degrees*. In the case of aluminium alloy, the roller bend test is to be carried out. However, proper method of guided bend test may be substituted at the approval of the Surveyor.
2. In the case of guided bend test, the test specimen taken from the plate test assembly of Grade 1 is to be tested with the bending jig as shown in [Fig. 3.2](#), and the test specimen taken from either plate or pipe test assembly of Grades 2 and 3 is to be tested with the bending jig as indicated in [Fig. 3.1](#). However, the test specimen taken from pipe test assembly of Grade 1 is to be tested by the roller bend test with the bending jig as shown in [Fig. 3.3](#) under the test conditions shown in [Table 5.7](#).
3. In the case of roller bend test, the bend test is to be carried out with the bending jig as shown in [Fig. 3.3](#) under the test conditions shown in [Table 5.7](#).

5.3.6 Acceptance Criteria

The specimens are to show neither crack nor other serious defect greater than 3mm in length in any direction on the outside surface due to the bending.

Table 5.7 Test Conditions for Roller Bend Test

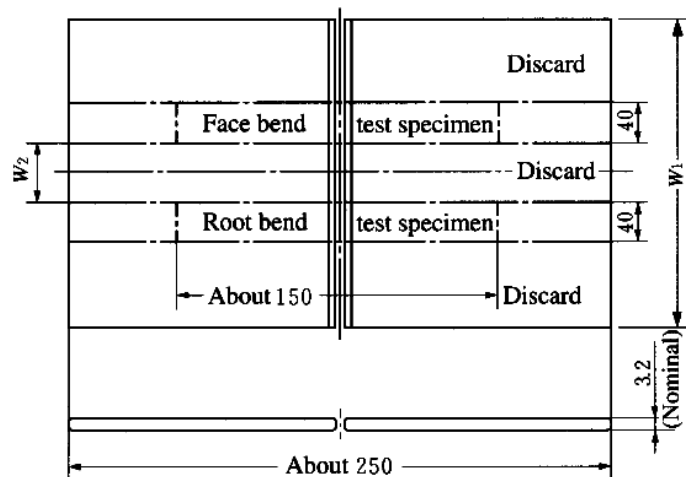
Test assembly		Radius of plunger
Mild steel	Grade 1 pipe	1.5t
	Grade 1 plate	2.0t
	Grade 2 plate	
	Grade 3 plate	
	Grade 2 pipe	
Stainless steel	Grade 3 pipe	$3\frac{1}{3}t$
	Grade 1 plate	
	Grade 2 plate	
Aluminium alloy	Grade 3 plate	
	Grade 1 pipe	
	Grade 2 pipe	
	Grade 3 pipe	

Note:

t: thickness of test specimen

Fig. 5.3 Dimensions and Types of Test Assemblies for Plates of Grade 1

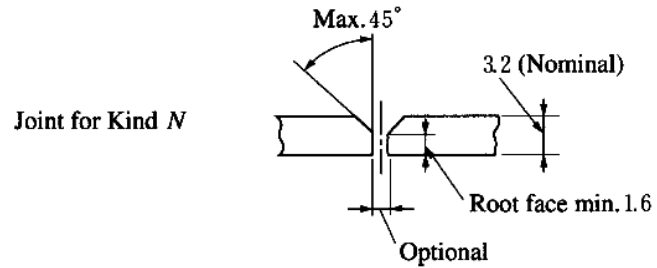
(a) Dimensions of test assembly (unit: mm)



W₁ : About 150 mm for manual welding and TIG welding
About 200 mm for semi-automatic welding.

W₂ : 30 mm or under for manual welding and TIG welding
About 40 mm for semi-automatic welding.

(b) Joint for mild steel and stainless steel test assemblies (unit: *mm*)



(c) Joint for aluminum alloy test assembly (unit: *mm*)

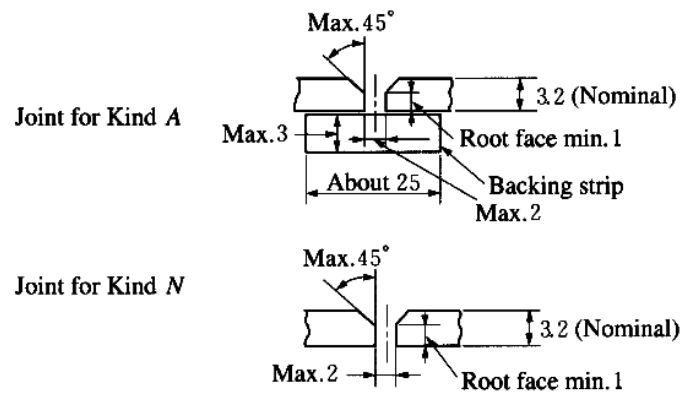
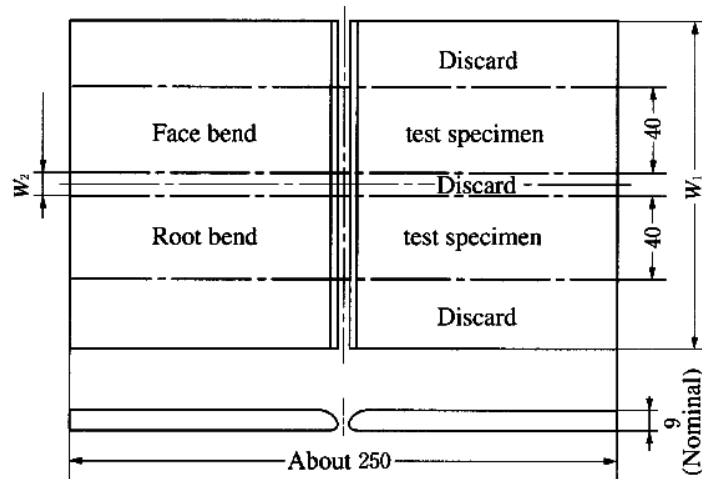


Fig. 5.4 Dimensions and Types of Assemblies for Plates of Grade 2

(a) Dimensions of test assembly (unit: *mm*)



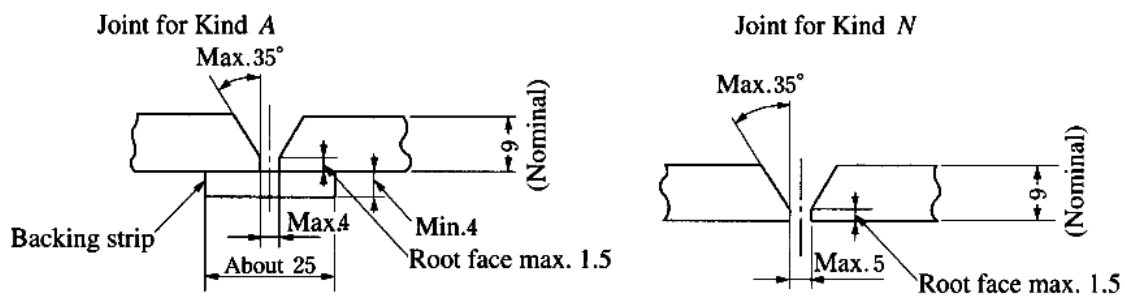
W_1 : About 150 *mm* for manual welding and *TIG* welding

 About 200 *mm* for semi-automatic welding

W_2 : 10 *mm* or under for manual welding and *TIG* welding

 About 40 *mm* for semi-automatic welding

(b) Join for mild steels and stainless steels test assemblies (unit: *mm*)



(c) Join for aluminium alloy test assemblies (unit: *mm*)

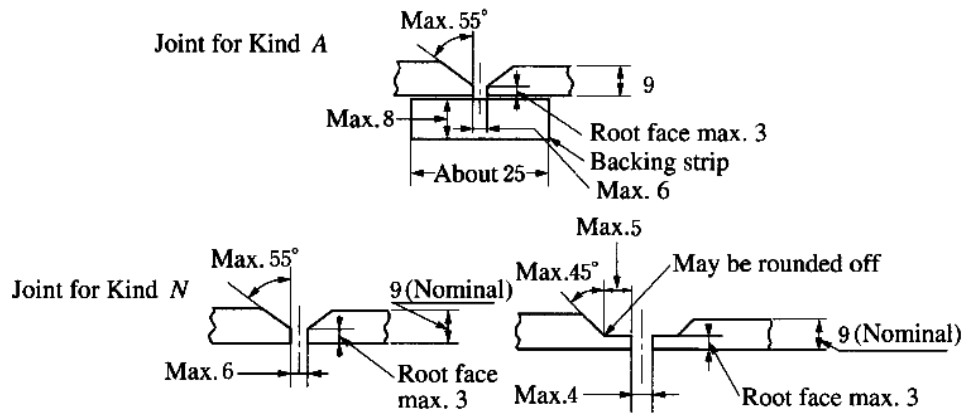
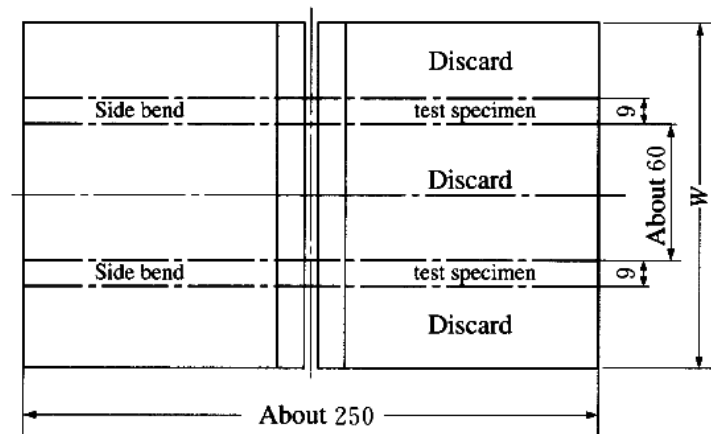


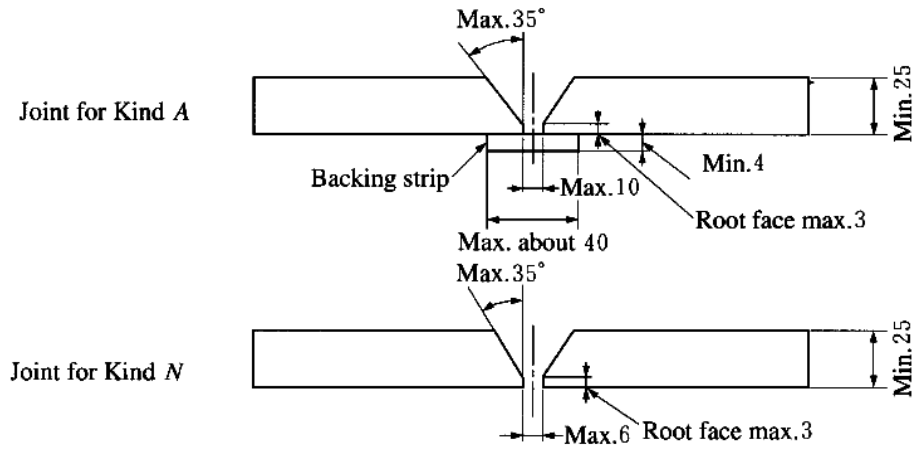
Fig. 5.5 Dimensions and Types of Test Assemblies for Plates of Grade 3

(a) Dimensions of test assembly (unit: *mm*)



W : About 150 *mm* for manual welding and *TIG* welding
About 200 *mm* for semi-automatic welding

(b) Type of joint for mild steels and stainless test assembly(unit: *mm*)



(c) Type of joint for aluminium alloy (unit: *mm*)

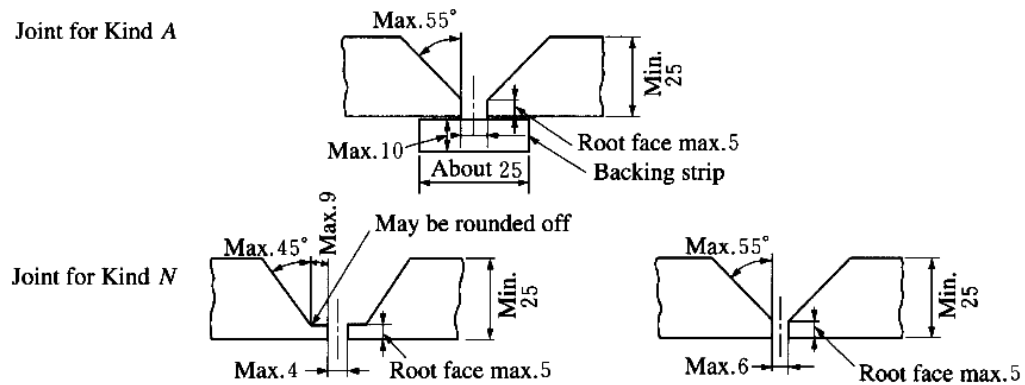
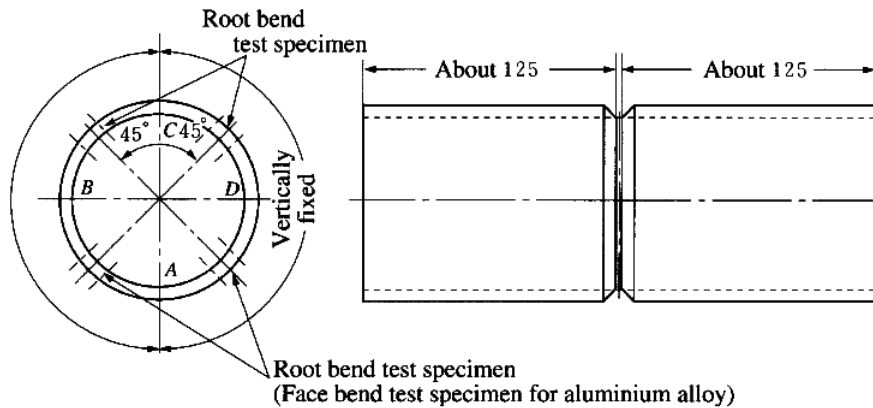
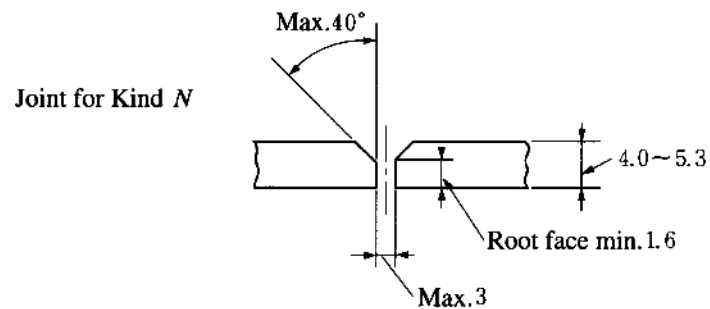


Fig. 5.6 Dimensions and Types of Test Assemblies for Pipes of Grade 1

(a) Dimensions of test assembly (unit: *mm*)



(b) Type of joint for mild steels and stainless steels (unit: *mm*)



(c) Type of joint for aluminium alloy (unit: *mm*)

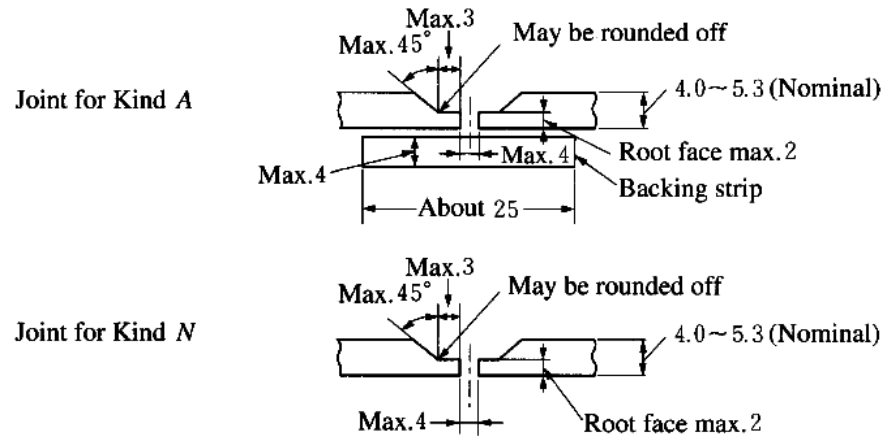
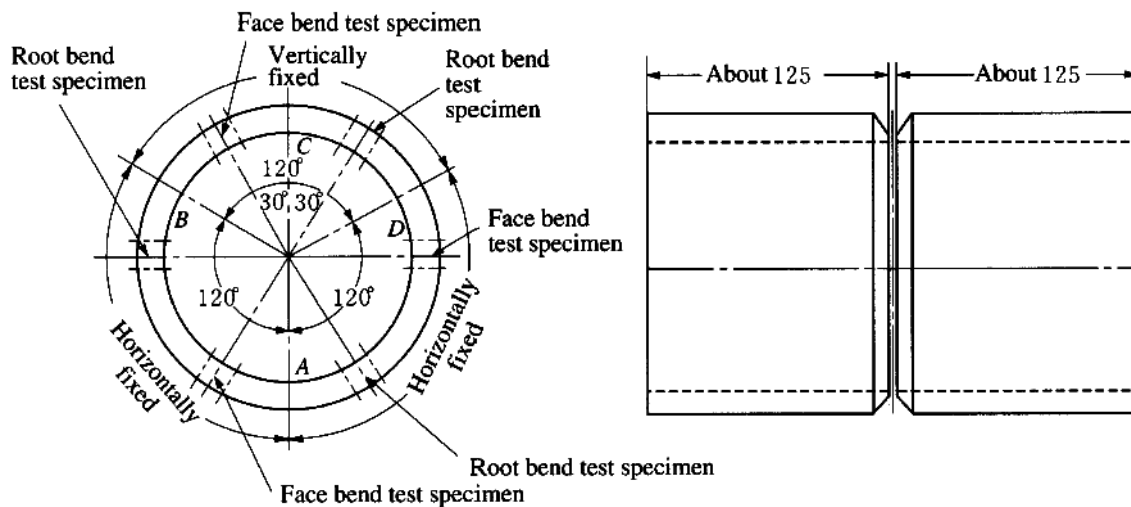
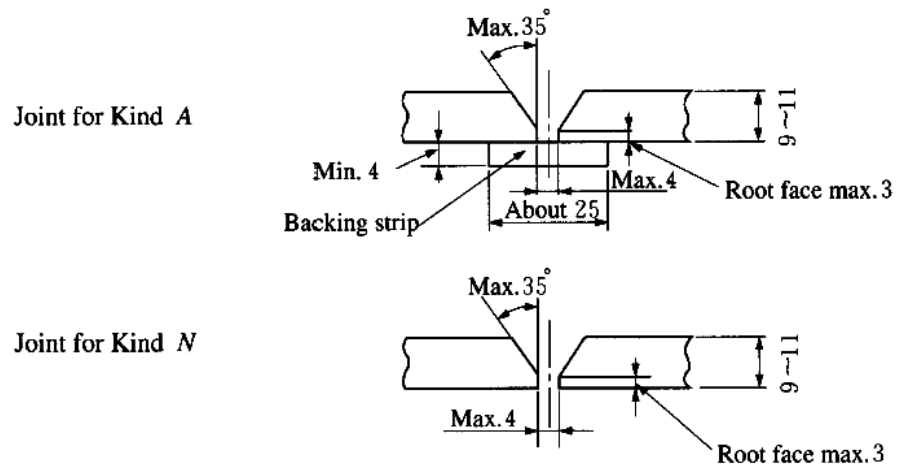


Fig. 5.7 Dimensions and Types of Test Assemblies for Pipes of Grade 2

(a) Dimensions of test assembly (unit: *mm*)



(b) Type of joint for mild steels and stainless steels (unit: mm)



(c) Type of joint for aluminium alloy (unit:mm)

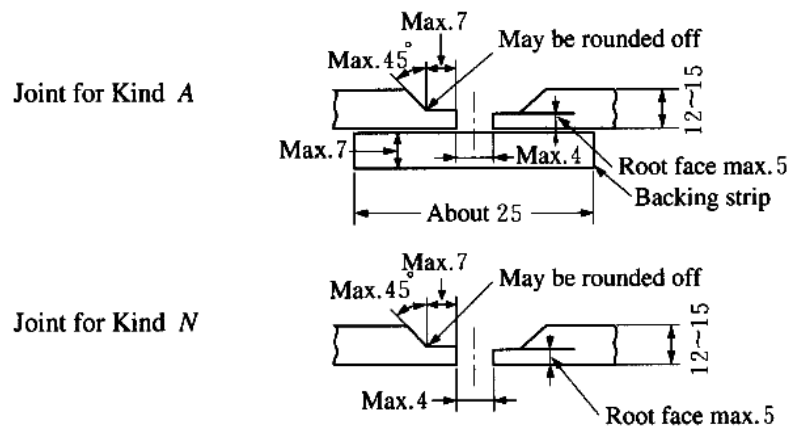
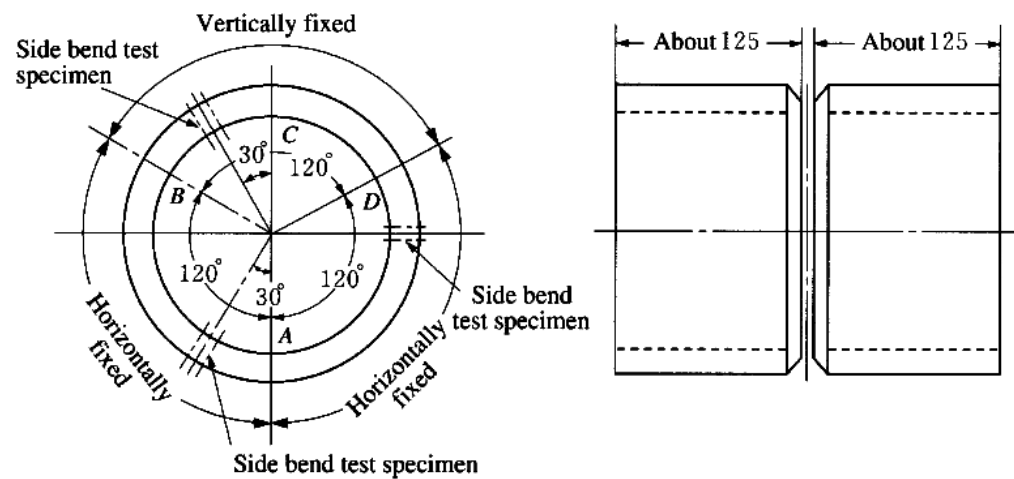
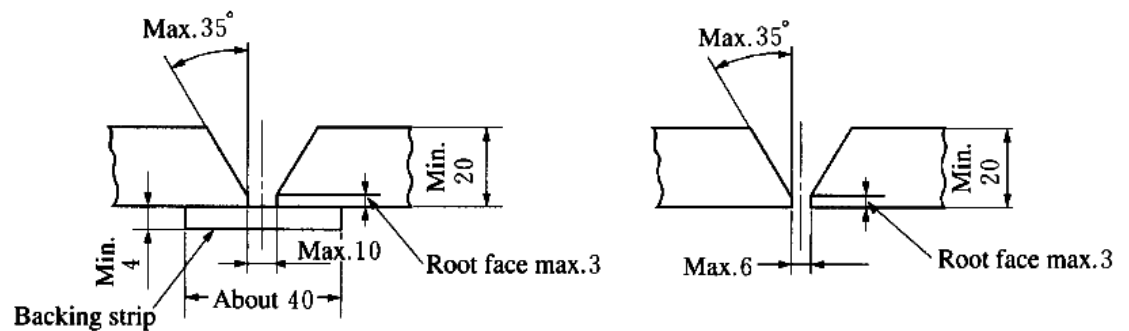


Fig. 5.8 Dimensions and Types of Test Assemblies for Pipes of Grade 3

(a) Dimensions of test assembly (unit:mm)

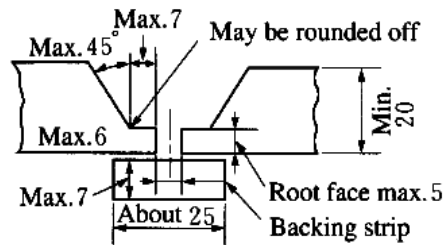


(b) Type of joint for mild steels and stainless steels (unit:mm)

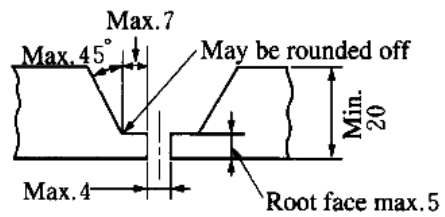


(c) Type of joint for aluminium alloy (unit: *mm*)

Joint for Kind A



Joint for Kind N



Chapter 6 WELDING CONSUMABLES

6.1 General

6.1.1 Application

The requirements in this Chapter apply to welding consumables corresponding to various materials used for hull construction, machinery, equipment, etc.

