Contents

RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part M 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 weldings where the manufacturer is to adhere to the requirements specified below.

(1) To ensure the quality of the weldings 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. To implement the tests, in lieu of traditional ordinary surveys where the Surveyor is in attendance, the Society may approve other survey methods which it considers to be appropriate.

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 The chemical composition is to be analyzed at an adequately equipped and completely staffed laboratory. The testing machines used for the mechanical testing of welded joints and welding consumables are to be those which have the effective certificates issued by the Society or other organization recognized by the Society in accordance with the "**Rules for Testing Machines**" or other standards deemed appropriate by the Society.

4 Where appropriate certifications for the welding procedure, the welder's 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 **2.1.7**, **Part B** 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 **12.2, Part 1**, **12.1.1, Part 2-6** and **12.1.2, Part 2-7, Part C**.

(3) Non-destructive inspection of weld

Non-destructive inspection of weld is to be carried out in accordance with **Chapter 8**. 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 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 rolled steels for offshore 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 0.6*L* amidship, 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 (brand, 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) Applicable member (only in cases where brittle fracture tests and technical documents related to such brittle fracture tests are omitted in **4.2.7-7**)

(10) 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 welder's 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 affect 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 hulls, rolled steels for low temperature service and high strength rolled steels for offshore 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 M2.1. The selection for steels not specified in Table M2.1 is to be as deemed appropriate by the Society.
(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.

(3) For the welding consumables used for high strength rolled steels for offshore structures, welding consumables different from those given in **Table M2.1** may be selected where deemed appropriate by the Society.

2 With respect to materials approved by the Society for use in welding consumables, materials other than approved materials may be used for backing. However, for the backing in welding consumables specified in **6.5**, other approved welding consumables are to be used.

Table M2.1 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, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, *L*1, *L*2, *L*3
	KB,*KD*	2, 3, 52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, *L*1, *L*2, *L*3
	KE	3, 53, 54, 53*Y*40, 54*Y*40, 55*Y*40, *L*1, *L*2, *L*3
	*KA*32, *KA*36	51, 52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, *L*2(2), *L*3, 2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42
	*KD*32, *KD*36	52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, *L*2(2), *L*3, 2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42
	*KE*32, *KE*36	53, 54, 53*Y*40, 54*Y*40, 55*Y*40, *L*2(2), *L*3, 2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42
	*KF*32, *KF*36	54, 54*Y*40, 55*Y*40, *L*2(2), *L*3, 4*Y*42, 5*Y*42
	*KA*40, *KD*40	52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, 3*Y*42, 4*Y*42, 5*Y*42, 2*Y*46, 3*Y*46, 4*Y*46, 5*Y*46, 63*Y*47
	*KE*40	53*Y*40, 54*Y*40, 55*Y*40, 3*Y*42, 4*Y*42, 5*Y*42, 3*Y*46, 4*Y*46, 5*Y*46, 63*Y*47
	*KF*40	54*Y*40, 55*Y*40, 4*Y*42, 5*Y*42, 4*Y*46, 5*Y*46
	*KE*47	63*Y*47
Rolled Steel for Low Temperature Service	*KL*24*A*	*L*1, *L*2, *L*3, 54, 54*Y*40, 55*Y*40,
	*KL*24*B*, *KL*27, *KL*33	*L*2, *L*3, 55*Y*40, 5*Y*42(3)
	*KL*37	*L*3, 55*Y*40, 5*Y*42
	*KL*9*N*53, *KL*9*N*60	*L*91, *L*92
High strength rolled steels for offshore structures	*KA*420	2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42, 2*Y*46, 3*Y*46, 4*Y*46, 5*Y*46, 2*Y*50, 3*Y*50, 4*Y*50, 5*Y*50
	*KD*420	3*Y*42,4*Y*42, 5*Y*42, 3*Y*46, 4*Y*46, 5*Y*46, 3*Y*50, 4*Y*50, 5*Y*50
	*KE*420	4*Y*42, 5*Y*42, 4*Y*46, 5*Y*46, 4*Y*50, 5*Y*50
	*KF*420	5*Y*42, 5*Y*46, 5*Y*50
	*KA*460	2*Y*46, 3*Y*46, 4*Y*46, 5*Y*46, 2*Y*50, 3*Y*50, 4*Y*50, 5*Y*50
	*KD*460	3*Y*46, 4*Y*46, 5*Y*46, 3*Y*50, 4*Y*50, 5*Y*50
	*KE*460	4*Y*46, 5*Y*46, 4*Y*50, 5*Y*50
	*KF*460	5*Y*46, 5*Y*50
	*KA*500	2*Y*50, 3*Y*50, 4*Y*50, 5*Y*50, 2*Y*55, 3*Y*55, 4*Y*55, 5*Y*55
	*KD*500	3*Y*50, 4*Y*50, 5*Y*50, 3*Y*55, 4*Y*55, 5*Y*55
	*KE*500	4*Y*50, 5*Y*50, 4*Y*55, 5*Y*55
	*KF*500	5*Y*50, 5*Y*55
	*KA*550	2*Y*55, 3*Y*55, 4*Y*55, 5*Y*55, 2*Y*62, 3*Y*62, 4*Y*62, 5*Y*62
	*KD*550	3*Y*55, 4*Y*55, 5*Y*55, 3*Y*62, 4*Y*62, 5*Y*62
	*KE*550	4*Y*55, 5*Y*55, 4*Y*62, 5*Y*62
	*KF*550	5*Y*55, 5*Y*62
	*KA*620	2*Y*62, 3*Y*62, 4*Y*62, 5*Y*62, 2*Y*69, 3*Y*69, 4*Y*69, 5*Y*69
	*KD*620	3*Y*62, 4*Y*62, 5*Y*62, 3*Y*69, 4*Y*69, 5*Y*69
	*KE*620	4*Y*62, 5*Y*62, 4*Y*69, 5*Y*69
	*KF*620	5*Y*62, 5*Y*69
	*KA*690	2*Y*69, 3*Y*69, 4*Y*69, 5*Y*69
	*KD*690	3*Y*69, 4*Y*69, 5*Y*69
	*KE*690	4*Y*69, 5*Y*69
	*KF*690	5*Y*69
	*KA*890	2*Y*89, 3*Y*89, 4*Y*89, 2*Y*96, 3*Y*96, 4*Y*96
	*KD*890	3*Y*89, 4*Y*89, 3*Y*96, 4*Y*96
	*KE*890	4*Y*89, 4*Y*96
	*KA*960	2*Y*96, 3*Y*96, 4*Y*96
	*KD*960	3*Y*96, 4*Y*96
	*KE*960	4*Y*96

Notes:

(1) The symbols of welding consumables listed above show the materials which are specified in **Table M6.1**, **Table**

M6.12, Table M6.21, Table M6.29 and Table M6.58, and have same mark at the end. (For example, "3" shows *KMW*3, *KAW*3, *KSW*3 and *KEW*3, "*L*3" shows *KMWL*3, *KAWL*3 and *KSWL*3, "3*Y*42" shows *KMW*3*Y*42, *KAW*3*Y*42 and *KSW*3*Y*42.)

(2) Welding consumables of "*L*2" is applicable to steel grade of *KA*32, *KD*32, *KE*32 or *KF*32 only.

(3) Welding consumables of "5*Y*42" is applicable to steel grade of *KL*33 only.

(4) For welding consumables used for the corrosion resistant steel for cargo oil tanks specified in 3.13, Part K, only welding consumables whose brands are listed in the "Particulars of Approval Conditions" for the corrosion resistant steel for cargo oil tanks are to be used. In cases where welding consumables not listed are used, measures deemed appropriate by the Society are to be taken.

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 K.

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 M3.1**, 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 M3.2** and **Table M3.3** according to the kind of test assembly.

2 Where the thickness of test assemblies is greater than the thickness of the bend test specimen prescribed in **Table M3.2**, 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 *U*4 specimens specified in **2.2.4, Part K** and to be of size and dimensions given in **Fig. K2.1**, **Tables K2.5** and **K2.6**.

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 K**.

3.3.2 Bend Test

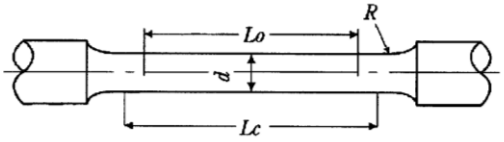
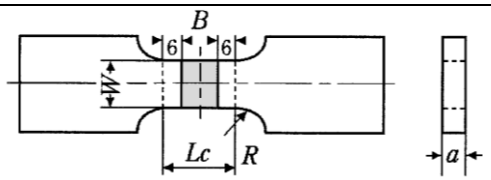
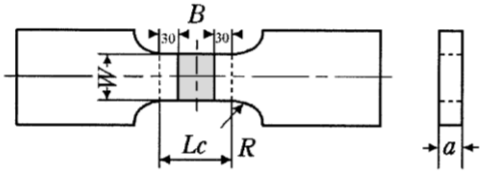
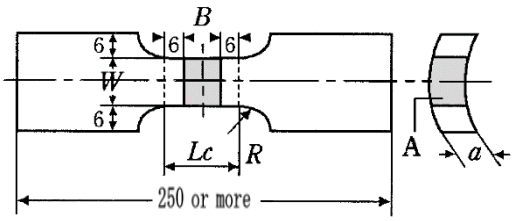
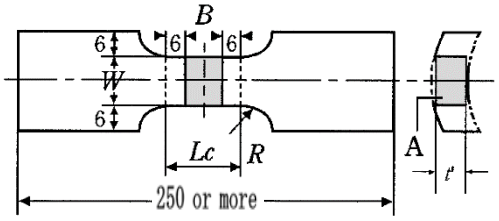
1 Unless otherwise specified, bend tests may be either a guided bend test or a roller bend test.