6.1.2 Grades

The grades of welding consumables are to be as specified in [6.2](#) through [6.9](#) according to test codes on the grade, strength and toughness of base materials.

6.1.3 Approval

1. Welding consumables are to have approval at each manufacturing plant and for each brand.
2. For approval to be granted, approval tests corresponding to the different grades of welding consumables are to be carried out as specified in [6.2](#) through [6.9](#), and the requirements in these tests are to be met satisfactorily.
3. The approval test for welding consumables which are not covered by the codes specified in this Chapter are to be carried out in accordance with test codes approved by the Society.
4. Where welding consumables which have been approved are intended to manufacture at manufacturing plants other than those of the manufacturers who manufacture the said welding materials the content of approval tests may be partially reduced subject to approval by the Society.
5. Where welding consumables which have been approved are intended to manufacture according to technical licensing agreements with those parties who manufacture the said welding consumables the content of approval tests may be partially reduced subject to approval by the Society.
6. Tests specified in [6.2](#) through [6.6](#) and [6.9](#) may be carried out on consumables which have been approved and the grades of strength and toughness may be changed accordingly. However, as a rule, the time for changes is to be limited to the time for annual inspection.
7. Where deemed necessary by the Society, tests other than those specified in this Chapter may be required.
8. In case of welding consumables for both butt welding and fillet welding, the welding positions approved through butt welding tests are to include the fillet welding position corresponding to butt welding.

6.1.4 Manufacturing Process, etc.

1. Welding consumables are to be manufactured at manufacturing plants which approved by the Society with respect to manufacturing equipment, manufacturing process and quality control.

2. Welding consumables are to be manufactured with uniform quality under the responsibility of the manufacturer.

6.1.5 Annual Inspections

1. Welding consumables which have been approved according to the preceding [6.1.3](#) are to undergo annual inspection specified in [6.2](#) through [6.9](#) and are to satisfactorily pass the inspection. Furthermore, annual inspection of welding consumables which have been approved in accordance with codes different from those specified in this Chapter are to be undertaken in accordance with test codes approved by the Society.

2. Annual inspection is as a rule to be carried out within a period not exceeding twelve months.

6.1.6 Tests and Inspections

1. Tests and inspections for the approval tests and annual inspection are to be carried out in the presence of the surveyor from the Society.

2. Welding conditions for the test materials (current, voltage, welding speed, etc.) are to be determined by the manufacturer. Furthermore, where both alternating current and direct current are available for the welding current, alternating current is to be used.

6.1.7 Retests

1. Where the tensile tests and bend tests fail to meet the requirements, twice as many test specimens as the number of failed test specimens are to be selected from the first test material or from a test material welded under the same welding conditions, and if all of test specimens pass the tests, then the tests are considered to be successful.

2. Where results of the impact test fail to meet the requirements and in cases other than those given in the following (1) and (2), retests may be carried out on a set of test specimens selected from the same test material as the one from which the failed test specimens were taken. In this case, the test specimens are considered to have passed the tests if the mean value of absorbed energy of a total of six test specimens, including the values of the failed specimens, is greater than the value of the specified minimum mean absorbed energy and, furthermore, if the number of test specimens among the said test specimens which are of lower energy than the specified value of minimum mean absorbed energy, and the number of test specimens which are of 70% lower energy than the specified value of minimum mean absorbed energy is less than two and one respectively.

(1) Where all test specimens fail to reach the specified value of minimum mean absorbed energy.

(2) Where two of the test specimens fail to reach 70% of the specified value of minimum mean absorbed energy.

3. Where the test specimens failed to meet the requirements in the preceding -1 and -2, new test specimens are to be selected under different welding conditions, and these new test specimens are to pass all specified items of the tests.

6.1.8 Packing and Marking

1. The approved welding consumables are to be packed thoroughly to maintain quality during transportation and storage.
2. All boxes or packages of approved welding consumables are to be clearly marked with descriptions which are deemed necessary by the Society.

6.2 Electrodes for Manual Arc Welding for Mild and High Tensile Steels and Steels for Low Temperature Service

6.2.1 Application

Electrodes for manual arc welding for mild and high tensile steels and steels for low temperature service, which given in following (1) and (2) (hereinafter referred to as “electrode” in [6.2](#)) are to be subjected to the approval test and annual inspections in accordance with the requirements in [6.2](#).

- (1) Electrodes for manual welding
 - (a) For butt welds (including one side welding)
 - (b) For fillet welds
 - (c) For both butt welds and fillet welds
- (2) Electrodes used in gravity welding or similar set-ups
 - (a) For fillet welds
 - (b) For both butt welds and fillet welds

6.2.2 Grades and Marks of Electrode

1. Electrodes are classified as given in [Table 6.1](#).
2. Where one back-bead welding is performed and electrodes pass the test, the suffix *U* is to be added to the end of their grade marks.
3. Low hydrogen electrodes which have passed the hydrogen test specified in [6.2.11](#) the suffixes given in [Table 6.9](#) are to be added the grade marks (after the *U* in the case of the preceding -2) of the said electrodes (Example: *RMW53UH10*).

Table 6.1 Grades and Marks

For mild steel	For high tensile steel	For steel for low temperature service
<i>KMW1</i>	<i>KMW52, KMW52Y40</i>	<i>KMWL1, KMWL91</i>
<i>KMW2</i>	<i>KMW53, KMW53Y40</i>	<i>KMWL2, KMWL92</i>
<i>KMW3</i>	<i>KMW54, KMW54Y40</i>	<i>KMWL3</i>

6.2.3 Approval Test

For the approval of electrodes, the tests specified in [6.2.4-1](#) to [6.2.4-4](#) are to be conducted for each brand of electrodes.

6.2.4 General Provisions for Test

1. Kind of test, number, thickness and dimensions of test assemblies, diameters of electrodes used for welding and welding positions, together with kinds and number of test specimens taken from each test assembly for electrodes given in [6.2.1\(1\)\(a\)](#) and [\(c\)](#) are to be as given in [Table 6.2](#). However, where deemed necessary by the Society, hot cracking tests deemed appropriate by the Society are to be conducted besides tests specified in this Table.
2. Kind of test, number, thickness and dimensions of test assemblies, diameter of electrodes used in the welding and welding positions, together with kinds and number of test specimens to be taken from each test assembly for electrodes given in [6.2.1\(1\)\(b\)](#), are to be as given in [Table 6.3](#).
3. Test for electrodes given in [6.2.1\(2\)](#) are to be in accordance with the requirements in the following [\(1\)](#) and [\(2\)](#):
 - (1) For electrodes given in [6.2.1\(2\)\(a\)](#), tests given in [Table 6.3](#) specified in the preceding [-2](#) are to be conducted.
 - (2) For electrodes given in [6.2.1\(2\)\(b\)](#), tests of the preceding [\(1\)](#) and butt weld test given in [Table 6.2](#) specified in the preceding [-1](#) are to be conducted.
4. Where both electrodes given in [6.2.1\(1\)](#) and [\(2\)](#) are requested approval tests specified for each electrode are to be conducted. However, deposited metal tests may be omitted for electrodes given in [6.2.1\(2\)](#).
5. Steel materials to be used in preparation of test assemblies are to be as given in [Table 6.4](#).

Table 6.2 Kinds of Test for Electrode

Kind of test	Test assembly					Kind and no. of test specimens taken from test assembly
	Welding position	Diameter of electrode (mm)	No. of test assemblies	Dimensions of test assembly	Thickness (mm)	
Deposited metal test	Flat	4	1 ⁽¹⁾	Fig. 6.1	20	Tensile test specimen: 1 Impact test specimen : 3
		max. diameter	1 ⁽¹⁾			
Butt weld test	Flat	First run: 4, Subsequent runs: 5 or over, Last two runs: max. dia.	1 ⁽²⁾	Fig. 6.2	15 ~ 20	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1 Impact test specimen: 3
		First run: 4, Second run: 5 or 6, Subsequent runs: max. dia.	1			
	Horizontal ⁽⁴⁾	First run: 4 or 5, Subsequent runs: 5	1			
	Vertical upward	First run: 3.2, Subsequent runs: 4 or 5	1			
	Vertical downward	(3)	1			
	Overhead	First run: 3.2, Subsequent runs: 4 or 5	1			
Fillet weld test ⁽⁵⁾	Horizontal vertical	The First side: max. dia., The Second side: min. dia.	1	Fig. 6.3	20	Macro test specimen ⁽⁷⁾ : 3 Hardness test specimen ⁽⁷⁾ : 3 Fracture test specimen: 2
Hydrogen test ⁽⁶⁾	Flat	4	4	(8)	12	Hydrogen test specimen: 1

Notes:

- 1 Where the diameter of the manufactured electrodes are of one type, there is to be one test assembly.
- 2 Where the tests are conducted solely in the flat position, this test assembly has been added.
- 3 Electrodes with diameters specified by the manufacturers are to be used.
- 4 For electrodes which have passed butt weld tests in the flat and vertical upward positions, tests in the horizontal position may be omitted subject to approval by the Society.
- 5 This test is added solely for electrodes used in both butt welds and fillet welds to which the preceding **note (4)** is applied.
- 6 To conduct solely for low hydrogen electrodes.

- 7 Test specimens used in macro test and hardness tests are considered to be the same.
- 8 Dimensions of test assembly are to be as specified in [6.2.5-3](#).

Table 6.3 Kinds of Test for Electrode

Kind of test	Test assembly					Kind and no. of test specimens taken from test assembly
	Welding position	Diameter of electrode (mm)	No. Of test assemblies	Dimensions of test assembly	Thickness (mm)	
Deposited metal test	Flat	4	1	Fig.M6.1	20	Tensile test specimen: 1 Impact test specimen: 3
		max. diameter	1			
Fillet weld test	Flat	The First side: max. dia., The Second side: min. dia.	1	Fig.M6.3	20	Macro test specimen ⁽¹⁾ :3 Hardness test specimen ⁽¹⁾ : 3 Fracture test specimen: 2
	Horizontal vertical		1			
	Vertical upward		1			
	Vertical downward		1			
	Overhead		1			
Hydrogen test ⁽²⁾	Flat	4	4	⁽³⁾	12	Hydrogen test specimen:1

Notes:

- 1 Test specimens used in macro tests and hardness tests are considered to be the same.
- 2 To conduct solely for low hydrogen electrodes.
- 3 Dimensions of test assembly are to be as specified in [6.2.5-3](#).

Table 6.4 Grades of Steel used for Test Assembly

Grade of electrode	Grade of steel used for test assembly ⁽¹⁾⁽²⁾
<i>KMW1</i>	<i>KA</i>
<i>KMW2</i>	<i>KA, KB or KD</i>
<i>KMW3</i>	<i>KA, KB, KD or KE</i>
<i>KMW52</i>	<i>KA32, KA36, KD32 or KD36</i>
<i>KMW53</i>	<i>KA32, KA36, KD32, KD36, KE32 or KE36</i>
<i>KMW54</i>	<i>KA32, KA36, KD32, KD36, KE32, KE36, KF32 or KF36</i>
<i>KMW52Y40</i>	<i>KA40 or KD40</i>
<i>KMW53Y40</i>	<i>KA40, KD40 or KE40</i>
<i>KMW54Y40</i>	<i>KA40, KD40, KE40 or KF40</i>
<i>KMWL1</i>	<i>KE or KL24A</i>
<i>KMWL2</i>	<i>KE, KL24A, KL24B, KL27 or KL33</i>
<i>KMWL3</i>	<i>KL27, KL33 or KL37</i>
<i>KMWL91</i>	<i>KL9N53 or KL9N60</i>
<i>KMWL92</i>	<i>KL9N53 or KL9N60</i>

Notes:

- 1 Notwithstanding the requirements in this Table, mild or high tensile steels may be used for deposited metal test assembly. In this case, appropriate buttering is to be carried out for *KMWL91* and *KMWL92*.
- 2 The tensile strength of high tensile steels *KA32*, *KD32*, *KE32* and *KF32* used in the butt weld test assemblies are to be greater than 490N/mm^2 .

6.2.5 Welding Procedure of Test Assemblies

1. Deposited Metal Test Assemblies ([Fig. 6.1](#))

- (1) Test assemblies are to be welded by single or multi-run layer welding according to the normal practice, and the direction of each run is to alternate from each end of the plate, each run of weld metal being not less than 2 mm but not more than 4 mm thickness.
- (2) After each run, the assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken at the centre of weld on the surface of seam.

2. Butt Weld Test Assemblies ([Fig. 6.2](#))

- (1) Test assemblies are to be welded in each welding position (flat, horizontal, vertical upward, vertical downward, overhead) which is recommended by the manufacturer.
- (2) After each run, the assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C the temperature being taken at the centre of weld on the surface of seam.
- (3) In all cases except one side welding, the back sealing runs are to be made with 4mm electrode in the welding position appropriate to each test sample, after cutting out the root run to clean metal. For

electrodes suitable for downhand welding only, the test assemblies may be turned over to carry out the back sealing run.

- (4) For one side weld test assemblies, all of the welding is done from one side such that beads with no defects are formed on the back. Further the root gaps are to be the maximum within the range specified by the manufacturer.

3. Hydrogen Assemblies

Test assemblies and welding procedures of hydrogen test are left to the discretion of the Society.

4. Fillet Weld Test Assemblies ([Fig. 6.3](#))

- (1) Test assembly is to be welded in each welding position (flat, horizontal, vertical upward, vertical downward, or overhead) which is recommended by the manufacturer.
 - (2) The first fillet is to be welded using the maximum size of electrode manufactured and the opposite side is to be welded using the minimum size electrode manufactured.
 - (3) In case of fillet welds using gravity or similar contact welding method, the fillet welding is to be carried out with electrodes of maximum length.
 - (4) The fillet size will in general be determined by the electrode size and the welding current employed during testing.
- 5.** After being welded, the test assemblies are not to be subjected to any heat treatment.
- 6.** The welded assemblies may be subjected to radiographic examination prior to taking test specimens from the assemblies.

Fig. 6.1 Deposited Metal Test Assembly (Unit: mm)

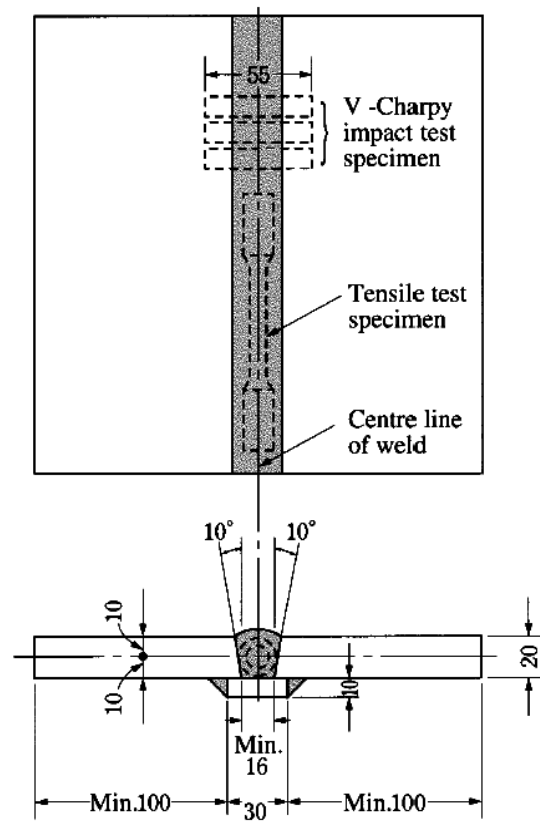


Fig. 6.2 Butt Weld Test Assembly (Unit: mm)

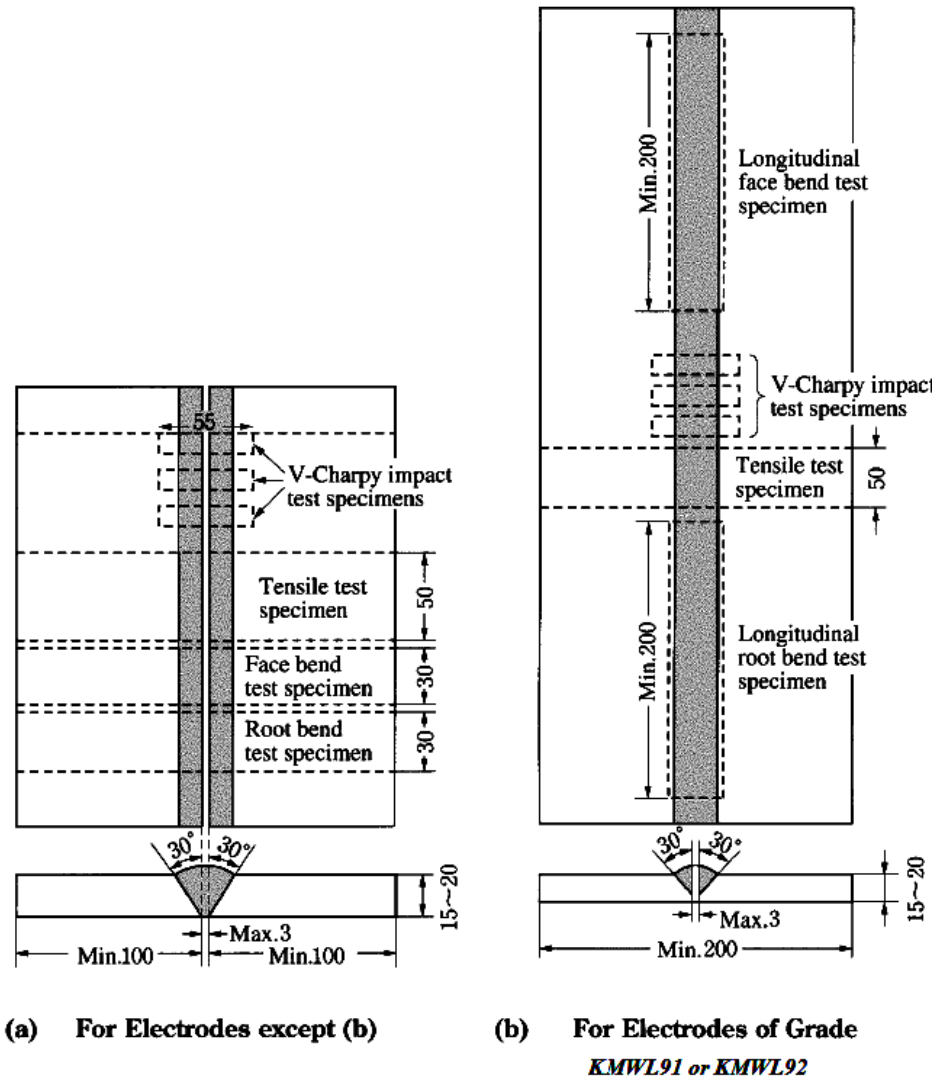
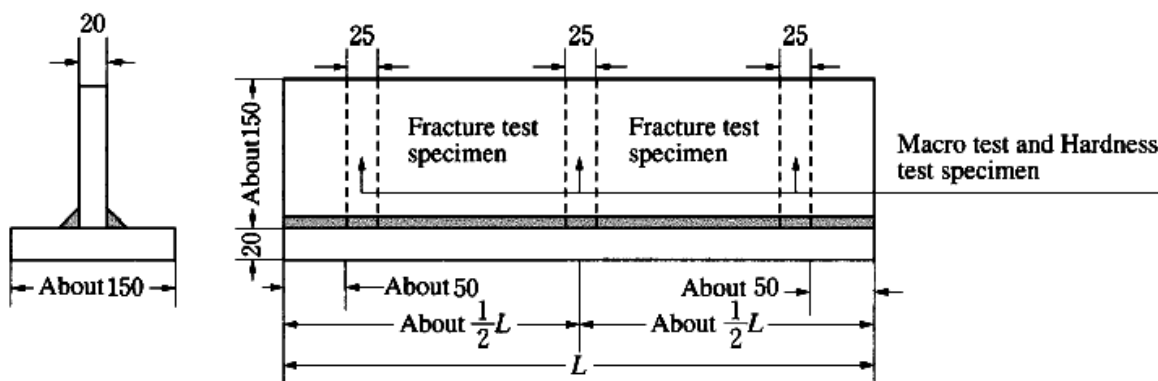


Fig. 6.3 Fillet Weld Test Assembly (Unit: mm)



(The length of the test assemblies L is to be sufficient to allow at least the deposition of the entire length of the electrode being tested.)

6.2.6 Deposited Metal Tensile Test

1. The tensile test specimens are to be U1A specimen shown in [Table 3.1](#), and the specimens are to be taken from each test assembly, care being taken that the longitudinal axis coincides with the centre of weld and the mid-thickness of plate.
2. The tensile test specimen may be subjected to a temperature not exceeding 250°C for a period not exceeding 16 hours for hydrogen removal, prior to testing.
3. The tensile strength, yield point and elongation of each test specimen are to comply with the requirements in [Table 6.5](#) appropriate to the kind of electrodes. Where the upper limit of tensile strength is exceeded, special consideration will be given to the approval of the electrode, taking the other mechanical properties shown in the test results and the chemical composition of deposited metal into consideration.

Table 6.5 Tensile Test Requirements for Deposited Metal

Grade of electrode	Tensile Strength (<i>N/mm</i> ²)	Yield point (<i>N/mm</i> ²)	Elongation (%)
<i>KMW1</i>	400 ~ 560	305 min.	22 min.
<i>KMW2</i>			
<i>KMW3</i>			
<i>KMW52</i>	490 ~ 660	375 min.	
<i>KMW53</i>			
<i>KMW54</i>			
<i>KMW52Y40</i>	510 ~ 690	400 min.	
<i>KMW53Y40</i>			
<i>KMW54Y40</i>			
<i>KMWL1</i>	400 ~ 560	305 min.	
<i>KMWL2</i>	440 ~ 610	345 min.	
<i>KMWL3</i>	490 ~ 660	375 min.	21 min.
<i>KMWL91</i>	590 min.	375 ⁽¹⁾ min.	25 min.
<i>KMWL92</i>	660 min	410 ⁽¹⁾ min.	

Note:

- 1 0.2% proof stress

6.2.7 Deposited Metal Impact Test

1. The impact test specimens are to be U4 specimens shown in [Table 2.5 in Part 10](#), and one set of three, test specimens is to be taken from each of the deposited metal test assembly. The test specimen is to be cut with its longitudinal axis transverse to the direction of welding, and the test specimen is to coincide with the mid-thickness of the plate shown in [Fig. 6.4](#).
2. The notch is to be positioned in the centre of weld and is to be cut in the face of test specimen perpendicular to the surface of plate.
3. Testing temperature and minimum mean absorbed energy are to comply with the requirements given in the [Table 6.6](#) appropriate to the grade of the electrode.
4. When the absorbed energy of two or more test specimens among the one set of specimens is under the required minimum mean absorbed energy or the absorbed energy of anyone of the test specimens is under 70% of the required minimum mean absorbed energy, the impact test is considered to be failed.

Fig. 6.4 Position of Impact Test Specimen (Unit: *mm*, *t*: Plate thickness)

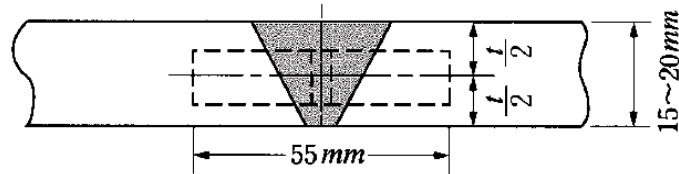


Table 6.6 Impact Test Requirements for Deposited Metal

Grade of electrode	Testing temperature(°C)	Minimum mean absorbed energy (J)
KMW1	20	47
KMW2	0	
KMW3	-20	
KMW52	0	
KMW53	-20	
KMW54	-40	
KMW52Y40	0	
KMW53Y40	-20	
KMW54Y40	-40	
KMWL1	-40	34
KMWL2	-60	
KMWL3	-60	
KMWL91	-196	27
KMWL92	-196	

6.2.8 Butt Weld Tensile Test

1. The tensile test specimen is to be U2A or U2B specimen shown in [Table 3.1](#), and test specimen is to be taken from each test assembly.
2. The tensile strength of test specimen is to comply with the requirements given in [Table 6.7](#).

Table 6.7 Tensile Test Requirements for Butt Weld

Grade of electrode	Testing Strength (N/mm ²)
KMW1, KMW2, KMW3	400 min.
KMW52, KMW53, KMW54	490 min.
KMW52Y40, KMW53Y40, KMW54Y40	510 min.
KMWL1	400 min.
KMWL2	440 min.
KMWL3	490 min.
KMWL91	630 min.
KMWL92	670 min.

6.2.9 Butt Weld Bend Test

1. The face bend and root bend test specimens are to be *UB-6* specimen shown in [Table 3.2](#), and the test specimens are to be taken from each test assembly. However, for *KMWL91* or *KMWL92*, the face bend and root bent specimens are to be *B-7* specimen shown in [Table 3.2](#), and the test specimens are to be taken longitudinally from each assembly.
2. The test specimens are to be capable of withstanding, without crack exceeding *3mm* long on the outer surface of other defects, being bent through an angle of *120 degrees* over a former having a radius of *1.5* times the thickness of test specimen. The radius and angle of the former for *KMWL91* and *KMWL92*, however, are to be *2* times the thickness of the specimen and *180 degrees* respectively.