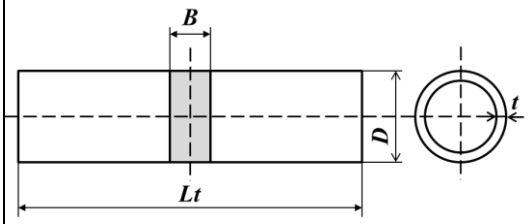
2 Guided bend test jigs are to be as shown in **Figs. M3.1** and **M3.2**.

3 Roller bend test jigs are to be as shown in **Fig. M3.3**.

4 Method of bending testing using a roller is to be as shown in **Fig. M3.4**.

Table M3.1 Size and Dimension of Tensile Test Specimens (*mm*)

Kind	Size of specimens		Dimensions[1]	Intended for
*U*1*A*	Deposited metal tensile test specimen		As a rule $d = 10$ $Lo = 50$ $Lc = 60$ $R \geq 10$	Deposited metal tensile test (Longitudinal tensile test)
1*B*			$d = 6.0$ $Lo = 24$ $Lc = 32$ $R \geq 6$	Deposited metal test: $t = 12$ (Welding consumables for stainless steel)
1*C*			$d = 12.5$ $Lo = 50$ $Lc = 60$ $R \geq 15$	Deposited metal test: $19 \leq t \leq 25$ (Welding consumables for stainless steel)
*U*2*A*	Butt weld tensile test specimen		$a = t$ [2] $W = 30$ $Lc = B + 12$ $R \geq 50$	Butt weld tensile test for plate
*U*2*B*			$a = t$ [2] $W = 12$ ($t \leq 2$) $W = 25$ ($t > 2$) $Lc = B + 60$ $R \geq 25$	
2*C*[3]			$a = t$ $W = 6$ ($D < 50$) $W = 20$ ($D \geq 50$) $Lc = B + 12$ $R \geq 50$ The sectional area of *A* is to be considered to be $W \times a$	Butt weld test for pipe: $t < 9$
2*D*[3]			$a = t'$ [2] $W = 6$ ($D < 50$) $W = 20$ ($D \geq 50$) $Lc = B + 12$ $R \geq 50$ The sectional area of *A* is to be finished to be rectangular. However, the machining allowance is to be minimum.	Butt weld test for pipe: $t \geq 9$

$2E$[4]	Butt weld tensile test specimen		$D < 50$ $Lt \geq 10 \times D$	Butt weld test for pipe: $D < 50$

Notes:

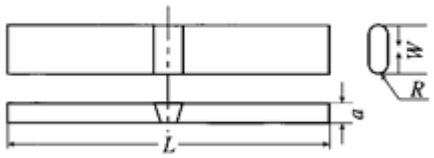
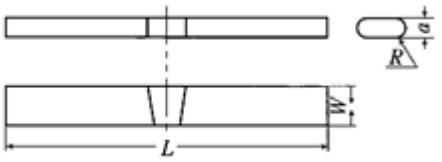
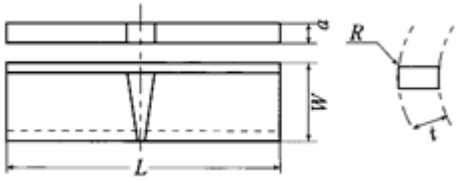
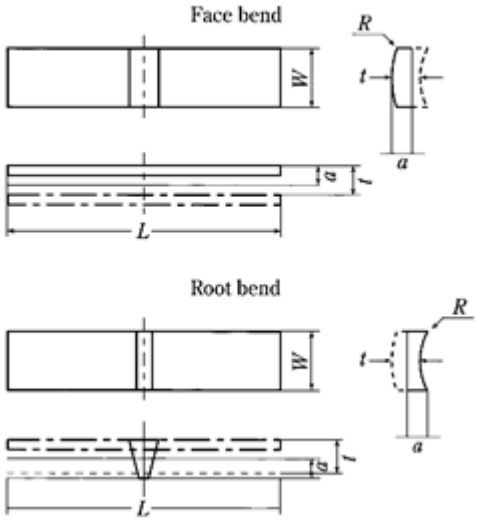
(1) The following designations are used.
d : diameter, a : thickness, W : width, Lo : gauge length, Lc : parallel part length, Lt : length of test assembly, R : transition radius, B : breadth of weld, t : thickness of test assembly, t' : thickness of hobbed test assembly, D : outside diameter of the pipe.

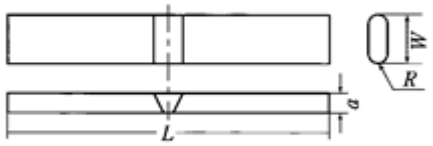
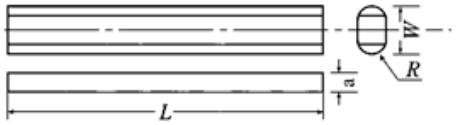
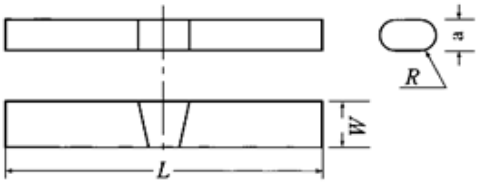
(2) When the thickness of the test piece is so large that it exceeds the capacity of the testing machine, the test piece may be divided to be tested.

(3) In the case of $D < 50$, test specimen $2E$ may be used instead of test specimens $2C$ and $2D$.

(4) The method of attaching the test assembly is to be in accordance with the provisions of *JIS Z* 3121 for test specimen 2.

Table M3.2 Size and Dimension of Bend Test Specimens(1)

Kind	Used for		Size of specimen	Dimensions	Intended for
UB-1	Welding procedure qualification tests	Face ro bend specimen		$a = t$ $W = 30$ $L \geq 200$ $R \geq 1 \sim 2$	Test assemblies for butt weld test for plate:
UB-2		Side bend specimen		$a = 10$ $W = t$(2) $L \geq 200$ $R \geq 1 \sim 2$	Test assemblies for butt weld test for plate: $t \geq 12$
B-3				$a = 10$ $W = t$(2) $L \fallingdotseq 200$ $R \leq 1.5$	Test assemblies for butt weld test for pipe: $t \geq 12$
B-4		Face and bend specimen		$a = t$ $W = 19$ $L \fallingdotseq 200$ $R \leq 1.5$ For the tube whose D is 34.0 to 60.6, W is to be 10. For the tube having D of 34.0 and under, the width obtained by dividing the tube longitudinally into four equal parts is to be the width of the test piece. In case of $D \leq 34.0$, the flattening of the inner and outer surfaces of the tube may be omitted by simply removing excessive convexity.	Test assemblies for butt weld test for pipe: $t < 10$
B-5				$a = 10$ $W = 40$ $L \fallingdotseq 200$ $R \leq 1.5$ For the tube having an D of 114.3 and under, W is to be 19.	Test assemblies for butt weld test for pipe: $t \geq 10$

UB-6	Approval tests and annual inspection for welding consumable	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
B-7		Face and root bend specimen		$a = 10$ $W = 40$ $L \geq 200$ $R \leq 1.5$	Butt weld test (welding consumables 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 electro-slag and electro gas and two-run technique MIG welding for aluminum alloy)

Notes:

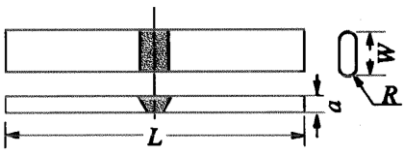
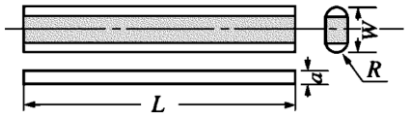
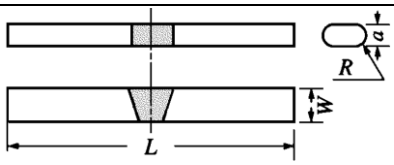
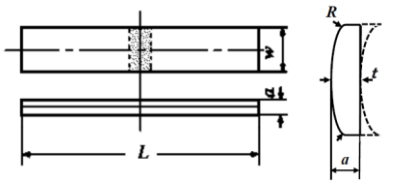
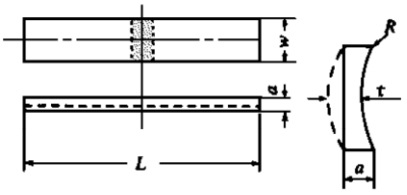
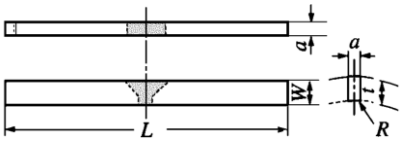
(1) The following designations are used:

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 40 *mm*, the test specimen may be divided to be tested.

Table M3.3 Size and Dimension of Bend Test Specimens (welder qualification test) (*mm*)[(1) (2)]

Kind	Size of specimen		Dimensions	Intended for
B-9	Face and root bend specimen		$a = t$ In cases where t exceeds 25 *mm*, a may be reduced to 25 *mm* with its surface machined on one side only (compression side). $W = 30$ $L \geq 200$ $R = 1$ to 2	Test assemblies for butt weld tests for plates.
B-10			$a = t$ In cases where t exceeds 10 *mm*, a may be reduced to 10 *mm* with its surface machined on one side only (compression side). $W \geq Ls + 30$ $L \geq 200$ $R \leq 0.2\,t$ (3 max.)	Test assemblies for butt weld tests for plates. (For nickel steel)
B-11	Side bend specimen		$a = 10$ $W = t$ [(3)] $L \geq 200$ $R = 1$ to 2	Test assemblies for butt weld tests for plates.
B-12[(4)]	Face and root bend specimen	 (Face bend specimen)  (Root bend specimen)	$a = t$ In cases where t exceeds 10 *mm*, a may be reduced to 10 *mm* with its surface machined on one side only (compression side). W is to be determined using the following equation, and W is to be 8 or above. For $D \leq 50$, $W = t + 0.1D$ For $D > 50$, $W = t + 0.05D$ (40 max.) $L \geq 250$ $R \leq 0.2\,t$ (3 max.)	Test assemblies for butt weld tests for tubes.
B-13[(4)]	Side bend specimen		$a = 10$ $W = t$ [(3)] $L \geq 250$ $R \leq 0.2\,t$ (3 max.)	Test assemblies for butt weld tests for tubes.

Notes:

(1) The following symbols are used:

a: thickness of test specimen, W: width of test specimen, L: length of test specimen, Ls: maximum width of the weld after machining

R: edge radius of test specimen, t: thickness of test assembly, D: external diameter of tube

(2) The edges of the test specimen on the tension side may be rounded by mechanical means.

(3) In cases where the thickness of the test assembly exceeds 40 *mm*, side bend test specimens may be divided into test specimens, each being at least 20 *mm* wide.

(4) Where D exceeds 25 t, the B-9 or B-11 test specimen may be used.

Fig. M3.1 Guided Bend Test Jig (Unit: mm) (For Bend Test Specimen of 9 mm in Thickness)

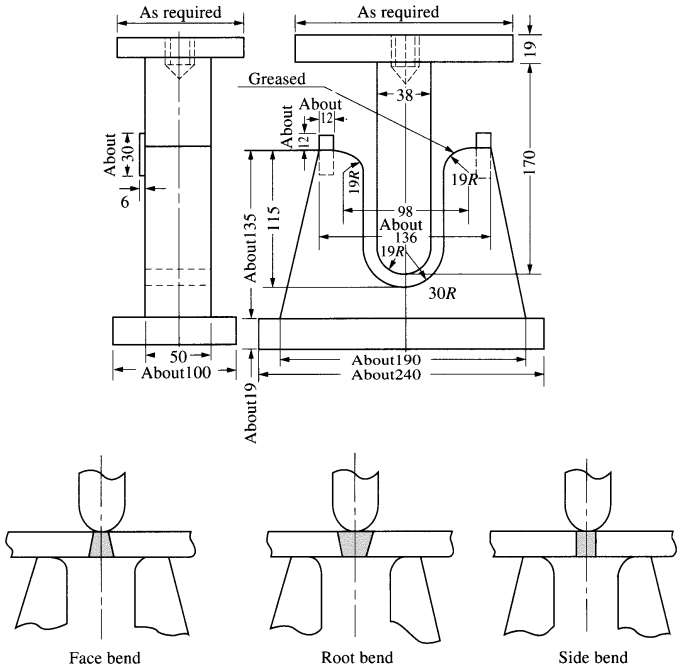


Fig. M3.2 Guided Bend Test Jig (Unit: *mm*) (For bend test specimen of 3.2 *mm* in thickness)

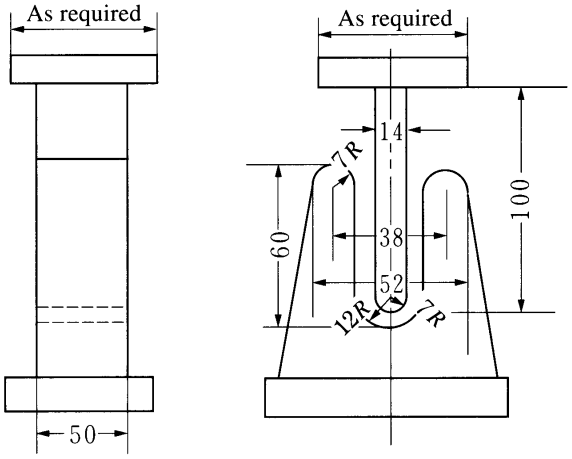
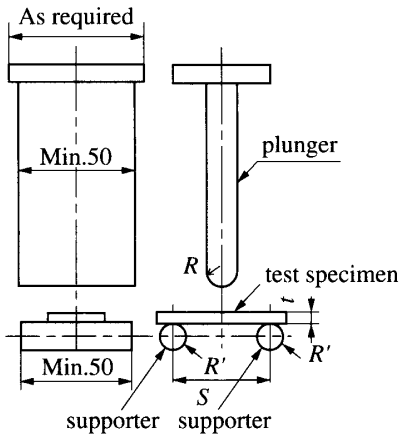


Fig. M3.3 Jigs for Roller Bend Test (Unit: *mm*)



Note:

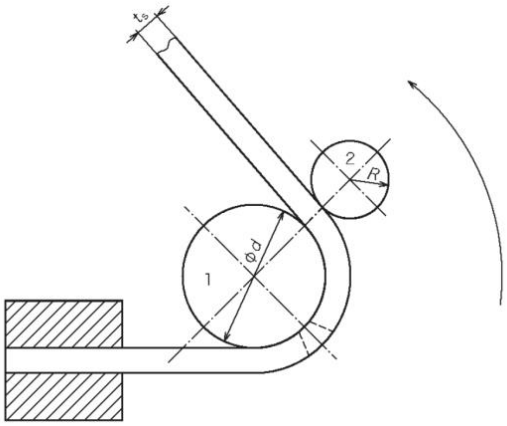
t :thickness of test specimen

R :radius of plunger

R' :radius of supporting roller (not specified)

S *:span between supports* $\{2\,(R + R' + t + 2)\}$

Fig. M3.4 Method of bending testing using a roller (Units: *mm*)



Notes:

1: Inner roller, 2: Outer roller

L_f: Initial distance between contact of the roller and the centerline of the weld

$0.7\,d < L_f < 0.9\,d$

D: Diameter of the inner roller

Chapter 4 WELDING PROCEDURE AND RELATED SPECIFICATIONS

4.1 General

4.1.1 Application*

1 This Chapter applies to the approval of welding procedure and related specifications mainly for hull construction as well as pipes and piping systems, etc., unless specified in another chapter.

2 This chapter correspondingly applies to the welding procedure and related specifications for the approval of steel castings and steel forgings which is to be of a weldable quality used for hull structures.

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 **(4)**.

(1) Where the welding procedures are first adopted for welding works specified in **Chapter 2**.

(2) Where the welding procedures are first adopted for pipes belonging to Group I and II, piping systems for ships carrying dangerous chemicals in bulk, and cargo and process piping systems for ships carrying liquefied gases in bulk.

(3) Where the items described in the approved welding procedure specifications are altered.

(4) Where considered necessary by the Surveyor.

2 The specifications which correspond 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** to **4.6** 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 high strength rolled steels for offshore structures, the tests are to be carried out for every kind of 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** to **4.5** 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 high strength rolled steels for offshore structures are in accordance with the following **(1)** through **(6)**, 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 M4.1**.

(2) Thickness

The range of the thickness is in accordance with in **Table M4.2**.

(3) Leg length of fillet welding

The range of the leg length of fillet welding is in accordance with in **Table M4.3**.

(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) High strength rolled steels for offshore structures

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 (6)** of **Table M4.2**, the welding procedures are considered applicable to that toughness grade tested and one strength level below.

(d) Notwithstanding the requirements given in **(a)** to **(c)**, welding procedures for *KE*47 within the same and below toughness grades are considered applicable to one lower strength level. However, for the large heat input welding specified in **Note (6)** of **Table M4.2**, the welding procedures are considered applicable to that toughness grade tested and the same strength level.

(5) Kinds of welding consumables

The welding consumables are to be not brand but grade (including all suffixes), except the large heat input specified **Note (6)** of **Table M4.2**.

(6) Welding position

(a) Welding position is in accordance with in **Table M5.10**. The welding position of T-joints with partial penetration and T-joints with full penetration are to be the same welding position as fillet weld joints.

(b) Approval tests are to be performed each welding position. However, to qualify a range of positions, test assemblies are to be welded for highest heat input position and lowest heat input position and all applicable tests are to be made on those assemblies. The above excludes welding in the vertical position with travel in the downward direction which will always require separate tests and only are acceptable for that position.

2 The scope of approval of the welding procedure and related specifications of steel pipes are to be in accordance with the following **(1)** through **(8)** on the condition that the other welding conditions are the same.

(1) Kind of weld joint

The kind of weld joint is to be in accordance with in **Table M4.1**. Set-on, Set-in and Set-through may be accepted regardless of the kind of pipe assembly used in the test except in the case of butt-welded joints.

(2) Thickness

The range of the thickness is to be in accordance with in **Table M4.2**.

(3) Outside diameter

(a) The range of the outside diameter is to be in accordance with in **Table M4.4**.

(b) In cases where plates are used as the test assembly in accordance with **4.2.3-4**, the lowest limit of the range is to be not less than 300 *mm*, notwithstanding **(a)**.

(4) Angles of pipe (or tube) fittings

The angles of pipe (or tube) fittings are not to be less than the angle of test assemblies or 60 degrees, whichever smaller, but is to be not more than 90 degrees. “Angles of pipe (or tubes) fittings” means the angle in “α” degrees between the centrelines of pipes (or tubes), or between pipes (or tubes) and plates on transverse sections as shown in **Fig. M4.13**.

(5) Leg length of fillet welding

The range of the leg length of fillet welding is to be in accordance with in **Table M4.3**.

(6) Kind of base metal

(a) The kinds of steel tubes for boilers and heat exchangers, steel pipes for pressure piping, headers and steel pipes for low

temperature service are to be as specified in **Table M4.5**.

(b) Other than for the pipes specified in **(a)**, the welding procedures are considered applicable only for grades which are the same as the grade of the test assembly.