6.2.10 Butt Weld Impact Test

1. The impact test specimens are to be *U4* specimen shown in [Table 2.5, Part 10](#), and one set of three test specimens are to be taken from each test assembly. The test specimen is to be set with its longitudinal axis transverse to the weld length and the centre of the test specimen is to be coincide with the mid-thickness of the plates.
2. Testing temperature and minimum mean absorbed energy are to be comply with the requirements given in [Table 6.8](#) appropriate to the grades of the electrode and welding position.
3. The requirements in the preceding [6.2.7-2](#) and [-4](#) are to be applied to this clause.

Table 6.8 Impact Test Requirements for Butt Weld

Grade of electrode	Testing temperature(°C)	Minimum mean absorbed energy (J)	
		Flat, Horizontal, Overhead	Vettical upward, Vertical downward
KMW1	20	47	34
KMW2	0		
KMW3	-20		
KMW52	0		
KMW53	-20		
KMW54	-40		
KMW52Y40	0		39
KMW53Y40	-20		
KMW54Y40	-40		
KMWL1	-40	27	27
KMWL2	-60		
KMWL3	-60		
KMWL91	-196		
KMWL92	-196		

6.2.11 Hydrogen Test

1. The hydrogen test is to be carried out through the glycerine method, mercury method, gas chromatographic method or other methods deemed appropriate by the Society.
2. The average volume of hydrogen is to comply with the requirements given in [Table 6.9](#) according to the test procedures specified in preceding -1 or the type of suffixes to be added to the grade marks.

Table 6.9 Requirements for Hydrogen Contents

Mark	Requirements for Hydrogen Contents (cm^3/g)		
	Glycerine method	Mercury method ⁽¹⁾	Gas chromatographic method ⁽¹⁾
H15	0.10 max.	0.15 max.	0.15 max.
H10	0.05 max.	0.10 max.	0.10 max.

Note:

- 1 The Society may designate the values for the average value of hydrogen which are lower than “0.10 max.” to be the code values.

6.2.12 Fillet Weld Macro-etching Test

1. For macro-etching test specimens, those with breadth of 25mm are selected from three places shown in [Fig. 6.3](#).
2. The macro-etching test is conducted on the section of welding joints, and no incomplete fusion and penetration or other harmful defects are to be present.

6.2.13 Fillet Weld Hardness Test

The hardness of weld metal, heat affected zone and base metal are to be measured at places given in [Fig. 6.5](#) for each test specimen which has undergone the macro-etching test specified in [6.2.12](#). The respective hardness are to be noted.

6.2.14 Fillet Weld Fracture Test

1. One of the test assemblies remaining after taking the macro-etching test specimens is to have the first fillet weld removed to facilitate fracture by applying force as shown in [Fig. 6.6](#), and the surface of the second fillet weld section is inspected. Next, on the other test assembly, the second fillet weld is to be removed and the same fracture test is to be carried out.
2. The surface of the fractured weld section is not to show evidence of incomplete penetration or other harmful defects.

Fig. 6.5 Hardness Test (Unit: mm)

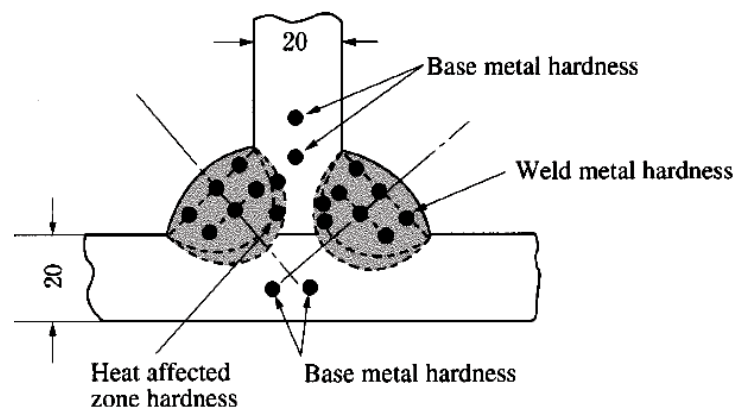
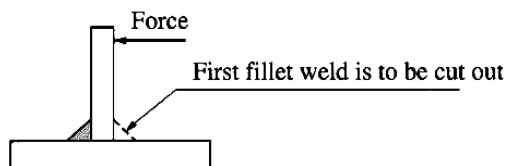


Fig. 6.6 Fracture Test



6.2.15 Annual Inspections

1. In the annual inspections, test specified in the following -2 and -3 are to conduct for each brand of the approved electrodes and they are to be passed satisfactorily.
2. The kinds of tests etc. in the annual inspections for manual welding electrodes are to be as given in [Table 6.10](#).
3. The kinds of test etc. in the annual inspections of electrodes used in gravity welding or other welding using similar welding devices are to be as given in [Table 6.11](#).
4. The welding process and requirements for test assemblies of tests specified in the preceding -2 and -3 to be as specified in [6.2.5](#) through [6.2.10](#).

Table 6.10 Kind of Test for Annual Inspection

Kind of test	Test assembly					Kind and no. of test specimens taken from test assembly
	Welding position	Diameter of electrode (mm)	Number	Dimensions	Thickness (mm)	
Deposited metal test	Flat	4 ⁽¹⁾	1	Fig.6.1	20	Tensile test specimen: 1 Impact test specimen: 3
		Exceeding 4, 8 max.	1			

Note:

- 1 Where deemed necessary by the Society, butt weld tests in the flat or vertical (either upward or downward) welding position specified in [Table 6.2](#) of [6.2.4-1](#) may be requested in place of deposited metal tests of 4mm diameter electrodes. In this case, impact test specimens (one set of three) are to be selected.

Table 6.11 Kind of Test for Annual Inspection

Kind of test	Test assembly					Kind and no. of test specimens taken from test assembly
	Welding position	Diameter of electrode (mm)	Number	Dimensions	Thickness (mm)	
Deposited metal test	Flat	4 min.	1	Fig.6.1	20	Tensile test specimen: 1 Impact test specimen: 3

6.2.16 Changes in Grades

1. Where changes in grades relating to the strength or toughness of approved electrodes are to be made, the tests specified in -2 or -3 are to be carried out according to the requirements in [6.1.3-6](#), and the electrodes must pass the tests satisfactorily.
2. For changes in grades relating to strength, annual inspection specified in [6.2.15](#) and the butt weld tests specified in [6.2.4-1](#) are to be conducted.

3. For changes in grades relating to toughness, annual inspection specified in [6.2.15](#) and, among the butt weld tests specified in [6.2.4-1](#), only the impact test are to be conducted.

6.3 Automatic Welding Consumables for Mild Steels, High Tensile Steels and Steels for Low Temperature Service

6.3.1 Application

1. Welding consumables for mild steels, high tensile steels and steels for low temperature service, which given in following (1) through (3) (in case of single electrodes, hereinafter referred to as automatic welding consumables in [6.3](#)) are to be subjected to the approval tests and annual inspections in accordance with the requirements in [6.3](#).

- (1) Submerged arc automatic welding consumables
 - (2) Gas shielded arc automatic welding consumables (solid wire automatic welding consumables and fluxed wire automatic welding consumables with shielding gas).
 - (3) Self-shielded arc automatic welding consumables (fluxed wire automatic welding consumables without shielding gas).
2. Approval tests and annual inspections for automatic welding materials of multiple electrodes are to be in accordance with the requirement specified in [6.1.3-3](#) and [6.1.5-2](#).

6.3.2 Grades and Marks of Automatic Welding Consumables

1. The automatic welding consumables are classified into grades as given in [Table 6.12](#).
2. Automatic welding consumables which have passed the tests for each welding process given in [Table 6.15](#) are appended with suffixes shown in [Table 6.13](#) at the end of their marks.
3. In the preceding -2, a suffix *G* will be added to the grade mark for gas shielded arc automatic welding consumables, and a suffix *N* will be added for self-shielded arc automatic welding consumables. Further, the type of gas used is to be specified in [Table 6.14](#) and the suffix given in [Table 6.14](#) will be added after the suffix *G*. (Example: KAW53TMG (M1))

Table 6.12 Grades and Marks

For mild steel	For high tensile steel	For steel for low temperature service
KAW1 KAW2 KAW3	KAW51, KAW52Y40 KAW52, KAW53Y40 KAW53, KAW54Y40 KAW54	KAWL1, KAWL91 KAWL2, KAWL92 KAWL3

Table 6.13 Marks

Welding technique	Mark
Multi-run technique ⁽¹⁾	<i>M</i>
Two-run technique ⁽²⁾	<i>T</i>
Multi-run and Two-run technique	<i>TM</i>

Notes:

- 1 Multi-run technique refers to a welding process involving multiple passes.
- 2 Two-run technique refers to a welding process involving a single pass on both sides.

Table 6.14 Gas types

Group	Type	Gas composition (Vol. %)			
		<i>CO</i> ₂	<i>O</i> ₂	<i>H</i> ₂	<i>Ar</i>
<i>M1</i>	<i>M1-1</i>	1 ~ 5	—	1 ~ 5	Rest
	<i>M1-2</i>	1 ~ 5	—	—	Rest
	<i>M1-3</i>	—	1 ~ 3	—	Rest
	<i>M1-4</i>	1 ~ 5	1 ~ 3	—	Rest
<i>M2</i>	<i>M2-1</i>	6 ~ 25	—	—	Rest
	<i>M2-2</i>	—	4 ~ 10	—	Rest
	<i>M2-3</i>	6 ~ 25	1 ~ 8	—	Rest
<i>M3</i>	<i>M3-1</i>	26 ~ 50	—	—	Rest
	<i>M3-2</i>	—	11 ~ 15	—	Rest
	<i>M3-3</i>	6 ~ 50	9 ~ 15	—	Rest
<i>I</i>	<i>I-1</i>	—	—	—	100
<i>C</i>	<i>C-1</i>	100	—	—	—
	<i>C-2</i>	Rest	1 ~ 30	—	—
<i>E</i>	<i>E-1</i>	Except above			

Table 6.15 Kind of Test of Automatic Welding Consumables

Welding process	Kind of test ⁽⁸⁾		Grade of welding consumable	Test assembly			Kind and no. of test specimens taken from test assembly
				Number	Dimensions	Thickness (mm) ⁽³⁾	
Multi-run technique	Deposited metal test		KAW1, KAWL1 KAW2, KAWL2 KAW3, KAWL3 KAW51, KAWL91 KAW52, KAWL92	1	Fig. 6.7	20	Tensile test specimen: 2 Impact test specimen: 3
	Butt weld test		KAW53, KAW54, KAW52Y40 KAW53Y40 KAW54Y40	1 ⁽⁴⁾	Fig. 6.8	20 ~ 25	Tensile test specimen: 2 ⁽⁴⁾ Face bend test specimen: 2 ⁽⁴⁾ (6) Root bend test specimen: 2 ⁽⁴⁾ (6) Impact test specimen: 3
Two-run technique	Butt weld test	Submerged arc welding	KAW1, KAW51	1	Fig. 6.9	12 ~ 15	Tensile test specimen: 2
				1		20 ~ 25	Longitudinal tensile test specimen: 1 ⁽⁵⁾
			KAW2, KAW52Y40 KAW3, KAW53Y40	1		20 ~ 25	Face bend test specimen: 1
			KAW52, KAW54Y40 KAW53, KAW54	1		30 ~ 35	Root bend test specimen: 1 Impact test specimen: 3
		Gas shielded arc and self-shielded arc welding	KAW1, KAW2 KAW3 KAW51, KAW52 KAW53, KAW54	1		12 ~ 15 ⁽¹⁾	Tensile test specimen: 2
			KAW52Y40 KAW53Y40 KAW54Y40	1		20 ⁽²⁾	Longitudinal tensile test specimen : 1 ⁽⁵⁾
						20 ~ 25 ⁽¹⁾	Face bend test specimen: 1
						30 ~ 35 ⁽²⁾	Root bend test specimen: 1 Impact test specimen: 3
	Butt weld test		KAWL1, KAWL2, KAWL3, KAWL91, KAWL92	1		12 ~ 15	Tensile test specimen: 2
				1		20 ~ 25	Longitudinal tensile test specimen : 1 ⁽⁵⁾ Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3
Multi-run and two-run technique	Deposited metal test		KAW1, KAWL1 KAW2, KAWL2 KAW3, KAWL3 KAW51, KAWL91 KAW52, KAWL92	(7)			
	Butt weld test		KAW53, KAW54, KAW52Y40 KAW53Y40 KAW54Y40				

Notes:

- 1 Thickness of test assemblies where applied maximum plate thickness is not more than 25mm.
- 2 Thickness of test assemblies where applied maximum plate thickness is more than 25mm.

- 3 Where thickness is restricted by welding process, thickness of test assemblies may be changed upon approval of the Society. In this case, the maximum test thickness is taken to be the maximum applied thickness.
- 4 The number of butt weld test assemblies for multi-run gas shielded arc and self-shielded arc welding techniques is to be one for each welding position. However, where there is more than one welding position, the number of tensile test specimens and bend test specimens selected from the test assemblies for each welding position may be half of the specified number.
- 5 Test specimens are to be selected from only the thicker of two test assemblies.
- 6 The number of face bend test and root bend test specimens selected from the butt weld test assemblies for KAWL91 and KAWL92 is to be one each.
- 7 Tests on both multi-run and two-run technique are to be conducted for multi-run and two-run welding respectively, and the number, dimensions and thickness of test assemblies, along with the kinds and number of test specimens selected from each test assembly are to be in accordance with each of the welding processes. However, the number of tensile test specimens in the deposited metal test for the multi-pass welding technique is to be one
- 8 The hydrogen test may be applied by request of the manufacturer.

6.3.3 Approval Test

1. For the approval of automatic welding consumables, the tests specified in [6.3.4-1](#) are to be conducted for each brand of automatic welding consumables.
2. For wire-gas automatic welding consumables, the test in the preceding -1 is to be performed for each type of gas given in [Table 6.14](#). Although, when the manufacturer of the consumables recommends gas types of the group of *M1*, *M2*, *M3* or *C* in [Table 6.14](#), the approval test is referred to one of following procedures.
 - (1) When the test is conducted in accordance with the preceding -1 on one of the gas type, the test on the other gas types belonging to the same category are allowed to be dispensed with.
 - (2) When the consumables is specified as applicable to any combination of the groups of *M1*, *M2* and *M3*, the test is allowed to limit any one of the gas type of *M1*, *M2* or *M3* in accordance with the preceding -1, subject to the agreement of the Society.

6.3.4 General Provisions for Tests

1. Kinds of tests, number, thickness and dimensions of test assemblies, kinds and number of test specimens taken from each test assembly for automatic welding consumables are specified in [Table 6.15](#).
2. Grades of steel to be used in preparation of test assemblies are to be as given in [Table 6.16](#).

Table 6.16 Grades of Steel used for Test Assembly

Grade of welding consumable	Grade of steel used for test assembly ⁽¹⁾⁽²⁾
KAW1	KA
KAW2	KA, KB or KD
KAW3	KA, KB, KD or KE
KAW51	KA32 or KA36
KAW52	KA32, KA36, KD32 or KD36
KAW53	KA32, KA36, KD32, KD36, KE32 or KE36
KAW54	KA32, KA36, KD32, KD36, KE32, KE36, KF32 or KF36
KAW52Y40	KA40 or KD40
KAW53Y40	KA40, KD40 or KE40
KAW54Y40	KA40, KD40, KE40 or KF40
KAWL1	KE or KL24A
KAWL2	KE, KL24A, KL24B, KL27 or KL33
KAWL3	KL27, KL33 or KL37
KAWL91	KL9N53 or KL9N60
KAWL92	KL9N53 or KL9N60

Notes:

- 1 Notwithstanding the requirements in this Table, mild or high tensile steels may be used for deposited metal test assembly. In this case, appropriate buttering is to be carried out for KAWL91 and KAWL92.
- 2 The tensile strength of high tensile steels KA32, KD32, KE32 and KF32 used in the butt weld test assemblies are to be greater than 490N/mm².

6.3.5 Welding Sequence of Test Assemblies

1. Deposited Metal Test Assemblies with Multi-run Technique (Fig. 6.7)

- (1) Test assemblies are to be welded in flat position by multi-run technique according to the normal practice. The deposition of each run is to be started alternately from each end of the plate and the thickness of layer is not to be less than the diameter of wire nor less than 4mm whichever is the greater for submerged arc automatic welding consumables. For gas shielded arc and self-shielded arc automatic welding consumables the thickness of layer is not to be less than 3mm.
- (2) After each run, the assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken at the centre of weld on the surface of seam.

2. Butt Weld Test Assemblies with Multi-run Technique (Fig. 6.8)

- (1) The face side of the test assemblies is to be multi-pass welded in flat position, and the corresponding welding procedure is to follow the requirements of the preceding -1. However, for wire-gas and self-shielded wire automatic welding consumables, the welding position is to be as specified by the manufacturer.

- (2) After completing the face welding, back welding is performed. In this instance, back chipping may be carried out to expose sound deposited metal at the root.
3. Butt Weld Test Assemblies with Two-run Technique ([Fig. 6.9](#))
 - (1) The maximum diameter of wire and edge preparation are to be in accordance with [Fig. 6.10](#), but some deviation may be allowed where accepted by the Society.
 - (2) Test assemblies are to be welded according to the normal practice in downward position by two-run technique where each run is to be started alternately from each end of the plate.
 - (3) After completing the first run, the assembly is to be left in still air until it is cooled to 100°C or below, the temperature being taken in the centre of weld on the surface of seam.
 4. After being welded, the test assemblies are not to be subjected to any heat treatment.
 5. The welded assemblies may be subjected to radiographic examination prior to taking test specimens from the assemblies.

Fig. 6.7 Deposited Metal Test Assembly with Multi-run Technique (Unit: mm)

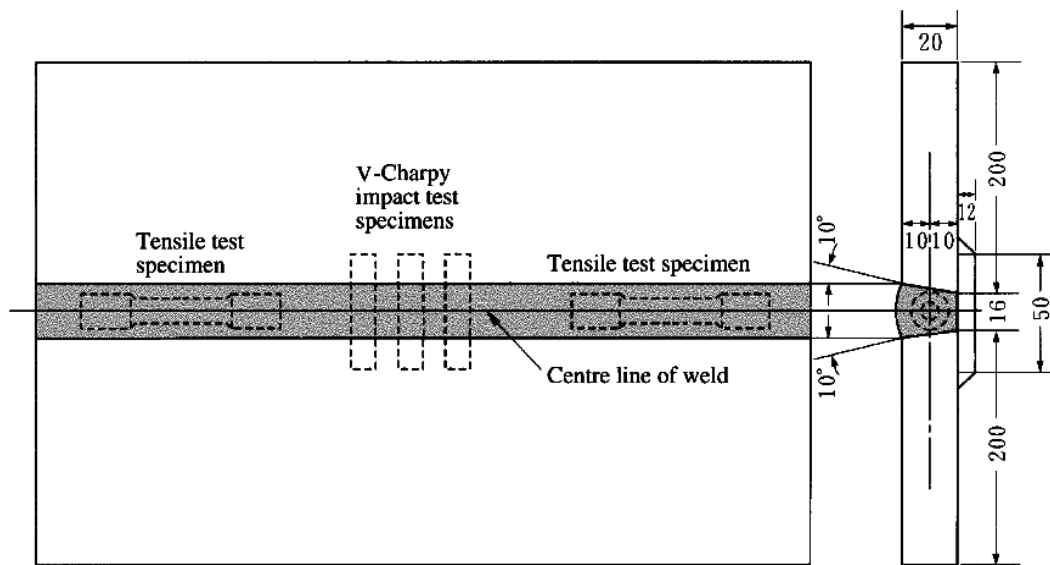


Fig. 6.8 Butt Weld Test Assembly with Multi-run Technique (Unit: mm)

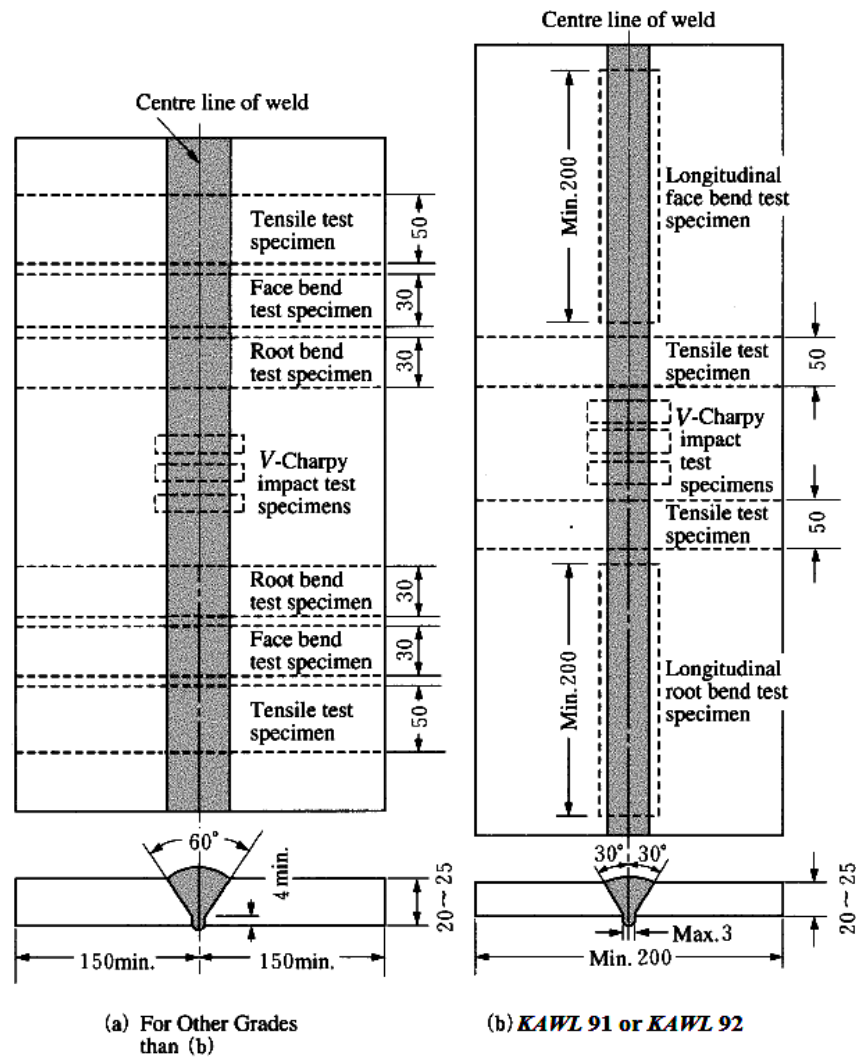


Fig. 6.9 Butt Weld Test Assembly with Two-run Technique (Unit: *mm*, *t* = Plate thickness)

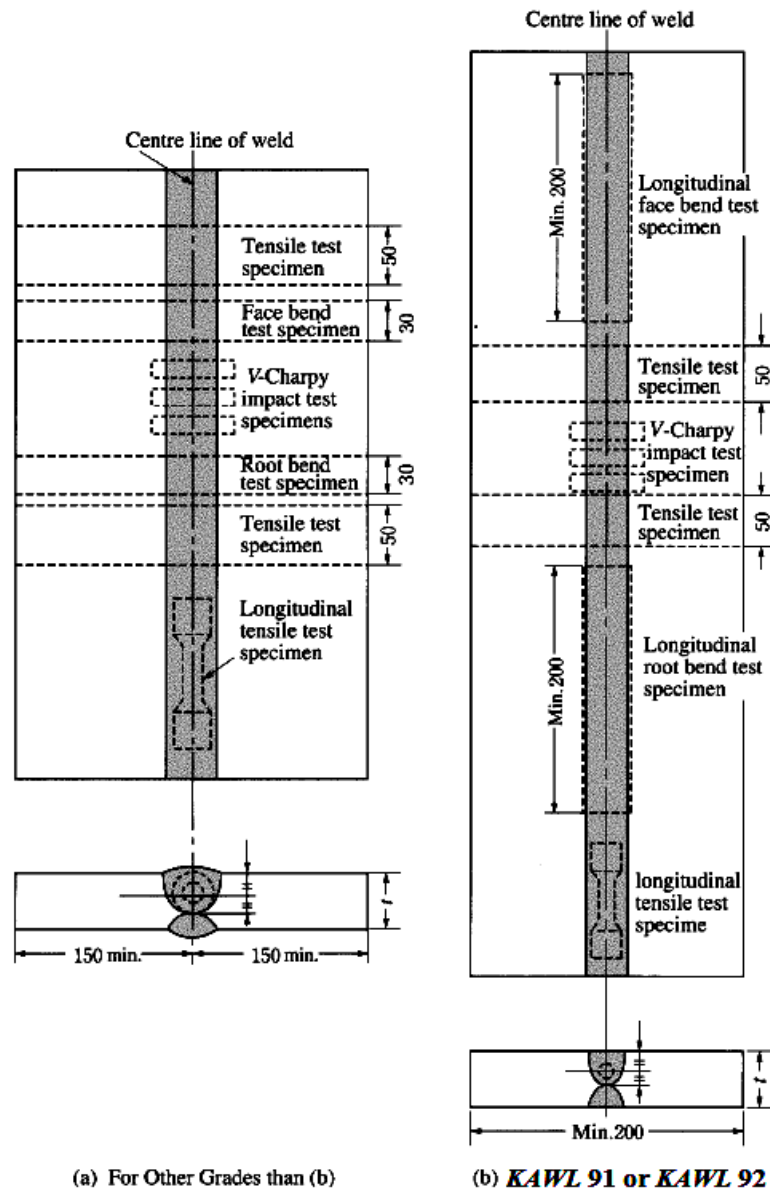

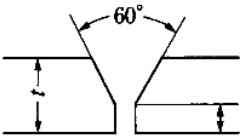
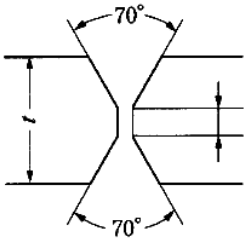


Fig. 6.10 Edge Preparation of Butt Weld Test Assembly with Two-run Technique (Unit: *mm*, *t* = Plate thickness)

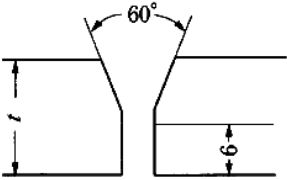
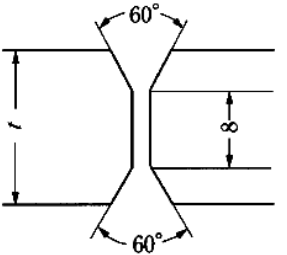
(a) Submerged Arc Welding Consumables

Thickness of test assembly	Edge preparation	Max. dia. of wire
12 ~ 15		5
20 ~ 25		6
30 ~ 35		7

Notes:

Root gap is not to be greater than 1.0 *mm*

(b) Wire gas and self shield wire welding consumables

Thickness of test assembly	Edge preparation	Max. dia. of wire
12 ~ 15		Maximum diameter of wire used is to be reported for information by manufacturer
20 ~ 25		

Note: For assemblies using plate over 25 mm in thickness, the edge preparation used is to be specified by the manufacturer.