(7) Kind of welding consumable

The welding consumable is to be selected according to grade (including all suffixes) not brand, except for the large heat inputs specified in Note (6) of **Table M4.2**.

(8) Welding position

(a) The welding position is to be in accordance with **Table M5.11**. The welding position of T-joints with partial penetration and full penetration is to be the same as the welding position for fillet weld joints.

(b) Approval tests are to be performed each welding position. However, to qualify a range of positions, test assemblies are to be welded for highest heat input position and lowest heat input position and all applicable tests are to be made on those assemblies. The above excludes welding in the tube position for welding downwards which will always require separate tests and only are acceptable for that position. With respect to the welding positions for rotating and fixed pipes (tubes), when the tests required for fixed pipes (tubes) are performed for *PB*, *PC* or *PD* respectively, the tests required for rotating pipes (tubes) may also be considered to have been performed respectively as shown in **Table M5.11**.

3 The restriction of welding procedure condition (e.g. heat input welding and preheating) in actual work is to be deemed appropriate by the Society.

4 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.

5 The range of approval of materials other than rolled steels for hull, high strength rolled steels for offshore structures and steel pipes is to be as deemed appropriate by the Society.

Table M4.1 Range of Approval for Type of Weld Joint

Type of weld joint for test assembly				Range of approval											
				A	B	C	D	E	F	G	H	I	J	K	L
Butt Welded joints	One side	With backing	A	○			○		○			○		○	○
		Without backing	B	○	○	○	○	○	○	○	○	○	○	○	○
		Gas backing	C	○		○	○		○		○	○		○	○
	Both side	With gouging	D				○					○		○	○
		Without gouging	E				○	○				○	○	○	○
T-joints with full penetration	One side	With backing	F						○			○		○	○
		Without backing	G						○	○	○	○	○	○	○
		Gas backing	H						○		○	○		○	○
	Both side	With gouging	I									○		○	○
		Without gouging	J									○	○	○	○
T-joints with partial penetration			K											○	○
Fillet weld joints			L												○

Table M4.2 Approved Range of Thickness[(1), (9)]

Thickness of test assemblies t (mm) [(2), (3), (4), (5)]	Approved range of thickness (mm) [(10)]			
	Butt welding[(4)]			Fillet welding
	Multi-run technique	Single-run technique or Two-run technique[(11)]	Large heat input welding process[(6)]	
$t \leq 100$	$0.5t$ to $2t$ [(7), (8)] (100 max)	$0.7t$ to $1.1t$ [(7), (8)] (100 max)	$0.7t$ to t	$0.5t$ to $2t$ [(7), (8)] (100 max)

Notes:

(1) Welding procedure used by dissimilar process (combination welding) is to be correspondingly applied to **Table M4.2**. In this case, thickness or throat thickness of each welding method is to be t.

(2) For unequal plate thickness or pipe wall 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) For T-joints with full penetration and T-joints with partial penetration, t is the thickness of test assembly on the open edge side and the requirements to be correspondingly applied are the requirements for butt welding.
(5) For branch connections, t is the thickness of main pipes and branch pipes respectively, and the requirements to be correspondingly applied are the requirements for butt welding.
(6) Large heat input welding means the welding with a welding heat input of not less than 50 *kJ/cm*.
(7) For the vertical-down welding and tube positions for welding downwards, the test piece thickness t is always taken as the upper limit of the range of application.
(8) For test assembly thickness not more than 12 *mm*, the specified minimum content is not applicable.
(9) For the kinds of test assemblies specified in **Table M4.12**, even though the test specimen has passed the hardness test specified in **4.2.9**, **4.3.6** and **4.4.6**, the upper limit of the thickness range of approval is to be restricted to the thickness of the test assembly when three or more of the hardness values in the heat affected zone are less than 25HV lower than the values specified in **Table M4.12**.
(10) For steel pipes for low temperature service, the upper limit is to be a maximum of 25 *mm* unless another value is considered appropriate by the Society.
(11) Two-run technique refers to a welding process involving a single pass on both sides.

Table M4.3 Applicable Leg Length of Fillet Welding

Approved range of leg length (*mm*)	
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 or tube position for welding downwards is applied, the approved range of thickness is to be f.

Table M4.4 Range of Approval Related to Outside Diameter of Pipe

Outside diameter D of test assembly (*mm*)(1)	Range of approval related to outside diameter (*mm*)(2)
$D \leqq 25$	0.5 D to 2 D
$D > 25$	0.5 D or more(3)

Notes:
(1) For non-circular sections, D is the dimension of the smaller side.
(2) For branch connections, the requirements are applied to main pipes and branch pipes.
(3) Lower limit of "0.5 D" is not to be less than 25 *mm*.

Table M4.5 Range of Approval Related to Kind of Steel

Kind and grade of test assembly		Approval range of grade
Steel tubes for boilers and heat exchangers	*KSTB*33	*KSTB*33
	*KSTB*35	*KSTB*33, *KSTB*35
	*KSTB*42	*KSTB*33(2), *KSTB*35(2), *KSTB*42
	*KSTB*12	*KSTB*12
	*KSTB*22	*KSTB*22
	*KSTB*23	*KSTB*23
	*KSTB*24	*KSTB*24
Steel pipes for pressure piping	*KSTPG*38 *KSTS*38 *KSTPT*38	*KSTPG*38, *KSTS*38, *KSTPT*38
	*KSTPG*42 *KSTS*42 *KSTPT*42	*KSTPG*38, *KSTS*38, *KSTPT*38 *KSTPG*42, *KSTS*42, *KSTPT*42
	*KSTS*49 *KSTPT*49	*KSTPG*38(2), *KSTS*38(2), *KSTPT*38(2) *KSTPG*42, *KSTS*42, *KSTPT*42 *KSTS*49, *KSTPT*49
	*KSTPA*12	*KSTPA*12
	*KSTPA*22	*KSTPA*22
	*KSTPA*23	*KSTPA*23
	*KSTPA*24	*KSTPA*24
Headers	*KBH*-1	*KBH*-1
	KBH-2	*KBH*-1, *KBH*-2
	KBH-3	*KBH*-3
	KBH-4	*KBH*-4
	KBH-5	*KBH*-5
	KBH-6	*KBH*-6
Steel pipes for low temperature service(1)	*KLPA*	*KLPA*
	KLPB	*KLPA*(2), *KLPB*
	KLPC	*KLPA*(2), *KLPB*(2), *KLPC*
	KLP2	*KLP2*
	KLP3	*KLP3*
	KLP9	*KLP9*

Notes:

(1) Only when the same kind of heat treatment is used.

(2) For the large heat inputs specified in **Note (6)** of Table M4.2, the welding procedures are not considered applicable to these grades.

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 M4.6 or equivalent materials by a manual, semi-automatic welding or automatic welding method, etc.

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 M4.6.

4.2.3 Test Assemblies and Welding

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. M4.1

3 Test assemblies are to be welded in the general conditions specified in welding procedure specifications.

4 Test assemblies for pipes over 300 *mm* 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 high strength rolled steels for offshore structures, 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 M4.6 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]	Measurement of ferrite content at weld surface (point)
Rolled steel for hull	*KA*, *KB*, *KD*, *KE* *KA*32, *KD*32, *KE*32, *KF*32, *KA*36, *KD*36, *KE*36, *KF*36, *KA*40, *KD*40, *KE*40, *KF*40	Whole length of welding joints	2	4[5]	3～8<*a*,*b*,*c*,*d*,*e*>[7]	1	1[10]	Whole length of welding joints	—
	*KE*47				4～8<*a*,*b*,*c*,*d*,*e*>[7]				
Rolled steels for lower temperature service	*KL*24*A*, *KL*24*B*, *KL*27, *KL*33, *KL*37, *KL*2*N*30, *KL*3*N*32, *KL*5*N*43				5 <*A*,*B*,*C*,*D*,*E*>[8]				
	*KL*9*N*53, *KL*9*N*60		4[4]	2[6]			1[14]		
Steel pipes for low temperature service	*KLPA*, *KLPB*, *KLPC*, *KLP*2, *KLP*3, *KLP*9		2	4					
Rolled steel for structure	*KA*420, *KD*420, *KE*420, *KF*420, *KA*460, *KD*460, *KE*460, *KF*460, *KA*500, *KD*500, *KE*500, *KF*500, *KA*550, *KD*550, *KE*550, *KF*550, *KA*620, *KD*620, *KE*620, *KF*620, *KA*690, *KD*690, *KE*690, *KF*690, *KA*890, *KD*890, *KE*890, *KA*960, *KD*960, *KE*960			4[5]	3～8<*a*,*b*,*c*,*d*,*e*>[7]		1		
Steel tubes for boiler and heat exchangers	*KSTB*33, *KSTB*35, *KSTB*42, *KSTB*12, *KSTB*22, *KSTB*23, *KSTB*24				—		—		
Steel pipe for pressure piping	*KSTPG*38, *KSTPG*42, *KSTS*38, *KSTS*42, *KSTS*49, *KSTPT*38, *KSTPT*42, *KSTPKT*49, *KSTPA*12, *KSTPA*22, *KSTPA*23, *KSTPA*24								
Headers	*KBH*-1, *KBH*-2, *KBH*-3, *KBH*-4, *KBH*-5, *KBH*-6								
Rolled stainless steels	*KSUS*304, *KSUS*304*L*, *KSUS*304*N*1, *KSUS*304*N*2, *KSUS*304*LN*, *KSUS*309*S*, *KSUS*310*S*, *KSUS*316, *KSUS*316*L*, *KSUS*316*N*, *KSUS*316*LN*, *KSUS*317, *KSUS*317*L*, *KSUS*317*LN*, *KSUS*321, *KSU*S347	Whole length of welding joints	2	4[5]	[9]	1	—	Whole length of welding joints	—

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]	Measurement of ferrite content at weld surface (point)
	*KSUS*329*J*1, *KSUS*329*J*3*L*, *KSUS*329*J*4*L*, *KSUS*323*L*, *KSUS*821*L*1									6 min.
Stainless steel pipes	*K*304*TP*, *K*304*LTP*, *K*309*STP*, *K*310*STP*, *K*316*TP*, *K*316*LTP*, *K*317*TP*, *K*317*LTP*, *K*321*TP*, *K*347*TP*				4					—
	*K*329*J*1*TP*, *K*329*J*3*LTP*, *K*329*J*4*LTP*									6 min.
Aluminium alloys [11]	5000 Series	5754*P*, 5086*P*, 5086*S*[12], 5083*P*, 5083*S*[12] 5383*P*, 5383*S*[12], 5059*P*, 5059*S*[12], 5456*P*			4[5]	—				—
	6000 Series	6005*AS*[13], , 6061*P*, 6061*S*[13] , 6082*S*[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. M4.2** through **Fig. M4.4**.

(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. M4.1(D)**)

(5) Two specimens are to be taken from root bend and face bend respectively. (See **Fig. M4.1(A)**, **(E)** and **(F)**)

(6) The specimens are to be taken longitudinally. (See **Fig. M4.1(D)**).

(7) The specimens are to be taken in accordance with **Fig. M4.2** and **M4.3**.

(8) The position of notch for the specimen is to be shown in **Fig. M4.4**.

(9) Where found necessary by the Society, impact tests up to steels specially used for may be required.

(10) For *KA*36, *KD*36, *KE*36, *KF*36, *KA*40, *KD*40, *KE*40, *KF*40 and *KE*47 the tests are to be carried out.

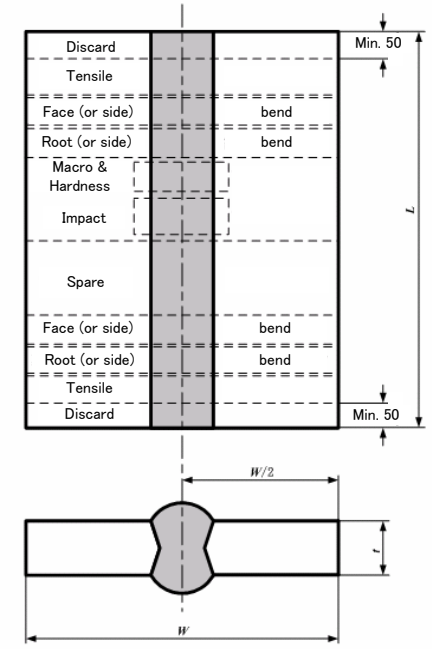
(11) All temper conditions indicated with grades are to be included (See **Table K8.3**).

(12) Rolled products which have the same grade and temper condition may be used.

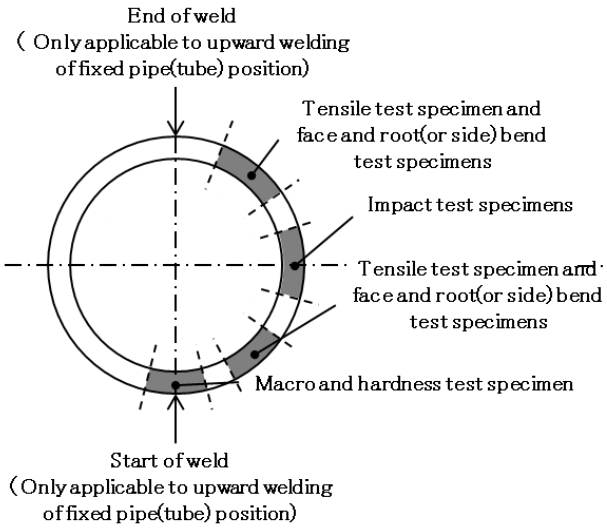
(13) Other rolled aluminium alloys of 6000 series with tensile strength 260 N/mm^2 and above may be used.

(14) The test is to be applied to *KL*37, *KL*5*N*43, *KL*9*N*53, *KL*9*N*60 and *KLP*9.

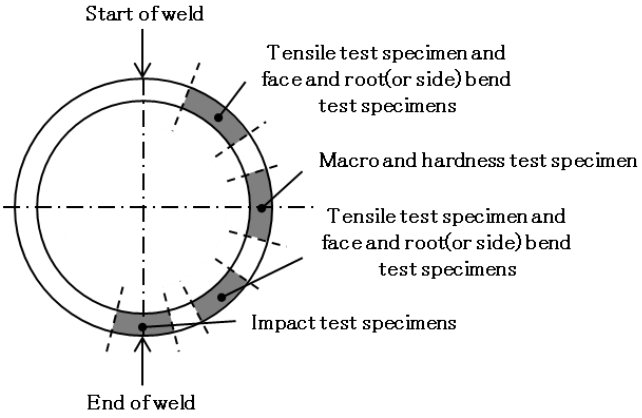
Fig. M4.1 Welding Procedure Qualification Test Assemblies (Unit: *mm*)



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



(B) Test Assembly for pipes (or tubes)
(except for the welding position shown in (C))



(C) Test Assembly for pipes (or tubes)
(downward welding of fixed pipe (or tube) position)

Notes:

(1) In Fig. (A), width (W) and length (L) of test specimens are as follows.
Manual welding and semi-automatic welding: $W \geq 300$ *mm*, $L \geq 350$ *mm*
Automatic welding: $W \geq 400$ *mm*, $L \geq 1000$ *mm*

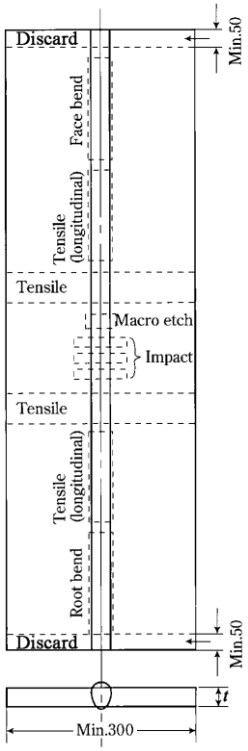
(2) The two root and two face bend test specimens may be substituted by four side bend specimens for $t \geq 12$ *mm*.

(3) Measurement of ferrite content at the weld surface (including weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in **Table M4.6**.

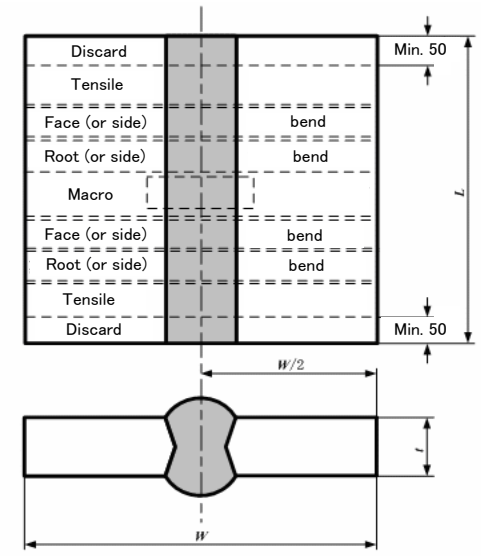
(4) The part measured for ferrite content in Fig. (B) and Fig. (C) may be an arbitrary selected part of the weld.

(5) The start and end points of the weld in Fig. (B) may be an arbitrary selected except in the case of the upward welding horizontally fixed pipe (or tube) position.

Fig. M4.1 Welding Procedure Qualification Test Assemblies (Unit: *mm*) (*Continued*)

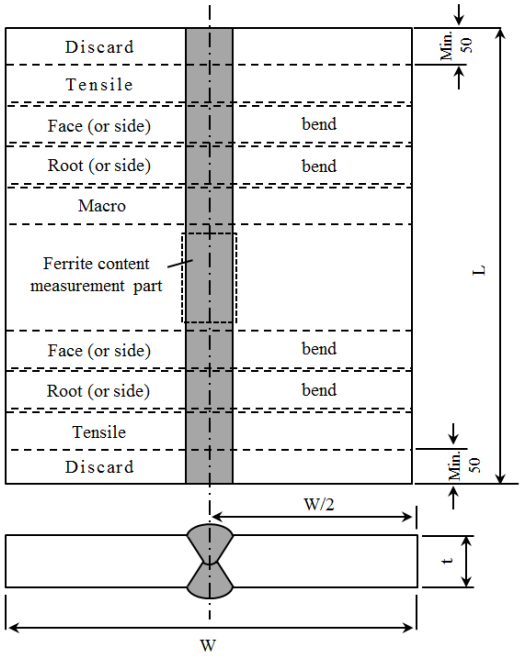


(D) Test Assembly for *KL9N*53 or *KL9N*60



(E) Test Assemblies for Aluminium Alloy Plates

Fig. M4.1 Welding Procedure Qualification Test Assemblies (Unit: *mm*) (*Continued*)



(F) Test Assemblies for Rolled Stainless Steel Plates

Notes:

(1) In Fig. (E) and (F), width (W) and length (L) of test assembly are as follows.
Manual welding and semi-automatic welding: $W \geq 300$ *mm*, $L \geq 350$ *mm*
Automatic welding: $W \geq 400$ *mm*, $L \geq 1000$ *mm*

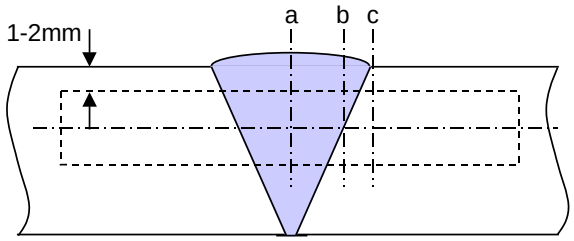
(2) The root and face bends may be substituted by 4 side bends for $t \geq 12$ *mm*.