6.3.6 Deposited Metal Tensile Test with Multi-run Technique

1. The tensile test specimens are to be U1A specimen shown in [Table 3.1](#) and two specimens are to be taken from test assembly. Care being taken that the longitudinal axis coincides with the centre of weld and the mid-thickness of plate.
2. The tensile strength, yield point and elongation of the deposited metal are to pass the requirements specified in [Table 6.17](#) according to the grade of automatic welding consumables. However, welding consumables whose tensile strength exceeds the upper limit of the requirements may pass the tests by giving consideration to other mechanical properties and chemical composition of the deposited metal.
3. The requirements in the preceding [6.2.6-2](#) are also to be applied to this paragraph.

Table 6.17 Tensile Test Requirements for Deposited Metal

Grade of welding consumable	Tensile Strength (<i>N/mm</i> ²)	Yield point (<i>N/mm</i> ²)	Elongation (%)
<i>KAW</i> 1	400 ~ 560	305 min.	22 min.
<i>KAW</i> 2			
<i>KAW</i> 3			
<i>KAW</i> 51	490 ~ 660	375 min.	
<i>KAW</i> 52			
<i>KAW</i> 53			
<i>KAW</i> 54			
<i>KAW</i> 52Y40	510 ~ 690	400 min.	
<i>KAW</i> 53Y40			
<i>KAW</i> 54Y40			
<i>KAW</i> L1	400 ~ 560	305 min.	
<i>KAW</i> L2	440 ~ 610	345 min.	
<i>KAW</i> L3	490 ~ 660	375 min.	21 min.
<i>KAW</i> L91	590 min.	375 ⁽¹⁾ min.	25 min.
<i>KAW</i> L92	660 min	410 ⁽¹⁾ min.	

Note:

1 0.2% proof stress

6.3.7 Deposited Metal Impact Test with Multi-run Technique

1. The impact test specimens are to be *U4* specimen shown in [Table 2.5, Part 10](#) and one set of three specimens are to be taken from test assembly. Longitudinal direction of the test specimen is to be perpendicular to the weld line and the centre line of the test specimen is to coincide with the half depth position of the test assembly as given in [Table 6.4](#) of the preceding [6.2.7](#).
2. Testing temperature and minimum mean absorbed energy are to meet the requirements of [Table 6.18](#) according to the grades of the automatic welding consumables.
3. The requirements in the preceding [6.2.7-2](#) and [6.2.7-4](#) are also to be applied to this paragraph.

Table 6.18 Impact Test Requirements for Deposited Metal

Grade of welding consumable	Testing temperature(°C)	Minimum mean absorbed energy (J)
KAW1	20	34
KAW2	0	
KAW3	-20	
KAW51	20	
KAW52	0	
KAW53	-20	
KAW54	-40	
KAW52Y40	0	39
KAW53Y40	-20	
KAW54Y40	-40	
KAWL1	-40	27
KAWL2	-60	
KAWL3	-60	
KAWL91	-196	
KAWL92	-196	

6.3.8 Butt Weld Tensile Test with Multi-run Technique

1. The tensile test specimens are to be U2A or U2B specimen shown in [Table 3.1](#) and two specimens are to be taken from each test assembly.
2. The tensile strength obtained from the tensile tests are to meet the requirements of [Table 6.19](#), according to the grades of the automatic welding consumables.

Table 6.19 Tensile Test Requirements for Butt Weld

Grade of welding consumable	Testing Strength(N/mm ²)
KAW1, KAW2, KAW3	400 min.
KMW51, KMA52, KAW53, KAW54	490 min.
KAW52Y40, KAW53Y40, KAW54Y40	510 min.
KAWL1	400 min.
KAWL2	440 min.
KAWL3	490 min.
KAWL91	630 min.
KAWL92	670 min.

6.3.9 Butt Weld Bend Test with Multi-run Technique

1. The face and root bent test specimens are to be *UB-6* specimen shown in [Table 3.2](#) and two test specimens are to be taken from each test assembly. For *KAWL91* or *KAWL92* face and root bend test specimen are to be *B-7* test specimens shown in [Table 3.2](#), and test specimens are to be taken longitudinally from each test assembly.
2. Bend test specimens are subjected to face bending and root bending by a push arm with inner radius corresponding to 1.5 times the plate thickness, and even at bending angle of greater than 120 *degrees* cracks exceeding 3mm on the outer surface of bending or any other defects is not to develop. However, the inner radius and bending angle of *KAWL92* are to be 2.0 times the plate thickness and 180 *degrees* respectively.

6.3.10 Butt Weld Impact Test with Multi-run Technique

1. The impact test specimens are to be *U4* specimen shown in [Table 2.5 in Part 10](#) and one set of three specimens are to be taken from test assembly. Longitudinal direction of the test specimen is to be perpendicular to the weld line and the centre line of the test specimen is to coincide with the half depth position of the test assembly as given in [Table 6.4](#) of the preceding [6.2.7](#).
2. Testing temperature and the minimum mean absorbed energy are to meet the requirements of [Table 6.18](#) according to the grades of the automatic welding consumables.
3. The requirements in the preceding [6.2.7-2](#) and [6.2.7-4](#) are also to be applied to this paragraph.

6.3.11 Butt Weld Tensile Test with Two-run Technique

1. The tensile test specimens are to be *U2A* or *U2B* specimen shown in [Table 3.1](#) and two specimens are to be taken from each assembly.
2. The tensile strength obtained from the tensile tests are to meet the requirements of [Table 6.19](#), according to the grades of the automatic welding consumables.
3. Where the automatic welding consumables are used for two-run technique only, one longitudinal tensile test specimen of *U1A* shown in [Table 3.1](#) is to be machined from the thicker test assembly and the longitudinal axis is to coincide with the centre of weld about 7mm below the plate surface on the side from which the second run was made.
4. The test specimen specified in preceding -3 may be subjected to a temperature not exceeding 250°C for a period not exceeding 16 *hours* for hydrogen removal prior to testing.
5. The requirements for tensile tests specified in preceding -3 and -4 are to be as given in [Table 6.17](#) according to the grades of the automatic welding consumables. Where the upper limit of tensile strength exceeds the standard value, special consideration will be given to the approval of the welding consumables, taking the other mechanical properties shown in the test results and the chemical composition of deposited metal into consideration.

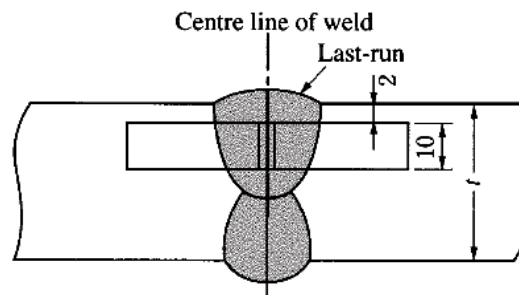
6.3.12 Butt Weld Bend Test with Two-run Technique

1. The face and root bent test specimens are to be *UB-6* specimen shown in [Table 3.2](#) and test specimens are to be taken from each test assembly. However, for *KAWL91* and *KAWL92*, the face bend and face and root bend test specimens are to be *B-7* test specimens, and test specimens are to be taken longitudinally from each test assembly.
2. The requirements in [6.3.9-2](#) are to be applied to this clause.

6.3.13 Butt Weld Impact Test with Two-run Technique

1. The impact test specimens are to be *U4* specimen shown in [Table 2.5 in Part 10](#), and one set of three specimens are to be taken from test assembly. Longitudinal direction of the test specimen is to be perpendicular to the weld line and the surface line of the test specimen is to coincide with the 2mm depth position of the test assembly as given in [Table 6.4](#) of the preceding [6.2.7](#).
2. Test temperature and the minimum mean absorbed energy are to meet the requirements of [Table 6.18](#) according to the grades of the automatic welding consumables.
3. The requirements in the preceding [6.2.7-2](#) and [6.2.7-4](#) are also to be applied to this clause.

Fig. 6.11 Position of Butt Weld Impact Test Specimen with Two-run Technique (Unit: mm, t =Plate thickness)



6.3.14 Hydrogen Test

The hydrogen tests are to be in accordance with the requirements specified in [6.2.11](#).

6.3.15 Annual Inspections

1. In the annual inspection, test specified in the following -2 are to be conducted for each approved brand, and the consumables are to meet the corresponding requirements.
2. The kinds of tests etc. involved in the annual inspections are to be as given in [Table 6.20](#).
3. Welding procedures and requirements for test assemblies specified in the preceding -2 are to be as specified in [6.3.5](#) through [6.3.13](#).

6.3.16 Changes in Grades

1. Where changes in grades relating to the strength or toughness of approved automatic welding consumables are to be made, the tests specified in **-2**, **-3** or **-4**, as applicable, are to be carried out according to the requirements in [6.1.3-6](#), and the electrodes must pass the tests satisfactorily.
2. Changes in grades concerning the strength and toughness of multi-run automatic welding consumables are to refer the following (1) and (2).
 - (1) For changes in grades concerning strength, the butt weld tests, specified in the annual inspections specified in [6.3.15](#) and in the requirements of [6.3.4-1](#), are to be conducted.
 - (2) For changes in grades concerning toughness, the butt weld impact tests, specified in the annual inspections specified in [6.3.15](#) and in the requirements of [6.3.4-1](#), are to be conducted.
3. Changes in grades concerning the strength and toughness of two-run automatic welding consumables are to refer the following (1) and (2).
 - (1) For changes in grades concerning strength, all tests specified in [6.3.4-1](#) are to be performed.
 - (2) For changes in grades concerning toughness, the butt weld impact tests, specified in the annual inspections of [6.3.15](#) and in [Table 6.15](#) of [6.3.4-1](#) using the thicker of two maximum applied thickness of the test assemblies, are to be conducted.
4. Changes in grades concerning the strength or toughness of automatic welding consumables for multi-run and two-run use are to be as specified in the preceding **-2** or **-3**.

Table 6.20 Kind of Test for Annual Inspection

Grade of welding consumable	Welding process	Kind of test		Test assembly			Kind and no. of test specimens taken from test assembly
				Number	Dimensions	Thickness (mm)	
KAW1 KAW2 KAW3 KAW51 KAW52 KAW53 KAW54 KAW52Y40 KAW53Y40 KAW54Y40 KAWL1 KAWL2 KAWL3 KAWL91 KAWL92	Multi-run technique	Deposited metal test		1	Fig. 6.7	20	Tensile test specimen : 1 Impact test specimen : 3
	Two-run technique	Butt weld test	Submerged arc welding	1	Fig. 6.9	20	Tensile test specimen: 1 Longitudinal tensile test specimen : 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3
			Gas shielded arc and self-shielded arc welding	1		20 ~ 25	Tensile test specimen: 1 Longitudinal tensile test specimen : 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3
	Multi-run and two-run technique	Deposited metal test		1	Fig. 6.7	20	Tensile test specimen : 1 Impact test specimen : 3
		Butt ⁽¹⁾ weld test	Submerged arc welding	1	Fig. 6.9	20	Tensile test specimen: 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3
			Gas shielded arc and self-shielded arc welding	1		20 ~ 25	Tensile test specimen: 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3

Note:

- 1 Butt weld test for multi-run and two-run technique is to be carried out by two-run technique.

6.4 Semi-automatic Welding Consumables for Mild Steels, High Tensile Steels and Steels for Low Temperature Service

6.4.1 Application

Welding wires for semi-automatic welding for mild steels, high tensile steels and steels for low temperature service (hereinafter referred to as semi-automatic welding consumables) are to be subjected to the approval test and annual inspections in accordance with the requirements in [6.4](#).

6.4.2 Grades and Marks of Semi-automatic Welding Consumables

1. Semi-automatic welding consumables are classified into grades as given in [Table 6.21](#).

2. A suffix *G* will be added to the grade marks of semi-automatic welding consumables which use shield gas, and a suffix *N* will be added to the grade marks of semi-automatic welding consumables which do not use shield gas.

Further, the type of shield gas used is to be as specified in [Table 6.14](#) of [6.3.2-3](#), and the suffix given in Table will be added after suffix *G*. (Example : *KSW53G (M1)*)

Table 6.21 Grades and Marks

For mild steel	For high tensile steel	For steel for low temperature service
<i>KSW1</i>	<i>KSW51, ,KSW52Y40</i>	<i>KSWL1,KSWL91</i>
<i>KSW2</i>	<i>KSW52,KSW53Y40</i>	<i>KSWL2, KSWL92</i>
<i>KSW3</i>	<i>KSW53,KSW54Y40, KSW54</i>	<i>KSWL3</i>

6.4.3 Approval Test

1. For the approval of semi-automatic welding consumables, the test specified in [6.4.4-1](#) are to be conducted for each brand of semi-automatic welding consumables.

2. For semi-automatic welding consumables which use shield gas, the test in the preceding -1 is to be performed for each type of gas given in [Table 6.14](#). Although, when the manufacturer of the consumables recommends gas types of the group of *M1*, *M2*, *M3* or *C*, in [Table 6.14](#), the approval test is referred to one of the following procedures.

- (1) When the test is conducted in accordance with the preceding -1 on one of the gas type, the test on the other gas types belonging to the same category are allowed to be dispensed with.
- (2) When the consumables is specified as applicable to any combination of the group of *M1*, *M2* or *M3*, the test is allowed to limit any one of the gas types of *M1*, *M2* or *M3* in accordance with the preceding -1, subject to the agreement of the Society.

6.4.4 General Provisions for Tests

1. Kinds of test, number, thickness and dimensions of test assemblies, diameter of wire used for welding, and the kinds and number of test specimens taken from each test assembly, position for semi-automatic welding consumables used in butt welds or in both butt and fillet welds are to be as given in [Table 6.22](#).

2. The requirements in [6.2.4-2](#) are to be applied to the semi-automatic welding consumables used in fillet welds.

3. Steel plates to be used for test assemblies are to be as given in [Table 6.23](#), appropriate to the kind of semi-automatic welding consumables.

Table 6.22 Kind of Test for Semi-Automatic Welding Consumable

Kind of test ⁽⁶⁾	Test assembly					Kind and number. of test specimens taken from test assembly
	Welding position	Wire diameter (mm)	Number	Dimensions	Thickness (mm)	
Deposited metal test	Flat	Maximum diameter	1 ⁽¹⁾	Fig. 6.1	20	Tensile test specimen: 1 Impact test specimen : 3
		Minimum diameter	1 ⁽¹⁾			
Butt weld test	Flat	First run: Minimum diameter Remaining-run: Maximum diameter	1 ⁽²⁾	Fig. 6.2	15 ~ 20	Tensile test specimen: 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3
	Horizontal ⁽³⁾		1			
	Vertical upward		1			
	Vertical downward		1			
	Overhead		1			
Fillet weld test	Horizontal fillet ⁽⁴⁾	The first side: Maximum diameter The Second side: Minimum diameter	1	Fig. 6.3	20	Macro test specimen: 3 ⁽⁵⁾ Hardness test specimen: 3 ⁽⁵⁾ Fracture test specimen: 2

Notes:

- 1 Where the core diameter to be manufactured is of single variety, the number of test assembly is to be one.
- 2 Where tests are conducted solely in the flat position, one test assembly welded with of different wire diameters is to be added.
- 3 For semi-automatic welding consumables which have passed butt weld tests in the flat and vertical upward positions, the horizontal butt weld test may be omitted, upon approved by the Society.
- 4 This test is to be added solely against welding electrodes for use in both butt and fillet welds to which the preceding (3) apply.
- 5 The test specimens used in the macro-etching test and hardness test are to be the same.
- 6 The hydrogen test may be carried out at the request of the manufacturer.

Table 6.23 Grades of Steel used for Test Assembly

Grade of welding consumable	Grade of steel used for test assembly ⁽¹⁾⁽²⁾
KSW1	KA
KSW2	KA, KB or KD
KSW3	KA, KB, KD or KE
KSW51	KA32 or KA36
KSW52	KA32, KA36, KD32 or KD36
KSW53	KA32, KA36, KD32, KD36, KE32 or KE36
KSW54	KA32, KA36, KD32, KD36, KE32, KE36, KF32 or KF36
KSW52Y40	KA40 or KD40
KSW53Y40	KA40, KD40 or KE40
KSW54Y40	KA40, KD40, KE40 or KF40
KSWL1	KE or KL24A
KSWL2	KE, KL24A, KL24B, KL27 or KL33
KSWL3	KL27, KL33 or KL37
KSWL91	KL9N53 or KL9N60
KSWL92	KL9N53 or KL9N60

Notes:

- 1 Notwithstanding the requirements in this Table, mild or high tensile steels may be used for deposited metal test assembly. In this case, appropriate buttering is to be carried out for KSWL91 and KSWL92.
- 2 The tensile strength of high tensile steels KA32, KD32, KE32 and KF32 used in the test assembly is to be greater than 490N/mm².

6.4.5 Welding Sequence of Test Assemblies

1. Deposited Metal Test Assemblies ([Fig. 6.1](#))

- (1) The test assemblies are to be welded in flat position according the welding procedure recommended by the manufacturer and the thickness of each layer of weld metal is to be in range from 2mm to 6mm.
- (2) After each run, the assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken at the centre of weld on the surface of seam.

2. Butt Weld Test Assemblies ([Fig. 6.2](#))

- (1) Test assemblies are to be welded in each welding position (flat, horizontal, vertical upward, vertical downward and overhead) which is recommended by the manufacturer.
- (2) After each run, the assembly is to be left in still air until it has cooled to less than 250°C, but not below 100°C, the temperature being taken at the centre of weld on the surface of seam.

3. Fillet Weld Test Assemblies ([Fig. 6.3](#))

The test assemblies are to be in accordance with the requirements in [6.2.5-4](#).

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

5. The welded assemblies are to be subjected to radiographic examination prior to taking test specimens from the assemblies.

6.4.6 Deposited Metal Tensile Test

1. The tensile test specimens are to be *U1A* specimen shown in [Table 3.1](#) and one specimens is to be taken from each assembly, care being taken that the longitudinal axis coincides with the centre of weld and the mid-thickness of plate.
2. The tensile strength, yield point and elongation of each test specimens are to comply with the requirements in [Table 6.24](#) appropriate to the kind of welding consumables. Where the upper limit of tensile strength is exceeded, special consideration will be given to the approval of the semi-automatic welding consumables, taking the other mechanical properties shown in the test results and the chemical composition of deposited metal into consideration.
3. The requirements in preceding [6.2.6-2](#) are to be applied to [6.4.6](#).

Table 6.24 Tensile Test Requirements for Deposited Metal

Grade of welding consumable	Tensile Strength (<i>N/mm</i> ²)	Yield point (<i>N/mm</i> ²)	Elongation (%)
<i>KSW1</i>	400 ~ 560	305 min.	22 min.
<i>KSW2</i>			
<i>KSW3</i>			
<i>KSW51</i>	490 ~ 660	375 min.	
<i>KSW52</i>			
<i>KSW53</i>			
<i>KSW54</i>			
<i>KSW52Y40</i>	510 ~ 690	400 min.	
<i>KSW53Y40</i>			
<i>KSW54Y40</i>			
<i>KSWL1</i>	400 ~ 560	305 min.	
<i>KSWL2</i>	440 ~ 610	345 min.	
<i>KSWL3</i>	490 ~ 660	375 min.	21 min.
<i>KSWL91</i>	590 min.	375 ⁽¹⁾ min.	25 min.
<i>KSWL92</i>	660 min	410 ⁽¹⁾ min.	

Note:

- 1 0.2% proof stress

6.4.7 Deposited Metal Impact Test

1. The impact test specimens are to be *U4* specimens as shown in [Table 2.5, Part 10](#) and one set of three test specimens being taken from each of the deposited metal test assemblies. The test specimen is to be cut with

its longitudinal axis transverse to the direction of welding, and the centre of the test specimen is to be coincide with the mid-thickness of the plate.

2. Test temperature and minimum mean absorbed energy are to comply with the requirements given in the [Table 6.25](#) appropriate to the grade of the electrode.
3. The requirements in the preceding [6.2.7-2](#) and -4 are to be applied to [6.4.7](#).

Table 6.25 Impact Test Requirements for Deposited Metal

Grade of welding consumable	Testing temperature(°C)	Minimum mean absorbed energy (J)
KSW1	20	47
KSW2	0	
KSW3	-20	
KSW51	20	
KSW52	0	
KSW53	-20	
KSW54	-40	
KSW52Y40	0	
KSW53Y40	-20	
KSW54Y40	-40	
KSWL1	-40	34
KSWL2	-60	
KSWL3	-60	
KSWL91	-196	27
KSWL92	-196	

6.4.8 Butt Weld Tensile Test

1. The tensile test specimens are to be U2A or U2B specimen shown in [Table 3.2](#) and one specimen is to be taken from each assembly.
2. The tensile strength of each test specimen is to comply with the requirements given in [Table 6.26](#).

Table 6.26 Tensile Test Requirements for Butt Weld

Grade of welding consumable	Testing Strength(N/mm ²)
KSW1, KSW2, KSW3	400 min.
KSW51, KSW52, KSW53, KSW54	490 min.
KSW52Y40, KSW53Y40, KSW54Y40	510 min.
KSWL1	400 min.
KSWL2	440 min.
KSWL3	490 min.
KSWL91	630 min.
KSWL92	670 min.

6.4.9 Butt Weld Bend Test

1. The face and root bend specimens are to be *UB-6* specimen shown in [Table 3.2](#) and one specimen is to be taken from each test assembly. However, for *KSWL91* and *KSWL92*, the face and root bend specimens are to be *UB-7* specimen shown in [Table 3.2](#) and specimen is to be taken longitudinally from each test assembly.
2. The test specimens are to be capable of withstanding, without crack exceeding *3mm* long on the outer surface of the specimen or other defect, being bent through an angle of *120 degrees* over a former having a radius of 1.5 times the thickness of test specimen. The radius and angle of the former for *KMWL91* and *KMWL92*, however, are to be 2 times the thickness of the specimen and *180 degrees* respectively.

6.4.10 Butt Weld Impact Test

1. The impact test specimens are to be *U4* specimen as shown in [Table 2.5, Part 10](#) and one set of three test specimens being taken from each of the deposited metal test assemblies. The test specimen is to be cut with its longitudinal axis transverse to the direction of welding, and the centre of the test specimen is to be coincide with the mid-thickness of the plate.
2. Test temperature and minimum mean absorbed energy are to comply with the requirements given in the [Table 6.27](#) appropriate to the grades of the electrode and welding position.
3. The requirements in the preceding [6.2.7-2](#) and [6.2.7-4](#) are to be applied to this clause.

6.4.11 Hydrogen Test

The hydrogen tests are to be in accordance with the requirements specified in [6.2.11](#).

6.4.12 Fillet Weld Macro-etching Test

The macro-etching test is to be in accordance with the requirements in [6.2.12](#).

6.4.13 Fillet Weld Hardness Test

The hardness test is to be in accordance with the requirements in [6.2.13](#).

6.4.14 Fillet Weld Fracture Test

The fracture test is to be in accordance with the requirements in [6.2.14](#).

6.4.15 Annual Inspections

1. In the annual inspections, tests specified in the following -2 are to be conducted for each approved brand and they are to be passed satisfactorily.
2. The kinds of test etc. in the annual inspection are to be as given in [Table 6.28](#).
3. The welding procedures and requirements for the test assemblies for the tests specified in the preceding -2 are to be in accordance with the requirements in [6.4.5](#) through [6.4.10](#).

Table 6.27 Impact Test Requirements for Butt Weld

Grade of welding consumable	Testing temperature(°C)	Minimum mean absorbed energy (J)	
		Flat, Horizontal, Overhead	Vettical upward, Vertical downward
KSW1	20	47	34
KSW2	0		
KSW3	-20		
KSW51	20		
KSW52	0		
KSW53	-20		
KSW54	-40		
KSW52Y40	0		39
KSW53Y40	-20		
KSW54Y40	-40		
KSWL1	-40	27	27
KSWL2	-60		
KSWL3	-60		
KSWL91	-196		
KSWL92	-196		

Table 6.28 Kind of Test for Annual Inspection

Kind of test	Test assembly					Kind and no. of test specimens taken from test assembly
	Welding position	Diameter of wire (mm)	Number	Dimensions	Thickness (mm)	
Deposited metal test	Flat	(1)	1	Fig. 6.1	20	Tensile test specimen : 1 Impact test specimen : 3

Note:

- 1 The diameters of the wire are to be within the range specified by the manufacturers.

6.4.16 Changes in Grades

1. Where changes in grades relating to the strength or toughness of approved semi-automatic welding consumables are to be made, the tests specified in -2, or -3 are to be carried out according to the requirements in [6.1.3-6](#), and the semi-automatic welding consumables must pass the tests satisfactorily.
2. Where changes are to be made in the strength of the welding consumables, the annual inspection specified in [6.4.15](#) and the butt weld tests specified in [6.4.4-1](#), are to be carried out.
3. Where changes are to be made in the toughness of the welding consumables, the butt weld impact tests specified in the annual inspection in [6.4.15](#) and in [6.4.4-1](#), are to be carried out.

6.5 Electro-slag and Electro-gas Welding Consumables

6.5.1 Application

Electro-slag and electro-gas welding consumables for mild and high tensile steels (hereinafter referred to as “welding consumables” in [6.5](#)) are to be subjected to the approval test and annual inspections in accordance with the requirements in [6.5](#).

6.5.2 Grades and Marks of Welding Consumables

Welding consumables are classified into grades as given in [Table 6.29](#).

6.5.3 Approval Test

For the approval of welding materials, the tests specified in [6.5.4-1](#) are to be conducted for each brand of welding materials.

Table 6.29 Grades and Marks

For mild steel	For high tensile steel	
<i>KEW1</i>	<i>KEW51</i>	<i>KEW52Y40</i>
<i>KEW2</i>	<i>KEW52</i>	<i>KEW53Y40</i>
<i>KEW3</i>	<i>KEW53</i>	<i>KEW54Y40</i>
	<i>KEW54</i>	

6.5.4 General Provisions for Tests

1. Kinds of tests, number, thickness and dimensions of test assemblies, kinds and number of test specimens taken from each test assembly for welding consumables are to be as given in [Table 6.30](#).
2. Grades of steel to be used for test assemblies are to be as given in [Table 6.31](#).

Table 6.30 Kind of Test for Electro-slag and Electro-gas Welding Consumables

Kind of test	Test assembly			Kind and no. of test specimens taken from test assembly
	Number	Dimensions	Thickness ⁽¹⁾ (mm)	
Butt weld test	1	Fig. 6.12	20 ~ 25	Tensile test specimen: 2 Longitudinal tensile test specimen: 2 Side bend test specimen: 2
	1		35 ~ 45	Impact test specimen: 6 Macro test specimen: 2

Note:

- 1 Where thickness is restricted by welding process, thickness of test assemblies may be changed upon approval of the Society. In this case, the maximum thickness of test assemblies in thickness restrictions is to be taken as the maximum applicable thickness, as is to be certificated.

Table 6.31 Grades of Steel used for Test Assembly

Grade of welding consumable	Grade of steel used for test assembly ⁽¹⁾
<i>KEW1</i>	<i>KA</i>
<i>KEW2</i>	<i>KA, KB or KD</i>
<i>KEW3</i>	<i>KA, KB, KD or KE</i>
<i>KEW51</i>	<i>KA32 or KA36</i>
<i>KEW52</i>	<i>KA32, KA36, KD32 or KD36</i>
<i>KEW53</i>	<i>KA32, KA36, KD32, KD36, KE32 or KE36</i>
<i>KEW54</i>	<i>KA32, KA36, KD32, KD36, KE32, KE36, KF32 or KF36</i>
<i>KEW52Y40</i>	<i>KA40 or KD40</i>
<i>KEW53Y40</i>	<i>KA40, KD40 or KE40</i>
<i>KEW54Y40</i>	<i>KA40, KD40, KE40 or KF40</i>

Note:

- 1 The tensile strength of high tensile steels *KA32*, *KD32*, *KE32* and *KF32* used in the test assemble is to be greater than 490N/mm².

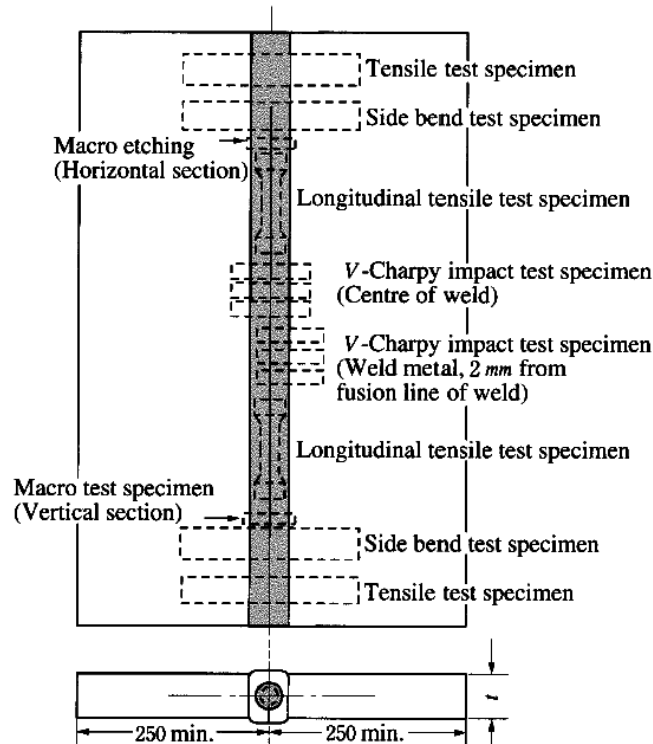
6.5.5 Welding Sequence of Test Assemblies

1. Butt weld test assemblies ([Fig. 6.12](#))

- (1) The edge preparation is to be in accordance with the recommendations by the manufacturer.
- (2) Test assemblies are to be welded upward in vertical position in one pass, generally, and in accordance with the practice recommended by the manufacturer.
2. After being welded, the test assemblies are not to be subjected to any heat treatment.
3. The welded assemblies may be subjected to radiographic examination prior to taking test specimens from the assemblies.

Fig. 6.12 Butt Weld Test Assembly

(Unit: *mm*, *t*=Plate thickness)



6.5.6 Tensile Test

1. Two tensile test specimens to be *U2A* or *U2B* specimen and two longitudinal tensile test specimens to be *U1A* specimen as shown in [Table 3.1](#) to be taken from each test assembly.
2. Longitudinal tensile test specimens may be subjected to the heat treatment not exceeding 250°C for a period not exceeding 16 *hours* for hydrogen removal prior to testing.
3. Tensile strength of each test specimen *U2A* or *U2B* is to comply with the requirements in [Table 6.32](#) according to the grade of welding consumable. Tensile strength, yield point and elongation of each longitudinal test specimen *U1A* are to comply with the requirements in [Table 6.33](#) according to the grade of welding consumable.

Where the upper limit of tensile strength is exceeded, special consideration will be given to the approval of the welding consumables, taking the other mechanical properties in the test results and chemical composition of deposited metal into consideration.

Table 6.32 Tensile Test Requirement

Grade of welding consumable	Testing Strength(N/mm^2)
KEW1 KEW2 KEW3	400 min.
KEW51 KEW52 KEW53 KEW54	490 min.
KEW52Y40 KEW53Y40 KEW54Y40	510 min.

Table 6.33 Longitudinal Tensile Test Requirement

Grade of welding consumable	Tensile Strength (N/mm^2)	Yield point (N/mm^2)	Elongation (%)
KEW1 KEW2 KEW3	400 ~ 560	305 min.	22 min.
KEW51 KEW52 KEW53 KEW54	490 ~ 660	375 min.	
KEW52Y40 KEW53Y40 KEW54Y40	510 ~ 690	400 min.	

6.5.7 Bend Test

1. Two pieces of side bend test specimen *UB-8* shown in [Table 3.2](#) are taken from each test assembly.
2. The test specimens are to be capable of withstanding, without fracture, being side bent through an angle of 180 *degrees* over a former having a radius of 2 times the thickness of test specimen. The test specimens may be considered as complying with the requirements if, on completion of the test, no crack or defect greater than 3mm can be seen on the outer surface of the test specimen.

6.5.8 Impact Test

1. The impact test specimens are to be *U4* specimen as shown in [Table 2.5, Part 10](#), and six specimens are taken from each test assembly. The test specimen is to be cut with its longitudinal axis perpendicular to the weld and the upper surface 2mm apart from the surface of test assembly as specified in [Fig. 6.13](#).

2. The position of the notch is to be in accordance with [Fig. 6.13\(a\)](#) and [\(b\)](#) respectively, and its longitudinal direction is to be perpendicular to the surface of the test assembly.
3. Testing temperature and each value of minimum mean absorbed energy is to be in accordance with the requirements in [Table 6.34](#) according to grade of welding consumable.
4. The requirements in [6.2.7-4](#). are to be applied to this clause.

Fig. 6.13 Position of Impact Specimen (Unit: mm, t = Plate thickness)

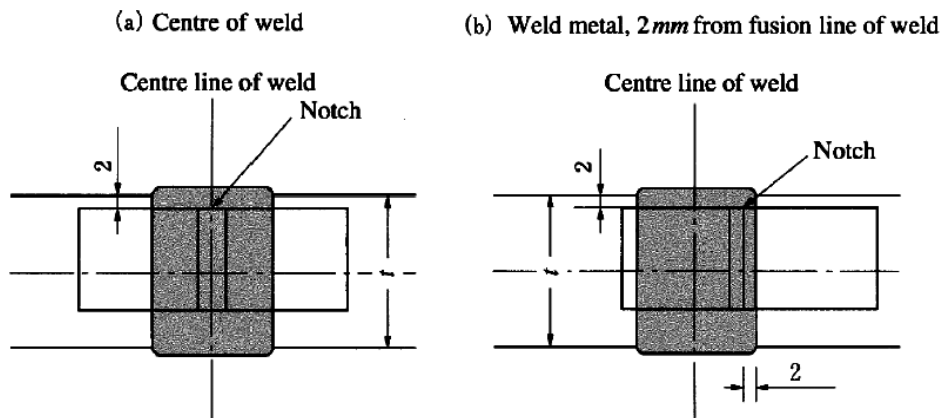


Table 6.34 Impact Test Requirement

Grade of welding consumable	Testing temperature(°C)	Minimum mean absorbed energy (J)
KEW1	20	34
KEW2	0	
KEW3	-20	
KEW51	20	
KEW52	0	
KEW53	-20	
KEW54	-40	
KEW52Y40	0	39
KEW53Y40	-20	
KEW54Y40	-40	

6.5.9 Macro-etching Test

1. Two macro-etching test specimens are to be taken from each test assembly. As for the surface to be tested, one is to be normal to the assembly surface and the other parallel to the assembly surface.

2. The welding joints on test specimens are to be polished and etched, and are to show complete fusion, penetration and sound metallurgical structure.

6.5.10 Annual Inspections

1. In the annual inspections, the approved welding consumables are to be subjected to the tests provided in -2.
2. The kinds of tests in the annual inspections are to be as given in [Table 6.35](#).
3. The welding procedure and requirements for test assemblies specified in -2 are to be in accordance with the requirements in [6.5.5](#) to [6.5.8](#).

Table 6.35 Kind of Test for Annual Inspection

Kind of test	Test assembly			Kind and no. of test specimens taken from test assembly
	Number	Dimensions	Thickness ⁽¹⁾ (mm)	
Butt weld test	1	Fig. 6.12	20 ~ 25	Tensile test specimen: 1 Longitudinal tensile test specimen : 1 Side bend test specimen : 2 Impact test specimen: 6 ⁽¹⁾ Macro test specimen : 1 ⁽²⁾

Notes:

- 1 Where approved by the Society, 3 pieces of impact test specimen may be taken from the centre of welded part.
- 2 The surface to be tested is to be vertical to the test assembly surface.

6.5.11 Changes in Grades

Where changes in grades relating to the strength or toughness of approved welding consumables are to be made, the tests specified in [6.5.4-1](#) are to be carried out according to the requirements in [6.1.3-6](#), and the welding consumables must pass the tests satisfactorily.

6.6 One Side Automatic Welding Consumables for Mild Steels, High Tensile Steels and Steels for Low Temperature Service

6.6.1 Application

1. Welding consumables for mild steels, high tensile steels and steels for low temperature service, which given in following (1) through (3) (hereinafter referred to in [6.6](#) as “one side automatic welding consumables”) are to be subjected to the approval tests and annual inspections in accordance with the requirements in [6.6](#).

- (1) Submerged arc one side automatic welding consumables
 - (2) Gas shielded arc one side automatic welding consumables (solid wire one side automatic welding consumables and fluxed wire one side automatic welding consumables with shielding gas)
 - (3) Self-shielded arc one side automatic welding consumables (fluxed wire one side automatic welding consumables without shielding gas).
2. Approval tests and annual inspections of one side covered electrodes for mild steels, high tensile steels and steels for low temperature service, and one side semi-automatic welding consumables are to be in accordance with the requirements specified in [6.1.3-3](#) and [6.1.5-1](#).
3. The backing consumables used for one side welding in combination with one side welding consumables of the preceding -1 and -2 are to be as deemed appropriate by the Society.

6.6.2 Grades and Marks of Welding Consumables

1. One side automatic welding consumables are classified into as given in [Table 6.12](#).
2. One side automatic welding consumables which have passed the tests for each welding process given in [Table 6.37](#) are to be appended with suffixes given in [Table 6.36](#) at the end of their marks.
3. In the preceding -2, suffix *G* will be added to the grade marks of gas shielded arc one side automatic welding consumables and a suffix *N* will be added to the grade marks of self-shielded arc one side automatic welding consumables. Further, the type of shield gas used is to be as specified in [Table 6.14](#) of [6.3.2-3](#), and the suffix given in [Table 6.14](#) will be added after the suffix *G*. (Example: *KAW53SMPG* (M1))

Table 6.36 Suffix

Welding technique	Suffixes
One-run technique ⁽¹⁾	<i>SP</i>
Multi-run technique ⁽²⁾	<i>MP</i>
One-run and Multi-run technique	<i>SMP</i>

Notes:

- 1 One-run technique refers to a welding process which is performed in one pass regardless of the number of electrodes.
- 2 Multi-run technique refers to a welding process which is performed in multiple passes regardless of the number of electrodes.

Table 6.37 Kinds of Test for One-side Automatic Welding Consumable

Grade of welding consumable	Welding process	Kind of test ⁽⁵⁾	Test assembly			Kind and no. of test specimens taken from test assembly	
			Number	Dimensions	Thickness ⁽¹⁾ (mm)		
KAW1 KAW2 KAW3 KAW51 KAW52 KAW53 KAW54 KAW52Y40 KAW53Y40 KAW54Y40 KAWL1 KAWL2 KAWL3 KAWL91 KAWL92	One-run technique	Butt weld test	1	Fig. 6.14	12 ~ 15	Tensile test specimen: 2 Longitudinal tensile test specimen : 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 6 ⁽⁴⁾ Macro-etching test specimen :1	
			1		20 ~ 25		
	Multi-run technique		1		12 ~ 15 ⁽²⁾ 20 ~ 25 ⁽³⁾	Tensile test specimen: 2 Longitudinal tensile test specimen : 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 6 ⁽⁴⁾ Macro-etching test specimen :1	
			1		20 ~ 25 ⁽²⁾ 30 ~35 ⁽³⁾		
			One-run and Multi-run technique		1	12 ~ 15 ⁽⁶⁾ 20 ~ 25 ⁽²⁾⁽⁷⁾ 30 ~35 ⁽³⁾⁽⁷⁾	Tensile test specimen: 2 Longitudinal tensile test specimen : 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 6 ⁽⁴⁾ Macro-etching test specimen :1
					1		

Notes:

- Where thickness is restricted by welding process, thickness of test assemblies may be changed upon approval of the Society. In this case, the maximum thickness of test assemblies restrictions is to be taken as the maximum applicable thickness, and is to be certified.
- Thickness of test assemblies corresponding to single electrodes.
- Thickness of test assemblies corresponding to multiple electrodes.
- Where thickness of test assemblies ranges between 12~15mm, the test specimens are to be 1 set of 3 impact test specimens given in [Fig. 6.15\(b\)](#).
- The hydrogen test may be carried out at the request of the manufacturer.
- Thickness of test assembly for one-run technique.
- Thickness of test assembly for multi-run technique.

6.6.3 Approval Test

- For the approval of one side automatic welding consumables, the tests specified in [6.6.4-1](#) are to be conducted for each brand and the semi-automatic welding consumables.

2. For one side automatic welding consumables, the test in the preceding -1, is to be performed for each type of gas given in [Table 6.14](#). Although, when the manufacturer of the consumables recommends gas types of the group of *M1*, *M2*, *M3* or *C* in [Table 6.14](#), the approval test is referred to one of the following procedures.

- 1 When the test is conducted in accordance with the preceding -1 on one of the gas type, the test on the other gas types belonging to the same category are allowed to be dispensed with.
- 2 When the consumables is specified as applicable to any combination of the groups of *M1*, *M2* and *M3*, the test is allowed to limit any one of the gas types of *M1*, *M2* or *M3* in accordance with the preceding -1, subject to the agreement of the Society.

6.6.4 General Provisions for Tests

1. Kinds of tests, number, thickness and dimensions of test assemblies, kinds and number of test specimens taken from each test assembly for one side automatic welding consumables are specified in [Table 6.37](#).
2. Grade of steel to be used in preparation of test assemblies are to be as given in [Table 6.38](#).

Table 6.38 Grades of Steel used for Test Assembly

Grade of welding consumable	Grade of steel used for test assembly ⁽¹⁾
<i>KAW1</i>	<i>KA</i>
<i>KAW2</i>	<i>KA, KB or KD</i>
<i>KAW3</i>	<i>KA, KB, KD or KE</i>
<i>KAW51</i>	<i>KA32 or KA36</i>
<i>KAW52</i>	<i>KA32, KA36, KD32 or KD36</i>
<i>KAW53</i>	<i>KA32, KA36, KD32, KD36, KE32 or KE36</i>
<i>KAW54</i>	<i>KA32, KA36, KD32, KD36, KE32, KE36, KF32 or KF36</i>
<i>KAW52Y40</i>	<i>KA40 or KD40</i>
<i>KAW53Y40</i>	<i>KA40, KD40 or KE40</i>
<i>KAW54Y40</i>	<i>KA40, KD40, KE40 or KF40</i>
<i>KAWL1</i>	<i>KE or KL24A</i>
<i>KAWL2</i>	<i>KE, KL24A, KL24B, KL27 or KL33</i>
<i>KAWL3</i>	<i>KL27, KL33 or KL37</i>
<i>KAWL91</i>	<i>KL9N53 or KL9N60</i>
<i>KAWL92</i>	<i>KL9N53 or KL9N60</i>

Note:

- 1 The tensile strength of high tensile steels *KA32*, *KD32*, *KE32* and *KF32* used in the test assemble is to be greater than 490N/mm².

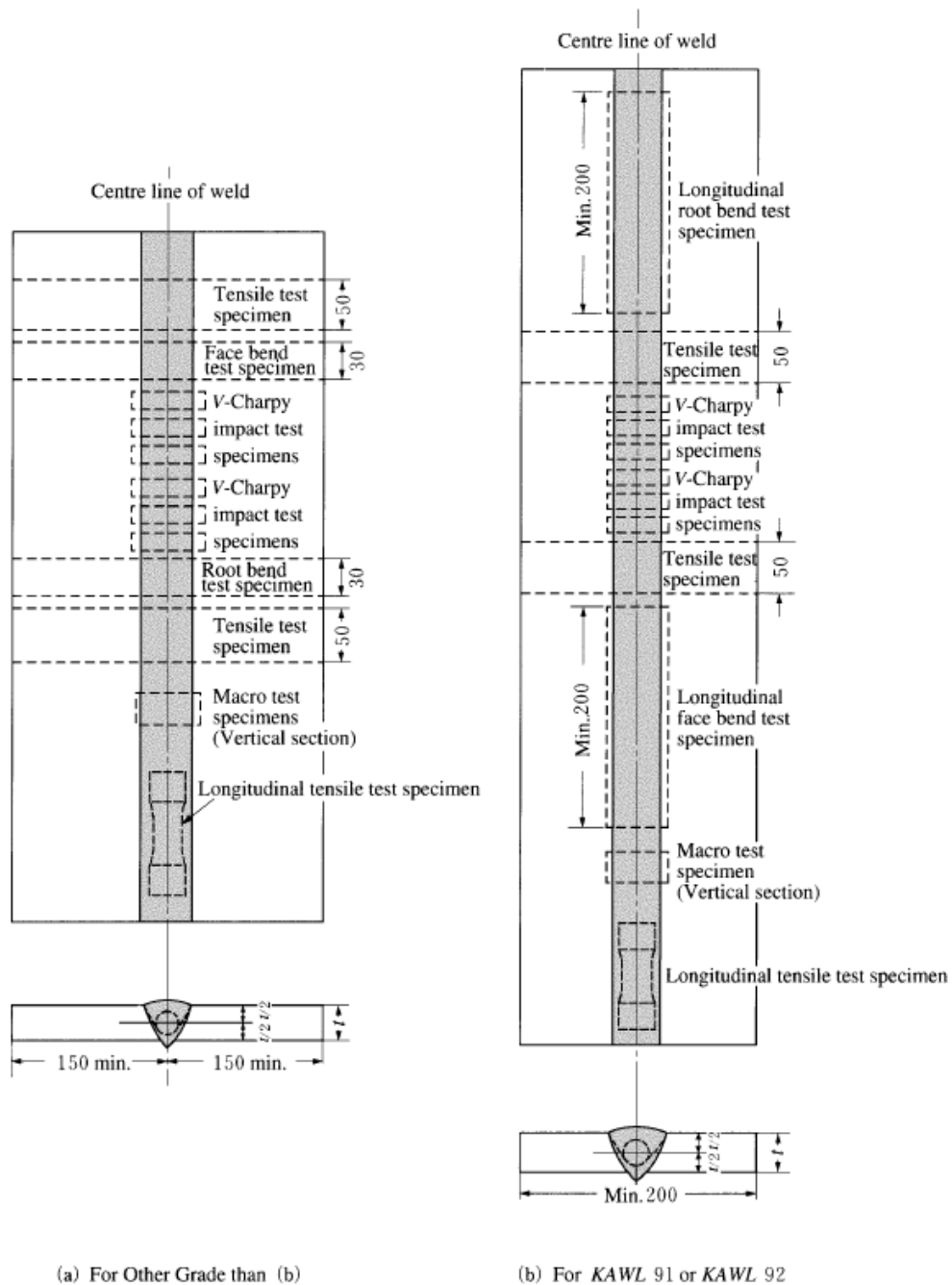
6.6.5 Welding Sequence of Test Assemblies

1. Butt Weld Test Assemblies with One-run and Multi-run Technique ([Fig. 6.14](#))



- (1) The edge preparations and root gaps of test assemblies, together with the diameter of core wire and the number of electrodes etc. are to be within the range specified by the manufacturer.
 - (2) Test assemblies are to be welded in flat position by one-run technique or multi-run technique according to the procedures specified by the manufacturer. However, for gas shielded arc and self-shielded arc one side automatic welding consumables, the welding position is to be specified by the manufacturer.
 - (3) In case of multi-run technique, after each run the assembly is to be left in still air until it has cooled to less than 250°C but not below 100°C, the temperature being taken at the centre of weld on the surface of seam.
2. After being welded, the test assemblies are not to be subjected to any heat treatment.
 3. The welded assemblies are to be subjected to radiographic examination prior to taking specimen from the assembly.