(3) For butt joint of dissimilar alloy material, longitudinal bend tests may be required by the Society.

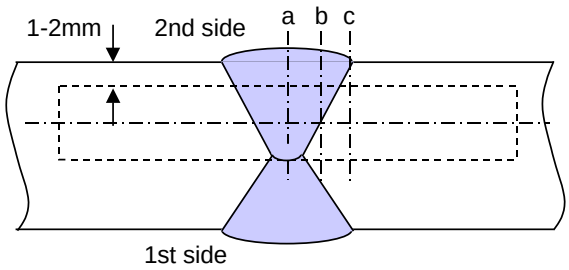
(4) Measurement of ferrite content at the weld surface (including weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in **Table M4.6**.

(5) The part measured for ferrite content may be an arbitrary selected part of the weld, excluding any discards.

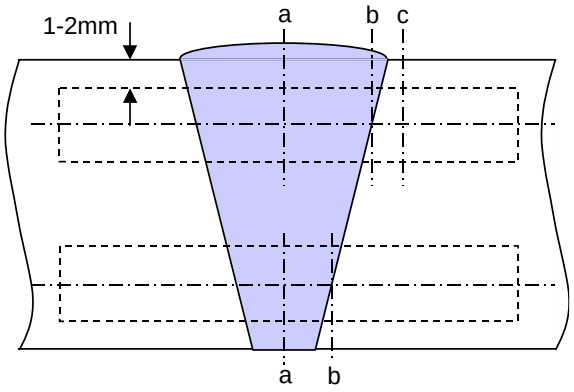
Fig. M4.2 Position of Notch for Impact Test Specimens for Rolled Steels for Hull and High Strength Rolled Steels for Offshore Structures (Where Welding Heat Input is not Greater than 50 *kJ/cm*, Unit: *mm*)



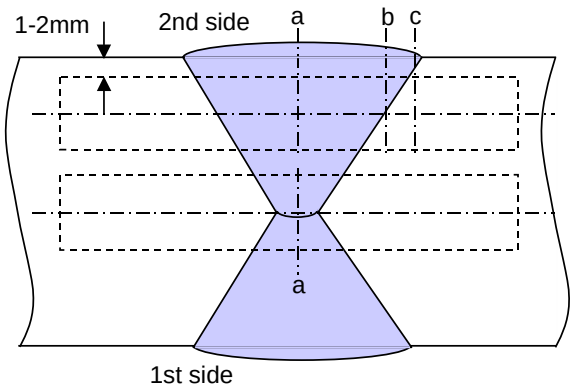
(a) For One side (t ≤ 50 *mm*)



(b) For Both side (t ≤ 50 *mm*)



(c) For One side (t > 50 *mm*)



(d) For Both side (t > 50 *mm*)

Notch location:

a: Center of weld “WM”

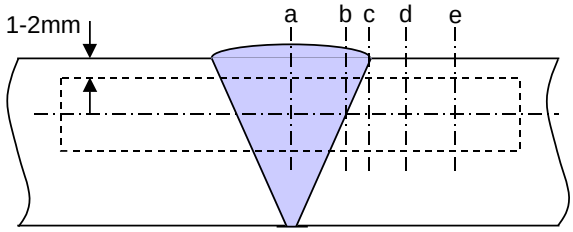
b: On fusion line “FL”

c: In HAZ, 2 *mm* from fusion line

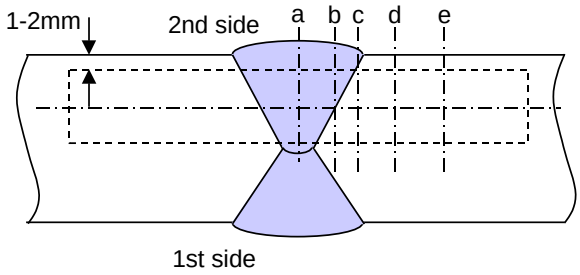
Note:

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

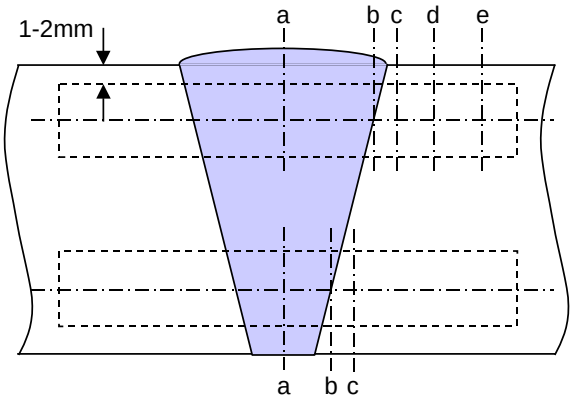
Fig. M4.3 Position of Notch for Impact Test Specimens for Rolled Steels for Hull and High Strength Rolled Steels for Offshore Structures (Where Welding Heat Input is Greater than 50 *kJ/cm*, Unit: *mm*)



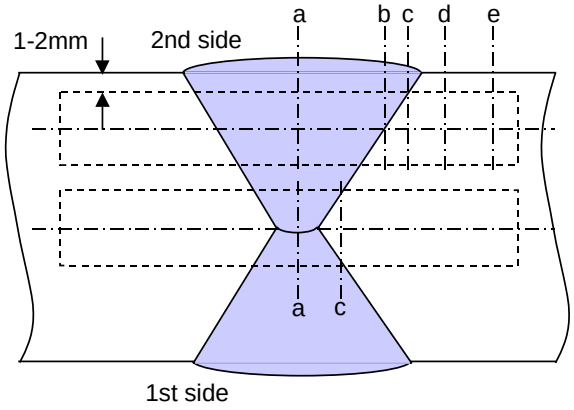
(a) For One side (t ≤ 20 *mm*)



(b) For Both side (t ≤ 50 *mm)*



(c) For One side (t > 20 *mm*)



(d) For Both side (t > 50 *mm*)

Notch location:

a: Center of weld “WM”

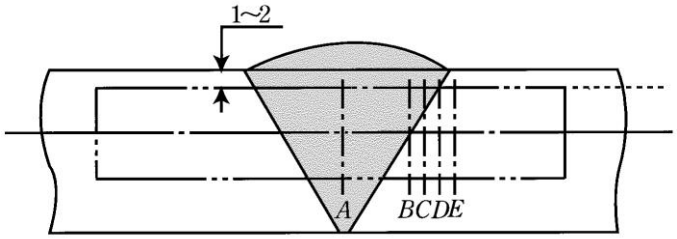
b: On fusion line “FL”

c: In HAZ, 2 *mm* from fusion line

d: In HAZ, 5 *mm* from fusion line

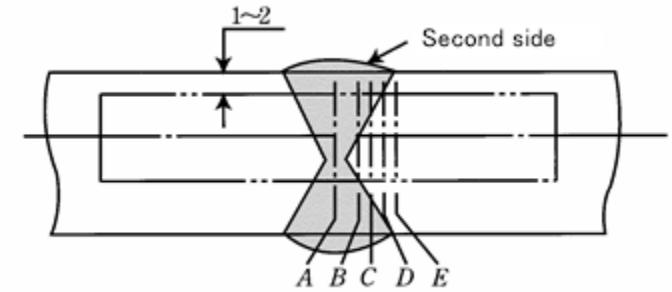
e: In HAZ, 10 *mm* from fusion line in case of heat input > 200 *kJ/cm*

Fig. M4.4 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, 1 *mm* from fusion line
D: In HAZ, 3 *mm* from fusion line
E: In HAZ, 5 *mm* from fusion line

a) For One side



b) For Both side

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*, *2D* or *2E* test specimens shown in **Table M3.1**. 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 M4.7**

2 The number of tensile test specimens taken from each test assembly is to be as shown in **Table M4.6**.

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.

4 Notwithstanding **-1** above, the ultimate tensile strength of the welded joints of steels where welding consumables different from those given in **Table M2.1** are selected in accordance with **2.4.1-1(3)** is not to be less than the minimum ultimate tensile strength of the selected welding consumable.

Table M4.7 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*	*L91* (7)	590 min. (1)	375 min.
			630 min. (2)	—
		L92 (7)	660 min. (1)	410 min. (1)
			670 min. (2)	—
Steel pipes for low temperature service	*KLP9*	*L91* (7)	630 min.	—
		L92 (7)	670 min.	—
Aluminium alloys (3)	5086*P*-*H*112 (4)		240 min.	—
	5086*P*-*H*116			
	5083*P*-*H*116		275 min.	—
	5083*P*-*H*321			
	5383*P*-*H*116		290 min.	—
	5383*P*-*H*321			
	5456*P*-*H*116 (6)			—
	5456*P*-*H*321 (6)			
	5059*P*-*H*116		330 min.	—
	5059*P*-*H*321			
	5086*S*-*H*111		240 min.	—
	5383*S*-*H*112		290 min.	—
	6061*P*-*T*6		170 min.	—
	6005*AS*-*T*5 (5) ,6005*AS*-*T*6 (5)			
	6061*S*-*T*6 (5)			
	6082*S*-*T*5 (5) ,6082*S*-*T*6 (5)			

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 12.5 *mm*

(5) See Notes (13) of **Table M4.6**.

(6) When the thickness is 40 *mm* or less.