Fig. 6.14 Butt Weld Test Assembly with One-run and Multi-run Technique (Unit: *mm*, *t*=Plate thickness)



6.6.6 Butt Weld Test with One-run and Multi-run Technique

1. Two tensile test specimens to be *U2A* or *U2B* as shown in [Table 3.1](#) and one longitudinal tensile test specimen to be *U1A* are to be taken from each test assembly. Care being taken that the longitudinal axis coincides with the centre of weld and the mid-thickness of plate.
2. The longitudinal tensile test specimen may be subjected to a temperature not exceeding 250°C for a period not exceeding 16 hours for hydrogen removal prior to testing.
3. Tensile strength of *U2A* or *U2B* test specimen is to be as given in [Table 6.19](#) of [6.3.8](#) according to the grades of one side automatic welding consumables. Tensile strength, yielding point and elongation of *U1A* longitudinal tensile test specimens are to be as given in [Table 6.17](#) of [6.3.8](#) according to the grades of one side automatic welding consumables. Where the upper limit of tensile strength is exceeded, special consideration will be given to the approval of the welding consumables, taking the other mechanical properties shown in the test results and the chemical composition of deposited metal into consideration.

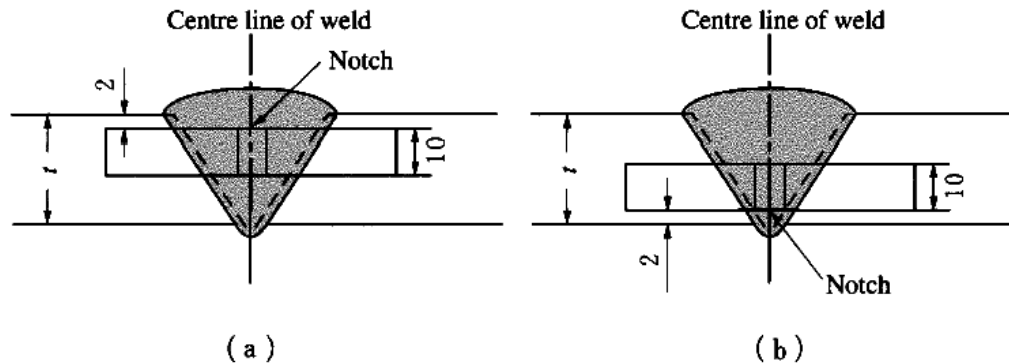
6.6.7 Butt Weld Bend Test with One-run and Multi-run Technique

The bend tests are to be in accordance with the requirements in [6.3.12](#).

6.6.8 Butt Weld Impact Test with One-run and Multi-run Technique

1. Two sets of impact test specimens to be *U4* test specimens as shown in [Table 2.5, Part 10](#) are to be taken from each test assembly. Longitudinal direction of the test specimen is to be perpendicular to the weld line and each position from which the test specimens are taken is to be (a) and (b) as shown in [Fig. 6.15](#).
2. Testing temperature and the value of minimum mean absorbed energy are to meet the requirements of [Table 6.18](#) according to the grades of one side automatic welding consumables.
3. The requirements in the preceding [6.2.7-2](#) and [6.2.7-4](#) are also to be applied to this paragraph.

Fig. 6.15 Position of Impact Test Specimen for Butt Weld with One-run and Multi-run Technique
(Unit: mm, t = Plate thickness)



6.6.9 Butt Weld Macro-etching Test with One-run and Multi-run Technique

1. Macro-etching test specimens are to be taken as shown in [Fig. 6.14](#). The surface to be tested is to be normal to the surface of the test assembly.
2. Both the welded parts and the weld junctions are to show complete fusion, penetration and sound metallurgical structure.

6.6.10 Hydrogen Test

The hydrogen tests are to be in accordance with the requirements specified in [6.2.11](#).

6.6.11 Annual Inspections

1. In the annual inspection, tests specified in the following -2 and -3 are to be conducted for each approved brand, and the consumables are to meet the corresponding requirements.
2. The kinds of tests in the annual inspection are to be as given in [Table 6.39](#).
3. The welding process and requirements of test assemblies used for test specified in the preceding -2 are to be in accordance with the requirements in [6.6.5](#) through [6.6.8](#).

Table 6.39 Kinds of Test at Annual Inspection

Grade of welding consumable	Welding process	Kind of test	Test assembly			Kind and no. of test specimens taken from test assembly
			Number	Dimensions	Thickness (mm)	
KAW1 KAW2 KAW3 KAW51 KAW52 KAW53 KAW54	One-run technique	Butt weld ⁽²⁾ test	1	Fig. 6.14	20	Tensile test specimen: 1 Longitudinal tensile test specimen : 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3 ⁽¹⁾
KAW52Y40 KAW53Y40 KAW54Y40 KAWL1	Multi-run technique		1		20 ~ 25	Tensile test specimen: 1 Longitudinal tensile test specimen : 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3 ⁽¹⁾
KAWL2 KAWL3 KAWL91 KAWL92	One-run and Multi-run technique		1		20 ~ 25	Tensile test specimen: 1 Longitudinal tensile test specimen : 1 Face bend test specimen: 1 Root bend test specimen: 1 Impact test specimen: 3 ⁽¹⁾

Notes:

- 1 The positions of notch and selection of impact test specimens are to be as given in [Fig. 6.15\(b\)](#).
- 2 The butt weld tests for one-run and multi-run technique are to be carried out by one-run technique.

6.6.12 Changes in Grades

Where changes in grades relating to the strength or toughness of approved one side automatic welding consumables are to be made, all the tests specified in [6.6.4-1](#) are to be carried out according to the requirements in [6.1.3-6](#), and one side automatic welding consumables must pass the tests satisfactorily.

6.7 Welding Consumables for Stainless Steel

6.7.1 Application

Welding consumables for stainless steels (hereinafter referred to as “welding consumables” in [6.7](#)) are to be subjected to the approval tests and annual inspections in accordance with the requirements in [6.7](#).

6.7.2 Grades and Marks of Welding Consumables

1. Welding consumables are classified into grades as given in [Table 6.40](#).
2. Submerged arc welding consumables which have passed the tests for each welding process given in [Table 6.42](#) are appended with suffixes shown in [Table 6.41](#) at the end of their marks.

3. For fluxed wire semi-automatic welding consumables in the preceding -1, a suffix *G* will be added to the grade marks of welding consumables which use shield gas, and a suffix *N* will be added to the grade marks of welding consumables which do not use shield gas. Further, the type of shield gas used is to be specified in [Table 6.14](#) of [6.3.2-3](#), and the suffix given in the table will be added after suffix *G*. (Example: KW308*G* (c))
4. For welding consumables of which the specified minimum proof stress is altered to other value subject to the approval of the Society, the value and “M” is to be suffixed to the grade marks of welding consumables. (Example: KW308*G*(C)-315M)

Table 6.40 Grades and Marks of Welding Consumables

Electrode for manual arc welding	Consumable for <i>TIG</i> and <i>MIG</i> welding	Flux wire semi-automatic welding	Consumable for submerged arc welding
<i>KD308</i>	<i>KY308</i>	<i>KW308</i>	<i>KU308</i>
<i>KD308L</i>	<i>KY308L</i>	<i>KW308L</i>	<i>KU308L</i>
<i>KD308N2</i>	<i>KY308N2</i>	<i>KW308N2</i>	–
<i>KD309</i>	<i>KY309</i>	<i>KW309</i>	<i>KU309</i>
<i>KD309L</i>	<i>KY309L</i>	<i>KW309L</i>	<i>KU309L</i>
<i>KD309Mo</i>	<i>KY309Mo</i>	<i>KW309Mo</i>	<i>KU309Mo</i>
<i>KD309MoL</i>	–	<i>KW309MoL</i>	–
<i>KD310</i>	<i>KY310</i>	<i>KW310</i>	<i>KU310</i>
–	<i>KY310S</i>	–	–
<i>KD310Mo</i>	–	–	–
<i>KD316</i>	<i>KY316</i>	<i>KW316</i>	<i>KU316</i>
<i>KD316L</i>	<i>KY316L</i>	<i>KW316L</i>	<i>KU316L</i>
<i>KD317</i>	<i>KY317</i>	<i>KW317</i>	<i>KU317</i>
<i>KD317L</i>	<i>KY317L</i>	<i>KW317L</i>	<i>KU317L</i>
–	<i>KY321</i>	–	–
<i>KD329J1</i>	–	–	–
<i>KD329J4L</i>	<i>KY329J4L</i>	<i>KW329J4L</i>	–
<i>KD2209</i>	<i>KY2209</i>	<i>KW2209</i>	–
<i>KD347</i>	<i>KY347</i>	<i>KW347</i>	<i>KU347</i>

Table 6.41 Suffix

Welding process	Suffix
Multi-run technique	<i>M</i>
Two-run technique	<i>T</i>
Multi-run and Two-run technique	<i>TM</i>

Table 6.42(a) Kinds of Test of Welding Consumables for Stainless Steel

Kind of welding consumables	Kind of test	Test assembly					Kind and no. of test specimens taken from test assembly
		Welding position	Dia. of ⁽¹⁾ electrode or wire (mm)	No.	Dimensions	Thickness (mm)	
Electrode for manual arc welding	Deposited metal test	Flat	3.2	1	Fig. 6.16	12	Tensile test specimen: 1
			4.0			19	
	Butt weld test	Flat	3.2 or 4.0	1	Fig. 6.17	9 ~ 12	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
		Horizontal		1			
		Vertical upward		1			
		Vertical downward		1			
Consumables for TIG welding	Deposited metal test	Flat	2.4	1	Fig. 6.16	12	Tensile test specimen: 1
			3.2	1		19	
	Butt weld test	Flat	2.0 ~ 3.2	1	Fig. 6.17	9 ~ 12	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
		Horizontal		1			
		Vertical upward		1			
		Vertical downward		1			
Consumables for MIG welding	Deposited metal test	Flat	1.2	1	Fig. 6.16	12	Tensile test specimen: 1
			1.6	1		19	
	Butt weld test	Flat	1.2 ~ 2.0	1	Fig. 6.17	9 ~ 12	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
		Horizontal		1			
		Vertical upward		1			
		Vertical downward		1			
Flux wire for semi-automatic welding	Deposited metal test	Flat	1.2 ~ 2.4	1	Fig. 6.16	12	Tensile test specimen: 1
			3.2 or max.dia.	1		19	
	Butt weld test	Flat	1.2 ~ 3.2	1	Fig. 6.17	9 ~ 12	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
		Horizontal		1			
		Vertical upward		1			
		Vertical downward		1			
		Overhead		1			

Table 6.42(b) Kinds of Test of Welding Consumables for Stainless Steel (Continued)

Kind of welding consumables		Kind of test	Test assembly					Kind and no. of test specimens taken from test assembly
			Welding position	Dia. of ⁽¹⁾ electrode or wire (mm)	No.	Dimensions	Thickness (mm)	
Consumables for sub-merged arc welding	Multi-run technique	Deposited metal test	Flat	1.2 ~ 4.0	1	Fig. 6.16	19 ~ 25	Tensile test specimen: 1
		Butt weld test	Flat	1.2 ~ 4.0	1	Fig. 6.18 (a)	19	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
	Two-run technique	Butt weld test	Flat	1.2 ~ 2.4	1	Fig. 6.18 (b)	12	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
			Flat	4.0	1		19	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
	Multi-run and Two-run technique	Deposited metal test	Flat	1.2 ~ 4.0	1	Fig. 6.16	19 ~ 25	Tensile test specimen: 1
		Butt weld test	Flat	1.2 ~ 4.0	1	Fig. 6.18 (a)	19	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
		Butt weld test	Flat	1.2 ~ 2.4	1	Fig. 6.18 (b)	12	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1
			Flat	4.0	1		19	Tensile test specimen: 1 Face bend specimen: 1 Root bend specimen: 1

Note:

- 1 Where approval is granted by the Society, the diameter of electrodes or wires may be changed.

6.7.3 Approval Test

1. For the approval of welding consumables, the tests specified in [6.7.4-1](#) are to be conducted for each brand of welding consumables.

2. For fluxed wire semi-automatic welding consumables, which use shield gas, the test in the preceding -1 is to be performed for each type of gas given in [Table 6.14](#). Although, when the manufacturer of the consumables recommends gas types of the group of *M1*, *M2* or *M3* in [Table 6.14](#), the approval test is referred to one of the following procedures.

- (1) When the test is conducted in accordance with the preceding -1 on one of the gas type, the test on the other gas types belonging to the same category are allowed to be dispensed with.
- (2) When the consumables is specified as applicable to any combination of the groups of *M1*, *M2* or *M3*, the test is allowed to limit any one of the gas types of *M1*, *M2* and *M3* in accordance with the preceding -1, subject to the agreement of the Society.

6.7.4 General Provisions for Tests

1. Kinds of test, number, thickness and dimensions of test assemblies, diameter of wire used for welding, and the kinds and number of test specimens taken from each test assembly in each welding position for welding consumables are to be given in [Table 6.42](#). However, additional tests according to steels, such as test on corrosion-resistance test, impact test, macro etching test, etc., except the test given in the table may be required where considered necessary by the Society.
2. The steel consumables used for tests are to be of those grades of steel specified in [Table 6.43](#) according to types of welding consumables, or those considered to be equivalent by the Society.

Table 6.43 Grades of Steel for Test Assembly

Grade of welding consumables	Grade of steel for test assembly
<i>KD308, KY308, KW308, KU308</i>	<i>KSUS304, KSUS304L</i>
<i>KD308L, KY308L, KW308L, KU308L</i>	
<i>KD308N2, KY308N2, KW308N2</i>	<i>KSUS304N2</i>
<i>KD309, KY309, KW309, KU309</i>	<i>KSUS309S</i>
<i>KD309L, KY309L, KW309L, KU309L</i>	
<i>KD309Mo, KY309Mo, KW309Mo, KU309Mo</i>	
<i>KD309MoL, KW309MoL</i>	
<i>KD310, KY310, KW310, KU310</i>	<i>KSUS310S</i>
<i>KY310S</i>	
<i>KD310Mo</i>	
<i>KD316, KY316, KW316, KU316</i>	<i>KSUS316, KSUS316L</i>
<i>KD316L, KY316L, KW316L, KU316L</i>	
<i>KD317, KY317, KW317, KU317</i>	<i>KSUS317, KSUS317L</i>
<i>KD317L, KY317L, KW317L, KU317L</i>	
<i>KY321</i>	<i>KSUS321</i>
<i>KD329J1</i>	<i>KSUS329J1</i>
<i>KD329J4L, KY329J4L, KW329J4L</i>	<i>KSUS329J4L</i>
<i>KD2209, KY2209, KW2209</i>	<i>KSUS329J3L</i>
<i>KD347, KY347, KW347, KU347</i>	<i>KSUS321, KSUS347</i>

Note:

Notwithstanding the requirements in this table, mild steel or high tensile steel may be used for deposited metal test assembly. In this case, appropriate buttering is to be carried out for test assembly.

6.7.5 Welding Sequence of Test Assemblies

1. Deposited metal test assemblies ([Fig. 6.16](#))

- (1) Test assemblies are to be welded in flat position according to the welding process recommended by the manufacturer.
 - (2) After each run, the test assembly is to be left in still air until it has cooled to less than 150°C, but not below 15°C, the temperature being taken at the centre of weld on the surface of seam.
- 2. Butt weld test assemblies (Fig. 6.17 and Fig. 6.18)**
- (1) Test assemblies are to be welded in each welding position (flat, horizontal, vertical upward, vertical downward and overhead) which is recommended by the manufacturer.
 - (2) After each run, the assembly is to be left in still air until it has cooled to less than 150°C, but not below 15°C, the temperature being taken at the centre of weld on the surface of seam.
3. After being welded, the test assemblies are not to be subjected to any heat treatment.
 4. The welded assemblies are to be subjected to radiographic examination prior to taking specimen from the assembly.

Fig. 6.16 Deposited Metal Test Assembly (Unit: mm)

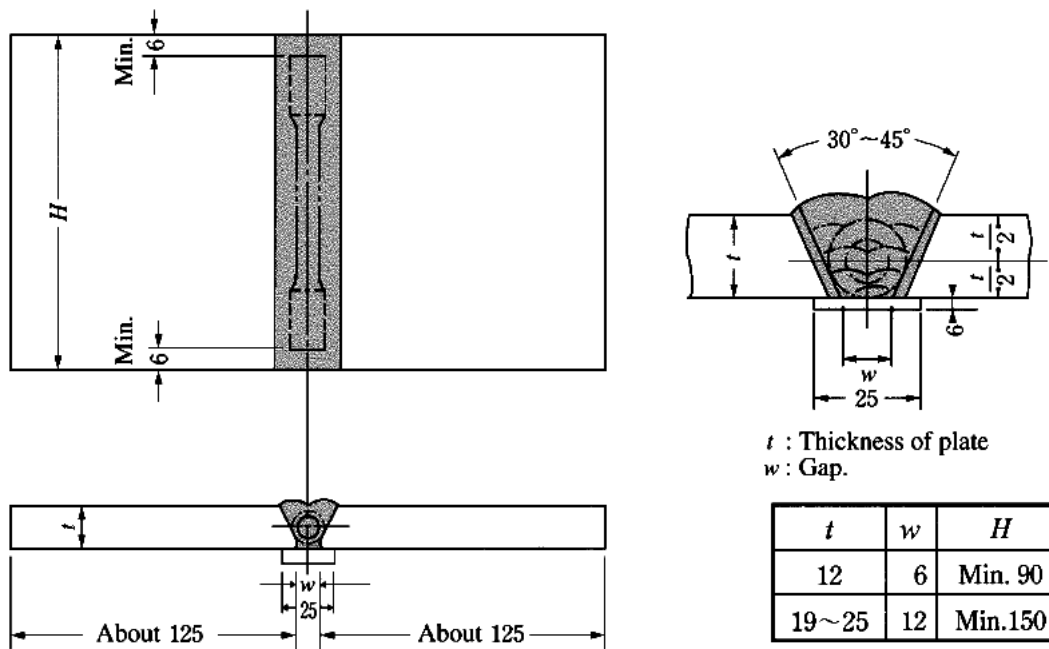
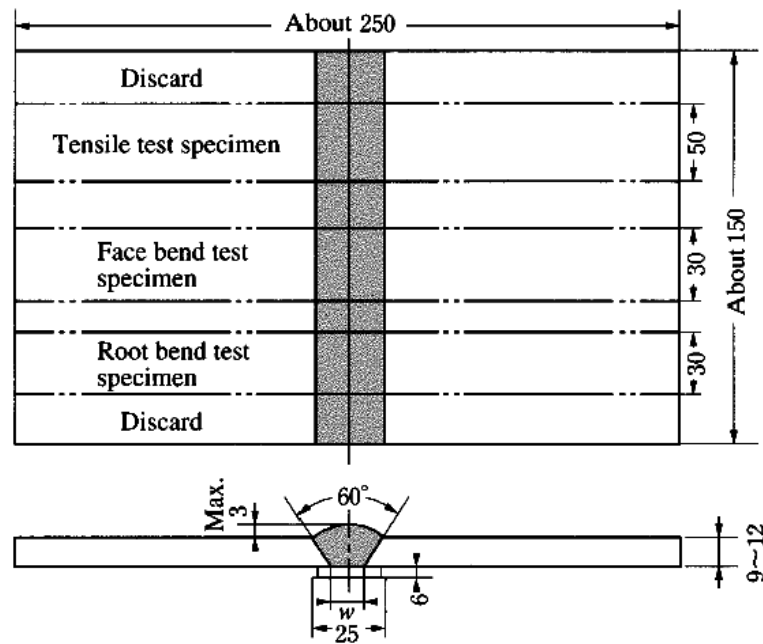
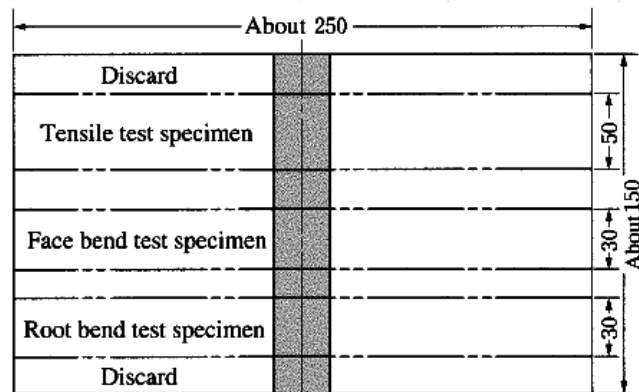


Fig. 6.17 Butt Weld Test Assembly for Electrode for Manual Arc Welding, Consumables *MIG* and *TIG* Welding Consumables and Flux Wire for Semi-automatic Welding (Unit: *mm*)

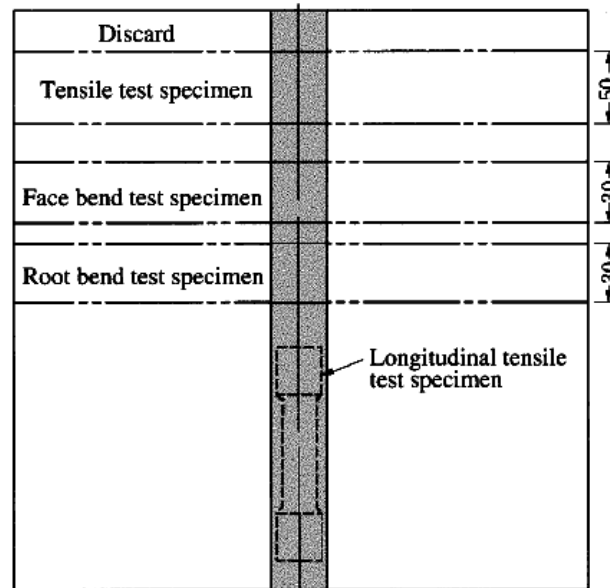


Kind of welding consumables	Electrode for manual arc welding	Consumables <i>TIG</i> welding	Consumables <i>MIG</i> welding	Flux wire semi-automatic welding
Gap <i>w</i> (<i>mm</i>)	Max. dia. of electrode	Max.5	Max.5	Max.6

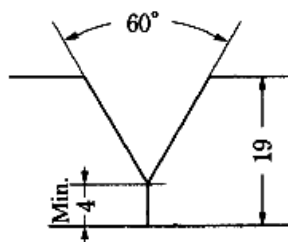
Fig. 6.18 Butt Weld Test Assembly for Submerged Arc Welding (Unit: mm)



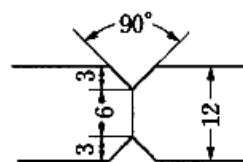
(a) Multi-run Technique



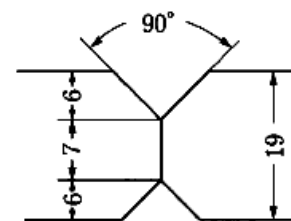
(b) Two-run Technique



(a) Edge Preparation for Multi-run Technique



(b) Edge Preparation for Two-run Technique, Thickness = 12 mm



(c) Edge Preparation for Two-run Technique, Thickness = 19 mm

6.7.6 Chemical Composition

1. Electrodes for manual arc welding and welding consumables for fluxed wire semi-automatic welding and for submerged arc welding are to have the chemical composition deposited metal analysis value complied with the requirements as given in [Table 6.44](#), [Table 6.46](#) and [Table 6.47](#).
2. *TIG* welding consumables and *MIG* welding consumables are to have chemical composition of ladle analysis value complied with the requirements as given in [Table 6.45](#).

6.7.7 Deposited Metal Tensile Test

1. The tensile test specimen are to be 1B or 1C specimen shown in [Table 3.1](#), and test specimen is to be taken from each test assembly. Further, where approved by the Society, one *U1A* tensile test specimen may be taken, care being taken that the longitudinal axis coincide with the centre of weld and the thickness. ([Fig. 6.16](#))
2. The tensile test specimens may be heated at below 250°C for 16 *hours* or less before conducting the tests for removing hydrogen.
3. The tensile strength, yield point and elongation of the test specimens are to be complied with the requirements of [Table 6.48](#), according to the grades of welding material. However, the specified value of the minimum proof stress may be altered to other values subject to the approval of the Society.

Table 6.44 Chemical Composition of Deposited Metal for Electrodes

Grade	Chemical composition of deposited metal (%)								
	<i>C</i>	<i>Si</i>	<i>Mn</i>	<i>P</i>	<i>S</i>	<i>Ni</i>	<i>Cr</i>	<i>Mo</i>	Others
<i>KD308</i>	0.08 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	—	—
<i>KD308L</i>	0.04 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	9.0~12.0	18.0~21.0	—	—
<i>KD308N2</i>	0.10 max	0.90 max.	1.00~4.00	0.04 max.	0.03 max.	7.0~11.0	20.0~25.0	—	<i>N</i> 0.12~0.30
<i>KD309</i>	0.15 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	—	—
<i>KD309L</i>	0.04 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	12.0~16.0	22.5~25.0	—	—
<i>KD309Mo</i>	0.12 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	2.0~3.0	—
<i>KD309MoL</i>	0.04 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	2.0~3.0	—
<i>KD310</i>	0.20 max	0.75 max.	2.50 max.	0.03 max.	0.03 max.	20.0~22.0	25.0~28.0	—	—
<i>KD310Mo</i>	0.12 max	0.75 max.	2.50 max.	0.03 max.	0.03 max.	20.0~22.0	25.0~28.0	2.0~3.0	—
<i>KD316</i>	0.08 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	11.0~14.0	17.0~20.0	2.0~2.75	—
<i>KD316L</i>	0.04 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	11.0~16.0	17.0~20.0	2.0~2.75	—
<i>KD317</i>	0.08 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	12.0~14.0	18.0~21.0	3.0~4.0	—
<i>KD317L</i>	0.04 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	12.0~16.0	18.0~21.0	3.0~4.0	—
<i>KD329J1</i>	0.08 max	0.90 max.	1.50 max.	0.04 max.	0.03 max.	6.0~8.0	23.0~28.0	1.0~3.0	—
<i>KD329J4L</i>	0.04 max	1.00 max.	0.5~2.5	0.04 max.	0.03 max.	8.0~11.0	23.0~27.0	3.0~4.5	<i>Cu</i> : 1.0 max. <i>N</i> : 0.08~0.30 <i>W</i> : 2.5 max.
<i>KD2209</i>	0.04 max	1.00 max.	0.5~2.0	0.04 max.	0.03 max.	7.5~10.5	21.5~23.5	2.5~3.5	<i>Cu</i> : 0.75 max. <i>N</i> : 0.08~0.20.
<i>KD347</i>	0.08 max	0.90 max.	2.50 max.	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	—	<i>Nb8X</i> <i>C</i> (%)~1.0

Table 6.45 Chemical Composition of Deposited Metal for TIG Electrodes or MIG Wires

Grade	Chemical composition of deposited metal (%)								
	<i>C</i>	<i>Si</i>	<i>Mn</i>	<i>P</i>	<i>S</i>	<i>Ni</i>	<i>Cr</i>	<i>Mo</i>	Others
KY308	0.08 max	0.65 max. (1)	1.0~2.5	0.03 max.	0.03 max.	9.0~11.0	19.5~22.0	—	—
KY308L	0.03 max	0.65 max. (1)	1.0~2.5	0.03 max.	0.03 max.	9.0~11.0	19.5~22.0	—	—
KY308N2	0.10 max	0.90 max.	1.0~4.0	0.03 max.	0.03 max.	7.0~11.0	20.0~25.0	—	N 0.12 ~0.30
KY309	0.12 max	0.65 max. (1)	1.0~2.5	0.03 max.	0.03 max.	12.0~14.0	23.0~25.0	—	—
KY309L	0.03 max	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	12.0~14.0	23.0~25.0	—	—
KY309Mo	0.12 max	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	12.0~14.0	23.0~25.0	2.0~3.0	—
KY310	0.15 max	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	20.0~22.5	25.0~28.0	—	—
KY310S	0.08 max	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	20.0~22.5	25.0~28.0	—	—
KY316	0.08 max	0.65 max. (1)	1.0~2.5	0.03 max.	0.03 max.	11.0~14.0	18.0~20.0	2.0~3.0	—
KY316L	0.03 max	0.65 max. (1)	1.0~2.5	0.03 max.	0.03 max.	11.0~14.0	18.0~20.0	2.0~3.0	—
KY317	0.08 max	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	13.0~15.0	18.0~20.5	3.0~4.0	—
KY317L	0.03 max	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	13.0~15.0	18.0~20.5	3.0~4.0	—
KY321	0.08 max	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	9.0~10.5	18.0~20.5	—	Ti9 X C(%)~1.0
KY329J4L	0.03 max	0.90 max.	0.5~2.5	0.03 max.	0.03 max.	8.0~11.0	23.0~27.0	3.0~4.5	Cu: 1.0 max. N: 0.08~0.30
KY2209	0.03 max	0.90 max.	0.5~2.0	0.03 max.	0.03 max.	7.5~9.5	21.5~23.5	2.5~3.5	Cu:0.75 max. N: 0.08~0.20
KY347	0.08 max	0.65 max. (1)	1.0~2.5	0.03 max.	0.03 max.	9.0~11.0	19.0~21.5	—	Nb10X C(%)~1.0

Note

- 1 Where approved by the Society, the value of *Si* may be taken greater than 0.65% but not greater than 1.00%.

Table 6.46 (a,b) Chemical Composition of Deposited Metal for Semi-automatic Welding

a) With Gas

Grade	Chemical composition of deposited metal (%)								
	<i>C</i>	<i>Si</i>	<i>Mn</i>	<i>P</i>	<i>S</i>	<i>Ni</i>	<i>Cr</i>	<i>Mo</i>	Others
<i>KW308</i>	0.08 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	—	—
<i>KW308L</i>	0.04 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~12.0	18.0~21.0	—	—
<i>KW308N2</i>	0.10 max	1.0 max.	1.0~4.0	0.04 max.	0.03 max.	7.0~11.0	20.0~25.0	—	<i>N</i> 0.12~0.30
<i>KW309</i>	0.10 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	—	—
<i>KW309L</i>	0.04 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	—	—
<i>KW309Mo</i>	0.12 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	2.0~3.0	—
<i>KW309MoL</i>	0.04 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	2.0~3.0	—
<i>KW310</i>	0.20 max	1.0 max.	0.5~2.5	0.03 max.	0.03 max.	20.0~22.0	25.0~28.0	—	—
<i>KW316</i>	0.08 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	11.0~14.0	17.0~20.0	2.0~3.0	—
<i>KW316L</i>	0.04 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	11.0~14.0	17.0~20.0	2.0~3.0	—
<i>KW317</i>	0.08 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	18.0~21.0	3.0~4.0	—
<i>KW317L</i>	0.04 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~16.0	18.0~21.0	3.0~4.0	—
<i>KW329J4L</i>	0.04 max	1.0 max.	0.5~2.0	0.04 max.	0.03 max.	8.0~11.0	23.0~27.0	2.5~4.0	<i>Cu</i> : 1.0 max. <i>N</i> : 0.08~0.30
<i>KW2209</i>	0.04 max	1.0 max.	0.5~2.0	0.04 max.	0.03 max.	7.5~10.0	21.0~24.0	2.5~4.0	<i>Cu</i> : 0.5 max. <i>N</i> : 0.08~0.20
<i>KW347</i>	0.08 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	—	<i>Nb8X</i> <i>C</i> (%)~1.0

b) Without Gas

Grade	Chemical composition of deposited metal (%)								
	<i>C</i>	<i>Si</i>	<i>Mn</i>	<i>P</i>	<i>S</i>	<i>Ni</i>	<i>Cr</i>	<i>Mo</i>	Others
<i>KW308</i>	0.08 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~11.0	19.5~22.0	–	–
<i>KW308L</i>	0.04 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~12.0	19.5~22.0	–	–
<i>KW308N2</i>	0.10 max	1.0 max.	1.0~4.0	0.04 max.	0.03 max.	7.0~11.0	20.0~25.0	–	<i>N</i> 0.12~0.30
<i>KW309</i>	0.10 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	23.0~25.5	–	–
<i>KW309L</i>	0.04 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	23.0~25.5	–	–
<i>KW309Mo</i>	0.12 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	2.0~3.0	–
<i>KW309MoL</i>	0.04 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	2.0~3.0	–
<i>KW310</i>	0.20 max	1.0 max.	0.5~2.5	0.03 max.	0.03 max.	20.0~22.0	25.0~28.0	–	–
<i>KW316</i>	0.08 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	11.0~14.0	18.0~20.5	2.0~3.0	–
<i>KW316L</i>	0.04 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	11.0~14.0	18.0~20.5	2.0~3.0	–
<i>KW317</i>	0.08 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	13.0~15.0	18.5~21.0	3.0~4.0	–
<i>KW317L</i>	0.04 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	13.0~15.0	18.5~21.0	3.0~4.0	–
<i>KW2209</i>	0.04 max	1.0 max.	0.5~2.0	0.04 max.	0.03 max.	7.5~10.0	21.0~24.0	2.5~4.0	<i>Cu</i> : 0.5 max. <i>N</i> : 0.08~0.20
<i>KW347</i>	0.08 max	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~11.0	19.0~21.5	–	<i>Nb8X</i> <i>C</i> (%)~1.0

Table 6.47 Chemical Composition of Deposited Metal for Submerged Arc Welding

Grade	Chemical composition of deposited metal (%)								
	<i>C</i>	<i>Si</i>	<i>Mn</i>	<i>P</i>	<i>S</i>	<i>Ni</i>	<i>Cr</i>	<i>Mo</i>	Others
<i>KU308</i>	0.08 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	–	–
<i>KU308L</i>	0.04 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	9.0~12.0	18.0~21.0	–	–
<i>KU309</i>	0.15 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	–	–
<i>KU309L</i>	0.04 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	12.0~14.0	22.5~25.0	–	–
<i>KU309Mo</i>	0.12 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	2.0~3.0	–
<i>KU310</i>	0.20 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	20.0~22.0	25.0~28.0	–	–
<i>KU316</i>	0.08 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	11.0~14.0	17.0~20.0	2.0~2.75	–
<i>KU316L</i>	0.04 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	11.0~16.0	17.0~20.0	2.0~2.75	–
<i>KU317</i>	0.08 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	12.0~14.0	18.0~21.0	3.0~4.0	–
<i>KU317L</i>	0.04 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	12.0~16.0	18.0~21.0	3.0~4.0	–
<i>KU347</i>	0.08 max	1.0 max.	2.5 max.	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	–	<i>Nb 8X</i> <i>C</i> (%)~1.0

Table 6.48 Tensile Test Requirements for Deposited Metal

Electrode manual welding	for arc	TIG and MIG welding consumable	Flux wire semi-automatic welding	Submerged arc welding consumable	Tensile strength (N/mm ²)	0.2% proof stress (N/mm ²)	Elongation (%)
KD308		KY308	KW308	KU308	550 min.	225 min.	35 min.
KD308L		KY308L	KW308L	KU308L	510 min.	205 min.	35 min.
KD308N2		KY308N2	KW308N2	—	690 min.	375 min.	25 min.
KD309		KY309	KW309	KU309	550 min.	225 min.	30 min.
KD309L		KY309L	KW309L	KU309L	510 min.	205 min.	30 min.
KD309Mo		KY309Mo	KW309Mo	KU309Mo	550 min.	225 min.	30 min.
KD309MoL		—	KW309MoL	—	510 min.	205 min.	30 ⁽¹⁾ min.
KD310		KY310	KW310	KU310	550 min.	225 min.	30 min.
—		KY310S	—	—	550 min.	225 min.	30 min.
KD310Mo		—	—	—	550 min.	225 min.	30 min.
KD316		KY316	KW316	KU316	550 min.	225 min.	30 min.
KD316L		KY316L	KW316L	KU316L	510 min.	205 min.	35 min.
KD317		KY317	KW317	KU317	550 min.	225 min.	30 min.
KD317L		KY317L	KW317L	KU317L	510 min.	205 min.	30 min.
—		KY321	—	—	550 min.	225 min.	30 min.
KD329J1		—	—	—	590 min.	390 min.	15 min.
KD329J4L		KY329J4L	KW329J4L	—	690 min.	450 min.	15 min.
KD2209		KY2209	KW2209	—	690 min.	450 min.	15 min.
KD347		KY347	KW347	KU347	550 min.	225 min.	30 min.

Note:

- 1 Elongation of KW309MoL is not be less than 20(%).

6.7.8 Butt Weld Tensile Test

1. The tensile test specimens are to be U2A or U2B specimen shown in [Table 3.1](#), and test specimen is to be taken from each test assembly.
2. The tensile strength of each test specimen is to comply with the requirements given in [Table 6.49](#).
3. Submerged arc welding consumables used only in the two-run technique are to be selected as U1A tensile test specimens of [Table 3.1](#), such that the longitudinal centre line of the test specimen from centre of thickness coincide with the weld centre line of the test assemblies and centre of thickness.
4. The longitudinal tensile test specimens specified in the preceding -3 may be heated at below 250°C for 16 hours or less before conducting the tests for removing hydrogen.
5. The requirements for tensile tests specified in the preceding -3 and -4 are to be given in [Table 6.48](#). However, the specified value of the minimum proof stress may be altered to other value subject to the approval of the Society.

6.7.9 Bend Test of Butt Welds

1. The face bend and root bend test specimens are to be *UB-6* specimen shown in [Table 3.1](#), and test specimens are to be taken from each assembly. ([Fig. 6.17](#) and [Fig. 6.18](#))
2. The test specimens are to be capable of withstanding without crack exceeding 3mm long on the outer surface of the specimen or other defects, being bent through an angle 120 degrees over a former having a radius of 1.5 times the thickness of test specimen.
3. For the test specified in the preceding -1 and -2, longitudinal bend test deemed appropriate by the Society may be accepted.

6.7.10 Annual Inspections

1. In the annual inspections, tests specified in the following -2, and -3, are conducted for each approved brand, and the welding consumables are to be passed these tests satisfactorily.
2. The kinds of tests etc. involved in the annual inspections are to be as given in [Table 6.50](#).
3. The welding procedure and requirements of test assemblies specified in [6.7.5](#) through [6.7.9](#).

Table 6.49 Tensile Test Requirements for Butt Weld

Electrode for manual arc welding	TIG and MIG welding consumable	Flux wire semi-automatic welding	Submerged arc welding consumable	Tensile strength (N/mm ²)
KD308	KY308	KW308	KU308	520 min. ⁽¹⁾
KD308L	KY308L	KW308L	KU308L	520 min. ⁽¹⁾
KD308N2	KY308N2	KW308N2	—	690 min.
KD309	KY309	KW309	KU309	520 min.
KD309L	KY309L	KW309L	KU309L	520 min.
KD309Mo	KY309Mo	KW309Mo	KU309Mo	520 min.
KD309MoL	—	KW309MoL	—	520 min.
KD310	KY310	KW310	KU310	520 min.
—	KY310S	—	—	520 min.
KD310Mo	—	—	—	520 min.
KD316	KY316	KW316	KU316	520 min. ⁽¹⁾
KD316L	KY316L	KW316L	KU316L	520 min. ⁽¹⁾
KD317	KY317	KW317	KU317	520 min. ⁽¹⁾
KD317L	KY317L	KW317L	KU317L	520 min. ⁽¹⁾
—	KY321	—	—	520 min.
KD329J1	—	—	—	590 min.
KD329J4L	KY329J4L	KW329J4L	—	620 min.
KD2209	KY2209	KW2209	—	620 min.
KD347	KY347	KW347	KU347	520 min.

Note:

1 Where the test assembly is made of *KSU304L*, *KSU316L* and *KSU317L*, the tensile strength is not to be less than $480N/mm^2$.

Table 6.50 Kinds of Test at Annual Inspections

Kind of welding consumables		Kind of test	Test assembly					Kind and no. of test specimens taken from test assembly
			Welding position	Dia. of electrode or wire (mm)	Number	Dimensions	Thickness (mm)	
Electrode for manual arc welding		Deposited metal test	Flat	3.2 ~ 4.0	1	Fig. 6.16	12 ~ 19	Tensile test specimen: 1
<i>TIG</i> welding Consumable		Deposited metal test	Flat	2.4 ~ 3.2	1	Fig. 6.16	12 ~ 19	Tensile test specimen: 1
<i>MIG</i> welding Consumable		Deposited metal test	Flat	1.2 ~ 1.6	1	Fig. 6.16	12 ~ 19	Tensile test specimen: 1
Flux wire for semi-automatic welding		Deposited metal test	Flat	1.2 ~ 3.2	1	Fig. 6.16	12 ~ 19	Tensile test specimen: 1
Consumable for sub-merged arc welding	Multi-run technique	Deposited metal test	Flat	1.2 ~ 4.0	1	Fig. 6.16	19 ~ 25	Tensile test specimen: 1
	Two-run technique	Butt weld test	Flat	2.4 ~ 4.0	1	Fig. 6.18 (b)	12 ~ 19	Tensile test specimen: 1 Longitudinal tensile test specimen : 1 Face bend specimen: 1 Root bend specimen: 1
	Multi-run and Two-run technique	Deposited metal test	Flat	1.2 ~ 4.0	1	Fig. 6.16	19 ~ 25	Tensile test specimen: 1
		Butt weld test	Flat	2.4 ~ 4.0	1	Fig. 6.18 (b)	12 ~ 19	Tensile test specimen: 1 Fracture bend specimen : 1 Root bend specimen: 1

6.8 Welding Consumables for Aluminium Alloys

6.8.1 Application

Welding consumables used for aluminium alloys mentioned in the following (1) and (2) (hereinafter referred to as “welding consumables” in [6.8](#)) are to be subjected to the approval tests and annual inspections in accordance with the requirements of this paragraph.

- (1) Rod-gas combinations for tungsten inert gas arc welding (*TIG* welding) or plasma arc welding
- (2) Wire electrode and wire gas combinations for metal-arc inert gas welding (*MIG* welding), tungsten inert gas arc welding or plasma arc welding

6.8.2 Grades and Marks of Welding Consumables

1. Grades and marks of welding consumables are classified as given in [Table 6.51](#).
2. Welding consumables using a specific shielding gas are to be suffixed with “G” at the end of the mark. Kinds of the shielding gases are classified as shown in [Table 6.52](#) and the kind is to be suffixed following to the mark *G*. (e.g. *KA15RBG(I-3)*)

Table 6.51 Grades and Marks

Kind of Welding consumables	Grade and Mark
Electrode	<i>KA15RA, KA15RB, KA15RC, KA16RD,</i>
Wire	<i>KA15WA, KA15WB, KA15WC, KA16WD,</i>

Table 6.52 Kind of Gas

Group	Kind	Gas composition (%)	
		<i>He</i>	<i>Ar</i>
<i>I</i>	<i>I-1</i>	—	100
	<i>I-2</i>	100	—
	<i>I-3</i>	1 ~ 33	Rest
	<i>I-4</i>	34 ~ 66	Rest
	<i>I-5</i>	67 ~ 95	Rest
<i>E</i>	<i>E-1</i>	Others	

6.8.3 Approval Test

1. For the approval of welding consumables, the tests specified in [6.8.4-1](#) are to be successfully conducted for each brand of welding consumables.

2. For welding consumables using a shielding gas, the tests specified in -1 are to be conducted for each kind of gas designated among [Table 6.52](#) by the manufacturer. However, where the manufacturer designates several kinds of gas which are classified into the group *I* in [Table 6.52](#) and the tests specified in -1 are to be conducted for any one kind of gas, the tests for the other kind of gas may be dispensed with subject to the approval of the Society.

3. When the manufacturer designated the gas classified into the group *E* in the tests specified in -2, the composition of the shielding gas is to be reported to the Society.

6.8.4 General Provisions of Tests

1. Kinds of test, welding position, number, thickness and dimensions of test assemblies, kind and number of test specimen taken from each test assembly for welding consumables are to be given in [Table 6.53](#).

2. The aluminium alloys used in preparation for test assembly corresponding to welding consumables are to as given in [Table 6.54](#).

Table 6.53 Kinds of Test for Welding Consumables

Kind of test	Test assembly				Kind and no. of test specimens taken from test assembly
	Welding position	Number	Dimensions	Thickness (mm)	
Deposited metal test (Chemical composition test)	Flat	1	Fig. 6.19	—	—
Butt weld test	Flat	1	Fig. 6.20	10 ~ 12	Tensile test specimen: 2 Face bend test specimen: 2 Root bend test specimen: 2 Macro-etching test specimen : 1
	Horizontal ⁽¹⁾	1			
	Vertical upward	1			
	Overhead	1			
	Flat	1	Fig. 6.20	20 ~ 25	Tensile test specimen: 2 Face bend test specimen: 2 Root bend test specimen: 2 Macro-etching test specimen : 1

Note:

1 Welding consumables satisfying the requirements for flat and vertical upward positions may be dispensed with the tests for horizontal position subject to the approval of the Society.

Table 6.54 Grade of Aluminium Alloys used for Test Assembly

Grade of welding consumable	Grade of aluminium alloys used for test assembly ⁽¹⁾	
<i>KA15RA, KA15WA</i>	5000 series	<i>5754P-O</i>
<i>KA15RB, KA15WB</i>		<i>5086P-O</i>
<i>KA15RC, KA15WC</i>		<i>5083P-O</i>
		<i>5383P-O</i>
		<i>5456P-O</i>
	<i>5059P-O</i>	
<i>KA16RD, KA16WD</i>	6000 series ⁽²⁾	<i>6005AS</i> <i>6061S</i> <i>6082S</i>

Notes:

- 1 Material symbols of aluminium alloys include the symbols of which is the temper condition.
- 2 Other rolled aluminium alloys of 6000 series with tensile strength 260N/mm^2 may be used.

6.8.5 Welding Sequence of Test Assemblies

1. Deposited weld metal test assembly ([Fig. 6.19](#))

- (1) The test assemblies are to be welded in flat position in accordance with the welding process designated by the manufacturer.
- (2) The size of test assembly corresponding to the welding consumables and welding process is to be of being taken a sufficient amount of pure weld metal for chemical analysis.

2. Butt weld test assemblies ([Fig. 6.20](#) and [Fig. 6.21](#))

- (1) The test assemblies are to be welded in each welding position designated by the manufacturer (downhand, horizontal, vertical-upward and overhead). The test assembly as shown by [Fig. 6.21](#) is to be welded in the downhand position.
- (2) On completion of each run, the test assemblies are to be allowed to cool naturally in air until the temperature measured at the surface of the centre of the welding joint is ambient temperature. However, the test assemblies for *KAl6RD* and *KAl6WD* are to be allowed to naturally ageing for a minimum period of 72 hours from the completion of welding before testing is carried out.

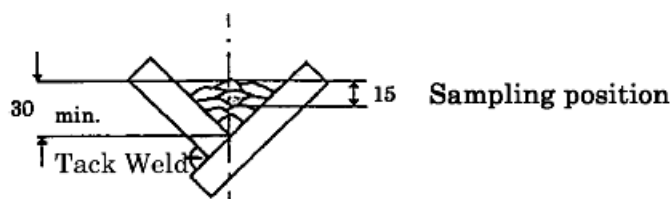
3. The test assemblies are not to be subjected to any heat treatment.

- The welded assemblies may be subjected to a radiographic examination prior to taking test specimens from the test assemblies.

6.8.6 Chemical Composition

The chemical composition of the welding consumables is to be determined by the analysis of the deposited weld metal specified in [Fig. 6.19](#) and the results of the analysis are to comply with the limit value specified by the manufacturer.

Fig. 6.19 Deposited weld metal test assembly (unit: mm)



6.8.7 Butt Weld Tensile Test

- The tensile test specimens are to be *U2A* or *U2B* specimen shown in [Fig. 3.1](#) and two test specimens are to be taken from each assembly.
- The tensile strength corresponding to the grade of welding consumables is to comply with the requirements as given in [Table 6.55](#).

Table 6.55 Tensile Test Requirements

Grade of welding consumable	Tensile strength (N/mm^2)
<i>KA15RA, KA15WA</i>	190min
<i>KA15RB, KA15WB</i>	240min
<i>KA15RC, KA15WC</i>	275min ⁽¹⁾
	290min ⁽²⁾
	330min ⁽³⁾
<i>KA16RD, KA16WD</i>	170min

Note:

- For test specimens of grade 5083P-O
- For test specimens of grade 5383P-O or 5456P-O
- For test specimens of grade 5059P-O

6.8.8 Butt Weld Bend Test

1. The face bend and root bend test specimens are to be *UB-6* specimen shown in [Table 3.2](#) and two test specimens are to be taken from each assembly.
2. The test specimens are to sustain the face and root bend tests over 180 *degrees* using a former having a diameter in accordance with [Table 6.56](#), without cracks exceeding 3mm in length and other any defects on the outer surface.