(7) The symbols for the welding consumables listed above indicate the materials specified in **Table M6.1**, **Table M6.12** and **Table M6.21**, and have same mark at the end. (For example, "*L*91" indicates *KMWL*91, *KAWL*91 and *KSWL*91)

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 M3.2**, and the test specimens are to be bent by the jig shown in **Table M4.8**. There is to be no crack nor any other defect greater than 3 *mm* 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 M4.6**.

Table M4.8 Bend Test Requirements for Butt Welded Joint

Kind of test assembly	Grade of test assembly	Maximum radius of plunger (*mm*)(1)	Bending angle (*degree*)
Steel pipes for low temperature service	*KLP*9	$\frac{10}{3}a$	180
High strength rolled steels for offshore structures	*KA*420, *KD*420, *KE*420, *KF*420, *KA*460, *KD*460, *KE*460, *KF*460, *KA*500,*KD*500, *KE*500, *KF*500	$\frac{5}{2}a$	
	*KA*550, *KD*550, *KE*550, *KF*550, *KA*620, *KD*620, *KE*620, *KF*620, *KA*690, *KD*690, *KE*690, *KF*690	3*a*	
	*KA*890, *KD*890, *KE*890, *KA*960, *KD*960, *KE*960	(5)	
Aluminium alloys (2)	5754*P* 5086*P*, 5086*S* (3) 5083*P*, 5083*S* (3) 5383*P*, 5383*S* (3) 5059*P*, 5059*S* (3) 5456*P* 6005*AS* (4) 6061*P*, 6061*S* (4) 6082*S* (4)	$\left(\frac{100 \times a}{A} - a\right) \times 0.5$	
Other materials		2*a*	

Notes:

(1) *a*: thickness of the test specimen specified in **Table M3.2** (*mm*)
A: minimum elongation specified in **Table K8.3** (*%*) and in the case of a combination of different alloys, the lowest individual value is to be used.

(2) See **Notes (11)** of **Table M4.6**.

(3) See **Notes (12)** of **Table M4.6**.

(4) See **Notes (13)** of **Table M4.6**.

(5) Standards deemed appropriate by Society

4.2.7 Impact Tests*

1 Impact test specimens are to be *U*4 specimens shown in **Table K2.5** and to be taken from the position shown in **Fig. M4.2** to **Fig. M4.4**. Where *U*4 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 K 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 M4.6** and **Fig. M4.2** to **Fig. M4.4**. 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 M4.9** to **Table M4.11** 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.

7 In cases where maximum thickness to be approved is more than 50 *mm* but not exceeding 70 *mm*, *CTOD* tests or deep notch tests (hereinafter referred to as "brittle fracture tests"), or technical documents related to such brittle fracture tests may be required in addition to impact tests; in cases where such maximum thickness to be approved exceeds 70 *mm*, brittle fracture tests are to be carried out in addition to impact tests or technical documents related to such brittle fracture tests are to be submitted to the Society. Also, brittle fracture tests described above are to be carried out at the maximum thickness to be approved. However, both brittle fracture tests and the technical documents related to such brittle fracture tests may be omitted where deemed appropriate by the Society.

Table M4.9 Impact Test Requirements for Butt Weld Joint

(Rolled Steel for Hull, where thickness of test assemblies is not greater than 50 *mm*)(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			
*KA*32, *KA*36	20			
*KD*32, *KD*36	0			
*KE*32, *KE*36	-20			
*KF*32, *KF*36	-40			
*KA*40	20		39	39
*KD*40	0			
*KE*40	-20			
*KF*40	-40			

Notes:

(1) In cases where the thickness of test assemblies exceeds 50 *mm* or *KE*47 is used, impact test requirements deemed appropriate by the Society are to be applied.

(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 anyone 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 27 *J*.

Table M4.10 Impact Test Requirements for Butt Welded Joint (Rolled Steels for Lower Temperature Service and Steel Pipes for Low Temperature Service)

Grade of steel	Testing temperature (℃)	*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		34	
KLP3	-95			
KLP9	-196		41	

Notes:

(1) Position of notch as shown in **Fig.M4.4**.

(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.

Table M4.11 Impact Test Requirements for Butt Weld Joints
(High Strength Rolled Steels for Offshore Structures)

Grade of steel	Testing temperature (℃)	Minimum mean absorbed energy (J)[1]		
		a[2]	B, c, d, e[2]	
			L[3]	T[3]
*KA*420	0	47	42	28
*KD*420	-20			
*KE*420	-40			
*KF*420	-60			
*KA*460	0		46	31
*KD*460	-20			
*KE*460	-40			
*KF*460	-60			
*KA*500	0	50	50	33
*KD*500	-20			
*KE*500	-40			
*KF*500	-60			
*KA*550	0	55	55	37
*KD*550	-20			
*KE*550	-40			
*KF*550	-60			
*KA*620	0	62	62	41
*KD*620	-20			
*KE*620	-40			
*KF*620	-60			
*KA*690	0	69	69	46
*KD*690	-20			
*KE*690	-40			
*KF*690	-60			
*KA*890	0	69	69	46
*KD*890	-20			
*KE*890	-40			
*KA*960	0	69	69	46
*KD*960	-20			
*KE*960	-40			

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 M4.2** and **Fig M4.3**.

(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.

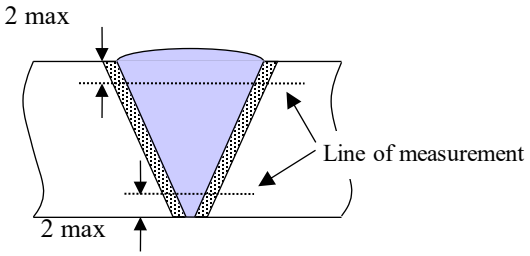
2 Macro examination shall include about 10 *mm* unaffected base metal.

4.2.9 Hardness Test

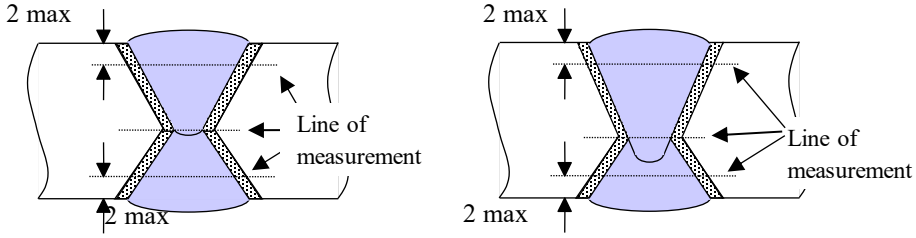
1 Vickers hardness is to be measured at the position shown in **Fig. M4.5**. The kinds of specimens for Vickers hardness are to be in accordance with the requirements specified given in **Table M4.12**.

2 The number of specimens for hardness test is to be in accordance with the requirements specified given in **Table M4.6**.

Fig. M4.5 Hardness Test (Unit: *mm*)



(a) For One side



(b) For Both side

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 1 *mm* on the basis of the bond.

(3) Test force is to be 98.07 *N*.

(4) For *KE*47, measurement at mid thickness line of is to be added.

Table M4.12 Requirements of Hardness Test

Kinds of test assembly		Vickers hardness (*HV*10)
Rolled steels for hull	*KA*36, *KD*36, *KE*36, *KF*36 *KA*40, *KD*40, *KE*40, *KF*40	350 max
	*KE*47	350 max(1)
High strength rolled steels for offshore structures	*KA*420, *KD*420, *KE*420, *KF*420 *KA*460, *KD*460, *KE*460, *KF*460	350 max
	*KA*500, *KD*500, *KE*500, *KF*500 *KA*550, *KD*550, *KE*550, *KF*550 *KA*620, *KD*620, *KE*620, *KF*620 *KA*690, *KD*690, *KE*690, *KF*690	420 max
	*KA*890, *KD*890, *KE*890, *KA*960, *KD*960, *KE*960	450 max
Rolled steels for low temperature service	*KL*37	350 max
	*KL5N*43, *KL9N*53, *KL9N*60	420 max
Steel pipes for low temperature service	*KLP*9	420 max

Note:

(1) Steels considered to have brittle crack arrest properties specified in **3.12, Part K** are to be 380 max.

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 High strength rolled steels for offshore structures are to be delayed for minimum of 48 hours, unless heat treatment has been carried out.

4.2.11 Measurement of ferrite content at weld surface

1 Measurement of ferrite content at weld surface (including weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in **Table M4.6**.

2 The ferrite content at the weld surface is to be measured for the part specified in **Fig. M4.1** prior to each test.

3 The ferrite content at the weld surface is to be measured by a method using magnetic device as specified in *JIS Z* 3119 or an equivalent method. The ferrite content of at least 6 points at different positions along the weld longitudinal direction is to be measured. Measurements are made at least 5 times at each point, and the highest value among the readings is to be used as the measured value. The measurement points are to include a minimum of 3 points in the weld metal and 3 points in the heat affected zone. However, where the width of the heat affected zone is narrow and difficult to carry out measurement, 6 points in the weld metal are to be measured.

4 The value of ferrite content at each measurement point is to be in the range of 30% to 70%.

5 Notwithstanding the requirements given in **-2** to **-4**, for welded joints of different grade of steels or when duplex stainless steel welding consumables are not used, the appropriate measurement points and the value of ferrite content are to be as deemed appropriate by the Society.

4.2.12 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 six 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 measurement of the ferrite content at the weld surface fails to meet the requirements, an additional 2 parts on the same test assembly may be retested. In such cases, measurement is to be carried out in accordance with the requirements in **4.2.11-1** and **-2** and all measurement point values are to be within the required range.

6 Where the test specimens fail to meet the requirements specified in either of preceding **-1** through **-5**, 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*

1 The requirements in **4.3** apply to the fillet weld joints of materials prescribed in shown in **Table M4.6** or equivalent materials

welded by a manual, semi-automatic or automatic welding method, etc.