Table 6.56 Former Diameter of Bend Test

Grade of welding consumable	Former diameter (mm) ⁽¹⁾
<i>KA15RA, KA15WA</i>	$3t$
<i>KA15RB, KA15WB</i>	$6t$
<i>KA15RC, KA15WC</i>	
<i>KA16RD, KA16WD</i>	

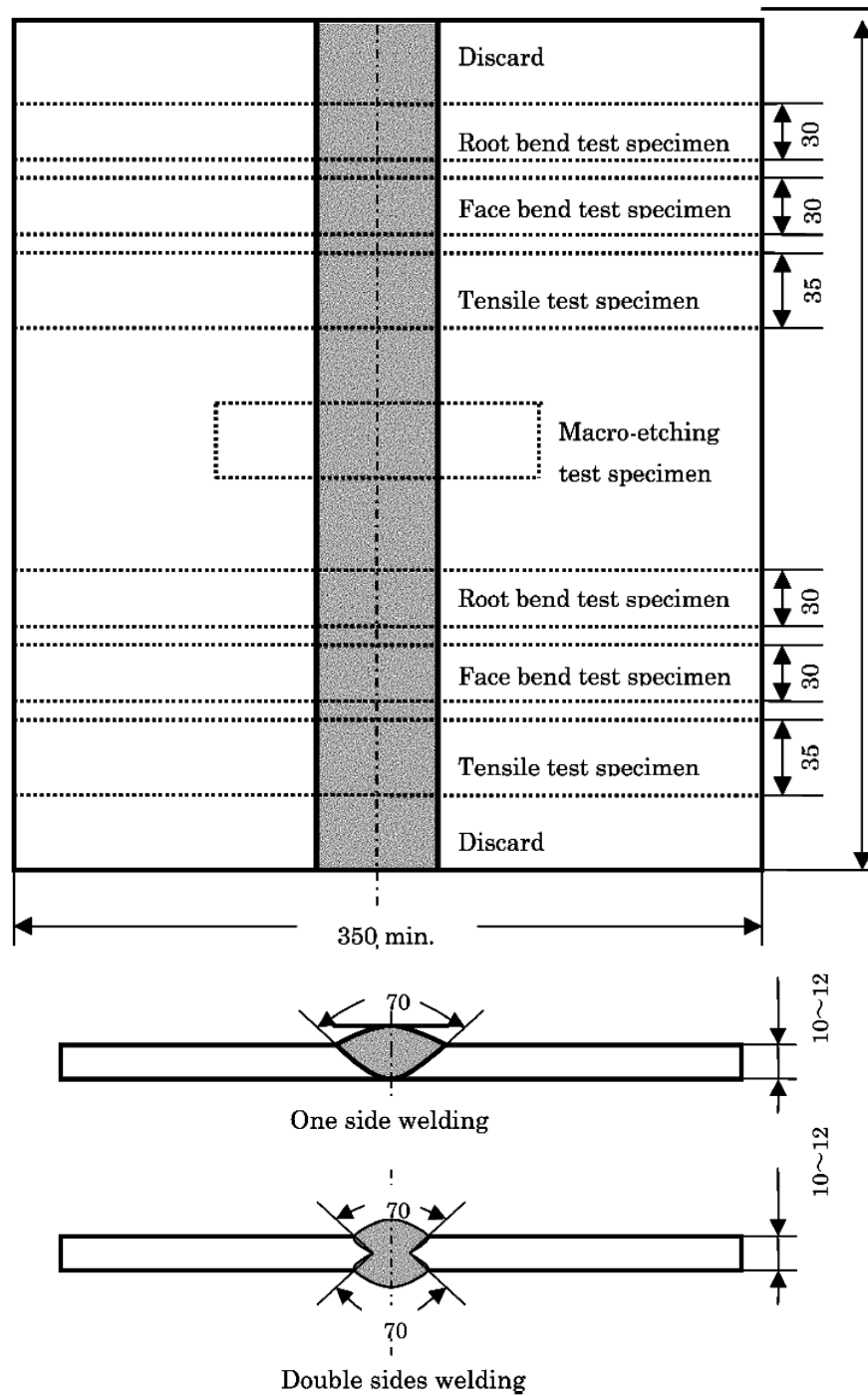
Note:

- 1 t : Thickness of the test specimen (mm)

6.8.9 Butt Weld Macro-etching Test

1. One macro-etching test specimen as shown in [Fig. 6.20](#) and [Fig. 6.21](#) is to be taken from the butt weld test assembly. The surface to be tested is to be normal to the surface of the test assembly.
2. The welding joint of macro etching test specimen is to be examined that there are not any imperfections such as lack of fusion, cavities, inclusions, pores or cracks.

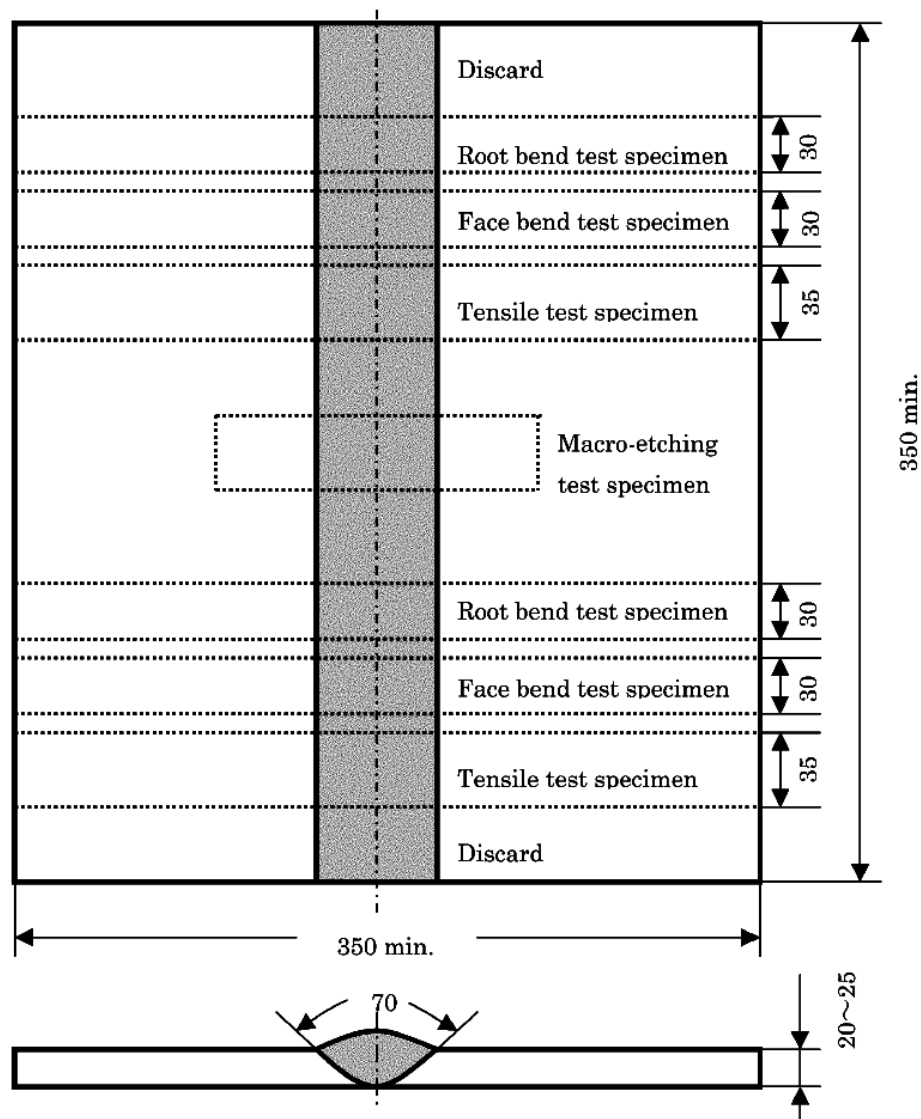
Fig. 6.20 Butt Weld Test Assembly with a thickness of 10 to 12mm (Unit: mm)



Notes:

- 1 Back sealing runs are allowed in single V weld assemblies.
- 2 In case of double V assembly both sides are to be welded in the same welding position.

Fig. 6.21 Butt Weld Test Assembly with a thickness of 20 to 25mm (Unit: mm)



Note:

- 1 Back sealing runs are allowed.

6.8.10 Annual Inspections

1. In the annual inspections, every approved welding consumables are to be subjected to the tests provided in -2 and are to be successfully examined.
2. Kinds of tests in the annual inspections are to be as given in [Table 6.57](#).
3. The welding procedure and requirements for test assemblies specified in -2 are to be in accordance with the requirements in [6.8.5](#) to [6.8.9](#).

6.9 Welding Consumables for Quenched and Tempered High Tensile Steels for Structures

6.9.1 Application

Welding consumables for quenched and tempered high tensile steels for structures, which are given in following (1) through (3) (hereinafter referred to as “welding consumables” in [6.9](#)) the approval test and annual inspections are to be in accordance with the requirements specified in [6.9](#).

- (1) Electrodes for manual arc welding (specified in [6.2.1\(1\)](#) and [\(2\)](#))
- (2) Automatic welding consumables (specified in [6.3.1-1\(1\),\(2\)](#) and [\(3\)](#). However, in this case, used only for multi-run technique in principle.)
- (3) Semi-automatic welding consumables

Table 6.57 Kinds of Tests in Annual Inspections

Kind of test	Test assembly				Kind and no. of test specimens taken from test assembly
	Welding position	Number	Dimensions	Thickness (mm)	
Deposited metal test (Chemical composition Analysis)	Flat	1	Fig. 6.19	—	—
Butt weld test	Flat	1	Fig. 6.20	10 ~ 12	Tensile test specimen: 2 Face bend test specimen: 2 Root bend test specimen: 2 Macro-etching test specimen : 1

6.9.2 Grades and Marks of Welding Consumables

1. Grades and marks of welding consumables are classified as give in [Table 6.58](#).
2. Where the welding consumables have passed the test specified in [6.9.3](#), the suffixes are to be added to the grade marks with same methods as specified in [6.2.2-2](#), [6.3.2-2](#) and -3 or [6.4.2-2](#), according to grade of welding consumables.
3. For low hydrogen electrodes which have passed the hydrogen test specified in [6.9.11](#) the suffixes given in [Table 6.63](#) are to be added to the grade marks (after the suffixes in the case of the preceding -2) of the said electrodes. (Example: *KMW3Y46H5*)

Table 6.58 Kinds and Grades

Electrode for manual arc welding	Welding consumables for Semi-automatic welding	Welding consumables for automatic welding
<i>KMW2Y42</i>	<i>KSW2Y42</i>	<i>KAW2Y42</i>
<i>KMW2Y46</i>	<i>KSW2Y46</i>	<i>KAW2Y46</i>
<i>KMW2Y50</i>	<i>KSW2Y50</i>	<i>KAW2Y50</i>
<i>KMW2Y55</i>	<i>KSW2Y55</i>	<i>KAW2Y55</i>
<i>KMW2Y62</i>	<i>KSW2Y62</i>	<i>KAW2Y62</i>
<i>KMW2Y69</i>	<i>KSW2Y69</i>	<i>KAW2Y69</i>
<i>KMW3Y42</i>	<i>KSW3Y42</i>	<i>KAW3Y42</i>
<i>KMW3Y46</i>	<i>KSW3Y46</i>	<i>KAW3Y46</i>
<i>KMW3Y50</i>	<i>KSW3Y50</i>	<i>KAW3Y50</i>
<i>KMW3Y55</i>	<i>KSW3Y55</i>	<i>KAW3Y55</i>
<i>KMW3Y62</i>	<i>KSW3Y62</i>	<i>KAW3Y62</i>
<i>KMW3Y69</i>	<i>KSW3Y69</i>	<i>KAW3Y69</i>
<i>KMW4Y42</i>	<i>KSW4Y42</i>	<i>KAW4Y42</i>
<i>KMW4Y46</i>	<i>KSW4Y46</i>	<i>KAW4Y46</i>
<i>KMW4Y50</i>	<i>KSW4Y50</i>	<i>KAW4Y50</i>
<i>KMW4Y55</i>	<i>KSW4Y55</i>	<i>KAW4Y55</i>
<i>KMW4Y62</i>	<i>KSW4Y62</i>	<i>KAW4Y62</i>
<i>KMW4Y69</i>	<i>KSW4Y69</i>	<i>KAW4Y69</i>
<i>KMW5Y42</i>	<i>KSW5Y42</i>	<i>KAW5Y42</i>
<i>KMW5Y46</i>	<i>KSW5Y46</i>	<i>KAW5Y46</i>
<i>KMW5Y50</i>	<i>KSW5Y50</i>	<i>KAW5Y50</i>
<i>KMW5Y55</i>	<i>KSW5Y55</i>	<i>KAW5Y55</i>
<i>KMW5Y62</i>	<i>KSW5Y62</i>	<i>KAW5Y62</i>
<i>KMW5Y69</i>	<i>KSW5Y69</i>	<i>KAW5Y69</i>

6.9.3 Approval Test

For the approval of welding consumables, the tests specified in [6.2.3](#), [6.3.3](#) or [6.4.3](#) are to be conducted for each brand of welding consumables.

6.9.4 General Provisions for Tests

1. Kinds of test, number, thickness, and dimensions of test assemblies, diameters of electrodes or wires used for welding and welding positions, together with kinds and number of test specimens taken from each test assembly for welding consumables are to be in accordance with the requirements specified given in [6.2.4](#), [6.3.4](#) or [6.4.4](#). However, [Note \(4\)](#) of [Table 6.2](#) and [Note \(3\)](#) of [Table 6.22](#) are not to be required. Provisions for automatic welding consumables are to be the requirements specified multi-run technique.
2. The grades of steels used for tests are to be those given in [Table 6.59](#) in corresponding to the grades of welding consumables, or those which considered equivalent by the Society.

Table 6.59 Grades of Steel for Test Assembly

Grade of welding consumables	Grade steel for test assembly ⁽¹⁾
KMW2Y42 ~ 69 KSW2Y42 ~ 69 KAW2Y42 ~ 69	KA420 ~ KA690
KMW3Y42 ~ 69 KSW3Y42 ~ 69 KAW3Y42 ~ 69	KA420 ~ KA690 or KD420 ~ KD690
KMW4Y42 ~ 69 KSW4Y42 ~ 69 KAW4Y42 ~ 69	KA420 ~ KA690, KD420 ~ KD690 or KE420 ~ KE690
KMW5Y42 ~ 69 KSW5Y42 ~ 69 KAW5Y42 ~ 69	KA420 ~ KA690, KD420 ~ KD690, KE420 ~ KE690 or KF420 ~ KF690

Note:

- 1 Notwithstanding the requirements in this table, mild or high tensile steels may be used for deposited metal test assembly. In this case, appropriate buttering is to be carried out.

6.9.5 Welding Sequence of Test Assemblies

Welding sequence of test assemblies are to be in accordance with the requirements specified in [6.2.5](#), [6.3.5](#) or [6.4.5](#) appropriate to the grade of the welding consumables.

6.9.6 Deposited Metal Tensile Test

1. Kinds, numbers and selection methods of the deposited metal tensile test specimens being taken from each test assembly are to comply with the requirements specified in [6.2.6-1](#), [6.3.6-1](#) or [6.4.6-1](#) according to the grade of the welding consumables.
2. The tensile strength, yield point (or proof stress) and elongation of each test specimen are to comply with the requirements specified in [Table 6.60](#) according to the grade of the welding consumables.

3. The provisions specified in the preceding [6.2.6-2](#) may be applied to the tensile test specimens.

6.9.7 Deposited Metal Impact Test

1. Kinds, numbers and selection methods of the deposited metal impact test specimens being taken from each test assembly are to comply with the requirements specified in [6.2.7-1](#), [6.3.7-1](#) or [6.4.7-1](#) according to the grade of the welding consumables.
2. The test temperature and minimum mean absorbed energy are to comply with the requirements specified given in [Table 6.60](#) according to the grade of the welding consumables.
3. The requirements specified in the preceding [6.2.7-2](#) and [-4](#) are to be applied to this test.

Table 6.60 Test Requirements for Deposited Metal

Grade of welding consumables	Tensile test				Impact test
	Tensile Strength (<i>N/mm</i> ²) ⁽¹⁾	Yield point or proof stress (<i>N/mm</i> ²)	Elongation (%)	Test temperature (°C)	Minimum mean absorbed energy (<i>J</i>)
<i>KMW2Y42, KSW2Y42, KAW2Y42</i>	530 ~ 680	420 min.	20 min.	0	47
<i>KMW3Y42, KSW3Y42, KAW3Y42</i>				-20	
<i>KMW4Y42, KSW4Y42, KAW4Y42</i>				-40	
<i>KMW5Y42, KSW5Y42, KAW5Y42</i>				-60	
<i>KMW2Y46, KSW2Y46, KAW2Y46</i>	570 ~ 720	460 min.		0	
<i>KMW3Y46, KSW3Y46, KAW3Y46</i>				-20	
<i>KMW4Y46, KSW4Y46, KAW4Y46</i>				-40	
<i>KMW5Y46, KSW5Y46, KAW5Y46</i>				-60	
<i>KMW2Y50, KSW2Y50, KAW2Y50</i>	610 ~ 770	500 min.	18 min.	0	50
<i>KMW3Y50, KSW3Y50, KAW3Y50</i>				-20	
<i>KMW4Y50, KSW4Y50, KAW4Y50</i>				-40	
<i>KMW5Y50, KSW5Y50, KAW5Y50</i>				-60	
<i>KMW2Y55, KSW2Y55, KAW2Y55</i>	670 ~ 830	550 min.		0	55
<i>KMW3Y55, KSW3Y55, KAW3Y55</i>				-20	
<i>KMW4Y55, KSW4Y55, KAW4Y55</i>				-40	
<i>KMW5Y55, KSW5Y55, KAW5Y55</i>				-60	
<i>KMW2Y62, KSW2Y62, KAW2Y62</i>	720 ~ 890	620 min.		0	62
<i>KMW3Y62, KSW3Y62, KAW3Y62</i>				-20	
<i>KMW4Y62, KSW4Y62, KAW4Y62</i>				-40	
<i>KMW5Y62, KSW5Y62, KAW5Y62</i>				-60	
<i>KMW2Y69, KSW2Y69, KAW2Y69</i>	770 ~ 940	690 min.	17 min.	0	69
<i>KMW3Y69, KSW3Y69, KAW3Y69</i>				-20	
<i>KMW4Y69, KSW4Y69, KAW4Y69</i>				-40	
<i>KMW5Y69, KSW5Y69, KAW5Y69</i>				-60	

Note:

- 1 Tensile strength specified in the table may be altered where deemed appropriate by the Society.

6.9.8 Butt Weld Tensile Test

1. Kinds and numbers of the butt weld tensile test specimens being taken from each test assembly are to comply with the requirements specified in [6.2.8-1](#), [6.3.8-1](#) or [6.4.8-1](#) according to the grade of the welding consumables.
2. The tensile strength of each test specimen is to meet the requirements given in [Table 6.61](#) according to the grade of the welding consumables.

6.9.9 Butt Weld Bend Test

1. Kinds and numbers of the butt weld face bend and root bend test specimens being taken from each test assembly are to comply with the requirements specified in [6.2.9-1](#), [6.3.9-1](#) or [6.4.9-1](#) according to the grade of the welding consumables.
2. The test specimens are to be subjected to face bend and root bend tests by using former having a radius given in [Table 6.62](#). Outer surface of the specimens is to be free from any cracks exceeding 3mm long or other defects when they are bent to the angle of 120 *degrees*.

6.9.10 Butt Weld Impact Test

1. Kinds, numbers and selection method of the butt weld impact test specimens being taken from each test assembly are to comply with the requirements specified in [6.2.10-1](#), [6.3.10-1](#) or [6.4.10-1](#) according to the grade of the welding consumables.
2. Testing temperature and minimum mean absorbed energy are to comply with the requirements specified given in [Table 6.60](#) according to the grade of the welding consumables.
3. The requirements specified in the preceding [6.2.7-2](#) and [-4](#) are to be applied to this tests.

Table 6.61 Tensile Strength Requirements for Butt Weld

Grade of welding consumables	Tensile Strength (N/mm^2)
<i>KMW2Y42, KSW2Y42, KAW2Y42 KMW3Y42, KSW3Y42, KAW3Y42 KMW4Y42, KSW4Y42, KAW4Y42 KMW5Y42, KSW5Y42, KAW5Y42</i>	530 min.
<i>KMW2Y46, KSW2Y46, KAW2Y46 KMW3Y46, KSW3Y46, KAW3Y46 KMW4Y46, KSW4Y46, KAW4Y46 KMW5Y46, KSW5Y46, KAW5Y46</i>	570 min.
<i>KMW2Y50, KSW2Y50, KAW2Y50 KMW3Y50, KSW3Y50, KAW3Y50 KMW4Y50, KSW4Y50, KAW4Y50 KMW5Y50, KSW5Y50, KAW5Y50</i>	610 min.
<i>KMW2Y55, KSW2Y55, KAW2Y55 KMW3Y55, KSW3Y55, KAW3Y55 KMW4Y55, KSW4Y55, KAW4Y55 KMW5Y55, KSW5Y55, KAW5Y55</i>	670 min.
<i>KMW2Y62, KSW2Y62, KAW2Y62 KMW3Y62, KSW3Y62, KAW3Y62 KMW4Y62, KSW4Y62, KAW4Y62 KMW5Y62, KSW5Y62, KAW5Y62</i>	720 min.
<i>KMW2Y69, KSW2Y69, KAW2Y69 KMW3Y69, KSW3Y69, KAW3Y69 KMW4Y69, KSW4Y69, KAW4Y69 KMW5Y69, KSW5Y69, KAW5Y69</i>	770 min.

Table 6.62 Butt Weld Bend Test for the Bend Radius

Grade of welding consumables	Radius of plunger (<i>mm</i>)
<i>KMW2Y42~50, KSW2Y42~50, KAW2Y42~50</i> <i>KMW3Y42~50, KSW3Y42~50, KAW3Y42~50</i> <i>KMW4Y42~50, KSW4Y42~50, KAW4Y42~50</i> <i>KMW5Y42~50, KSW5Y42~50, KAW5Y42~50</i>	2.0 <i>t</i>
<i>KMW2Y55~69, KSW2Y55~69, KAW2Y55~69</i> <i>KMW3Y55~69, KSW3Y55~69, KAW3Y55~69</i> <i>KMW4Y55~69, KSW4Y55~69, KAW4Y55~69</i> <i>KMW5Y55~69, KSW5Y55~69, KAW5Y55~69</i>	2.5 <i>t</i>

Note:

t: thickness of bend test specimens (*mm*) .

6.9.11 Hydrogen Test

1. Hydrogen Test is to be carried out for welding consumables except gas shielded arc solid wire by the glycerine method, mercury method, gaschromatographic method or other methods deemed appropriate by the Society.
2. The average volume of hydrogen is to comply with the requirements specified given in [Table 6.63](#) according to the test procedures specified in preceding -1 or the type of suffixes to be added to the grade marks.

Table 6.63 Requirements for Hydrogen Contents

Grade of welding consumables	Suffixes	Requirements for Hydrogen Contents (cm^3/g)		
		Glycerine method	Mercury method	Gas chromatographic method
<i>KMW2Y42~50</i> <i>KMW3Y42~50</i> <i>KMW4Y42~50</i> <i>KMW5Y42~50</i>	<i>H10</i>	0.05 max.	0.10 max.	0.10 max.
<i>KSW2Y42~50</i> <i>KSW3Y42~50</i> <i>KSW4Y42~50</i> <i>KSW5Y42~50</i>				
<i>KAW2Y42~50</i> <i>KAW3Y42~50</i> <i>KAW4Y42~50</i> <i>KAW5Y42~50</i>				
<i>KMW2Y55~69</i> <i>KMW3Y55~69</i> <i>KMW4Y55~69</i> <i>KMW5Y55~69</i>	<i>H5</i>	—	0.05 max.	0.05 max.
<i>KSW2Y55~69</i> <i>KSW3Y55~69</i> <i>KSW4Y55~69</i> <i>KSW5Y55~69</i>				
<i>KAW2Y55~69</i> <i>KAW3Y55~69</i> <i>KAW4Y55~69</i> <i>KAW5Y55~69</i>				

6.9.12 Fillet Weld Macro-etching Test

The fillet weld macro-etching test is to be in accordance with the requirements specified in [6.2.12](#).

6.9.13 Fillet Weld Hardness Test

The fillet weld hardness test is to be in accordance with the requirements specified in [6.2.13](#).

6.9.14 Fillet Weld Fracture Test

The fillet weld fracture test is to be in accordance with the requirements specified in [6.2.14](#).

6.9.15 Annual Inspections

Annual inspections are to comply with the requirements specified in [6.2.15](#), [6.3.15](#) or [6.4.15](#) according to the grade of the welding consumables. However, in general, annual inspections for automatic welding consumables is to comply with the requirements specified for multi-run technique.

6.9.16 Change in Grades

The changes in grades relating to the strength or toughness of approved welding consumables are to comply with the requirements specified in [6.2.16](#), [6.3.16](#) or [6.4.16](#) according to the grade of the welding consumables.