2 The requirements for branch connections in **4.6** are applicable in cases where the angles of the pipe (or tube) fittings of test assemblies are less than 90 degrees.

4.3.2 Kinds of Test*

Fillet weld joints are to be subjected to finished inspection, macro-structure inspection, hardness test, fracture, non-destructive inspection test and measurement of ferrite content at the weld surface. 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. M4.6**.

3 Test assemblies are to be welded in the general conditions specified in welding procedure specifications.

4 The assembly is to be welded on one side only, except in case deemed necessary by the Surveyor.

5 In case wheres the test assembly is a plate, 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 10 *mm* unaffected base metal.

4.3.6 Hardness Test

1 Vickers hardness is to be measured at the position shown in **Fig. M4.7**. The kinds of specimens for Vickers hardness are to be in accordance with the requirements specified given in **Table M4.12**.

2 The number of specimens for hardness test are to be in accordance with the requirements specified given in **Table M4.6**.

4.3.7 Fracture Tests

1 In cases where the test assembly is a plate, two (2) test specimens are to be taken from the remainder of the test assembly after the macro-structure specimen has been removed.

2 In cases where the test assembly is a pipe (or tube), an appropriate number of test specimens is to be taken from the remainder of the test assembly after the macro-structure specimen has been removed.

3 The test assemblies are to be broken by pressing as shown in **Fig. M4.6**, 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 (only for plate test assemblies), 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 High strength rolled steels for offshore structures are to be delayed for minimum of 48 hours, unless heat treatment has been carried out.

4.3.9 Measurement of ferrite content at weld surface

1 Measurement of ferrite content at the weld surface (including weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in **Table M4.6**.

2 The ferrite content at the weld surface is to be measured for the part specified in **Fig. M4.6** in accordance with the requirement in **4.2.11-3** to **-5** prior to each test.

4.3.10 Retests

1 Where visual inspection, macro-structure inspection, fracture test or non-destructive inspection test fails, the new test specimens

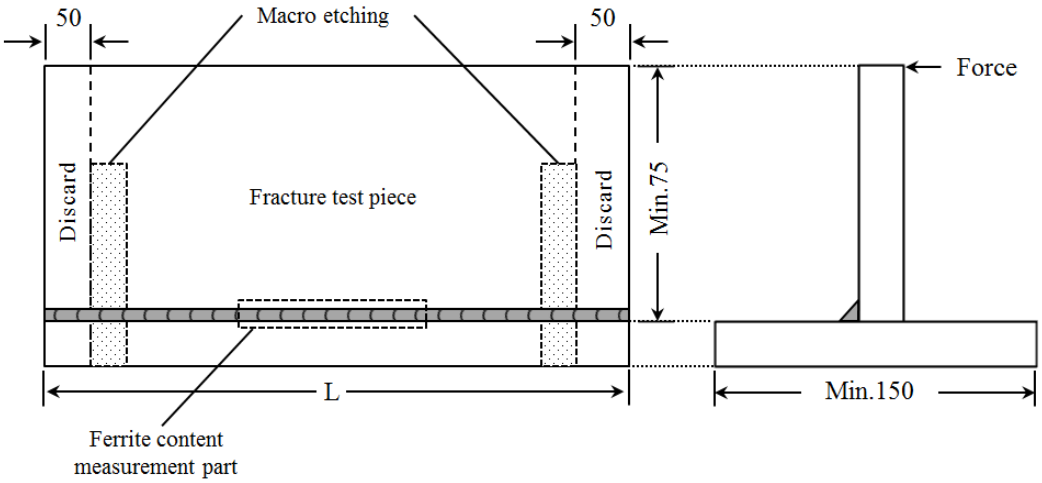
welded under the same welding conditions, are to be subject to retest, and all of these test specimens are to pass the test items specified.

2 Where the hardness test fails, the retest may be correspondingly applied to the requirement in **4.2.12-4**.

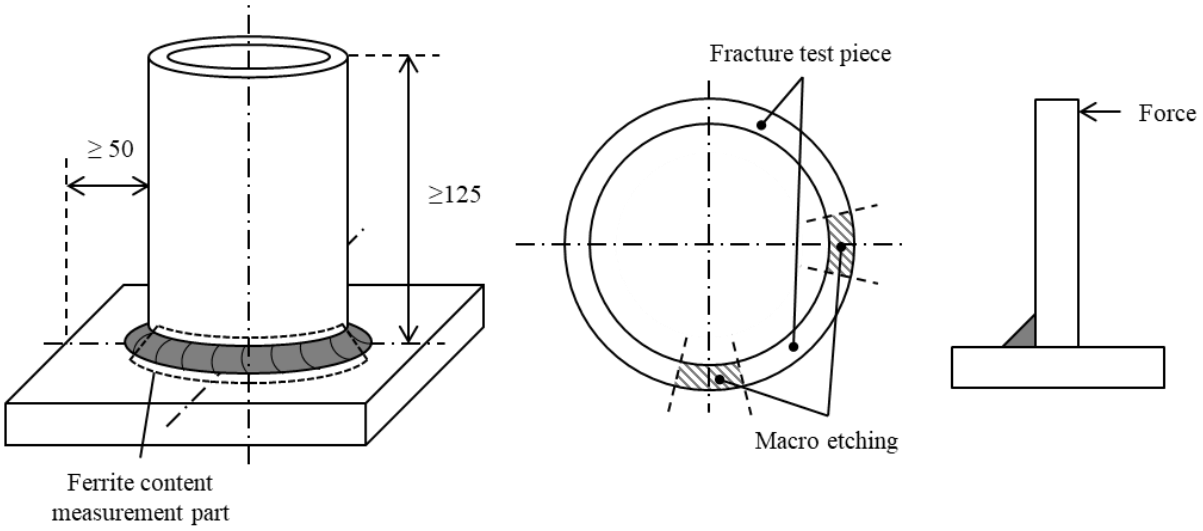
3 Where the measurement of the ferrite content at the weld surface fails to meet the requirements, a retest may be carried out by correspondingly applying the requirement in **4.2.12-5**.

Fig. M4.6 Test Assembly for Fillet Weld Joints (Unit: *mm*)

(a) Plate(1)(2)(3)(4)(7)



(b) Pipe (or Tube)(2)(3)(4)(5)(6)(7)



Notes:

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

(2) Measurement of ferrite content at the weld surface (including weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in **Table M4.6**.

(3) The part measured for ferrite content may be an arbitrarily selected part of the weld, excluding any discards.

(4) The thickness of a plate (or pipe) and the thickness of a flange may be different.

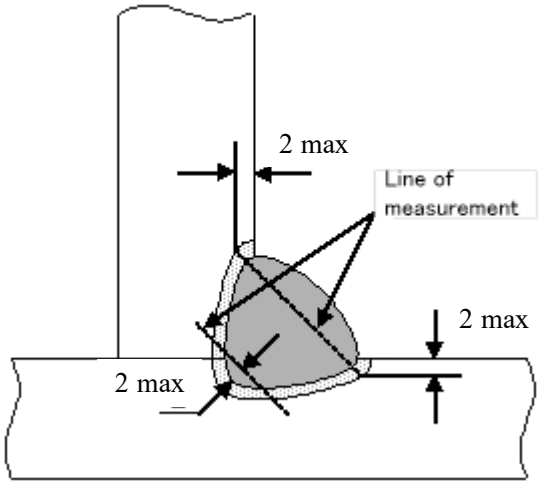
(5) The dimensions of flange material are arbitrary. However, the distance between the outer circle of a pipe (or tube) and the end of a flange is not to be less than 50 *mm* at the surface of the flange.

(6) For the upward welding and downward welding horizontally fixed pipe (or tube) positions, macro-structure specimens are to be taken from the bottoms and sides of test assemblies.

(7) Hardness tests may be carried out using one of the macro-structure specimens. In the case of the upward welding horizontally fixed pipe (or tube) position, macro-structure specimens are to taken from the bottoms of test assemblies; however, in the case of the downward welding horizontally fixed pipe (or tube) position, macro-structure specimens are

to be taken from the sides of test assemblies.

Fig. M4.7 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 1 *mm* on the basis of the bond.

(3) Test force is to be 98.07 *N*.

4.4 Tests for T-joints with Full Penetration

4.4.1 Application

1 The requirements in 4.4 apply to the T-joints with full penetration of materials prescribed in Table M4.6 or equivalent materials welded by a manual, semi-automatic or automatic welding method, etc.

2 The requirements for branch connections in 4.6 are applicable in cases where the angles of the pipe (of tube) fittings of test assemblies are less than 90 degrees.

4.4.2 Kinds of Test

T-joints with full penetration are to be subjected to finished inspection, macro-structure inspection, hardness test, non-destructive inspection test and the measurement of ferrite content at the weld surface.

4.4.3 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. M4.8.

3 Test assemblies are to be welded in the general conditions specified in welding procedure specifications.

4 The tack welds of test piece are to be the same procedure as actual work.

4.4.4 Finished Inspection

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

4.4.5 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.

4.4.6 Hardness Test

1 Vickers hardness is to be measured at the position shown in Fig. M4.9. The kinds of specimens for Vickers hardness are to be in accordance with the requirements specified given in Table M4.12.

2 The number of specimens for hardness tests is to be in accordance with the requirements specified in Table M4.6.

4.4.7 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 High strength rolled steels for offshore structures are to be delayed for minimum of 48 hours, unless heat treatment has been carried out.

4.4.8 Measurement of ferrite content at weld surface

1 Measurement of ferrite content at the weld surface (including weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in **Table M4.6**.

2 The ferrite content at the weld surface is to be measured for the part specified in **Fig. M4.8** in accordance with the requirement in **4.2.11-3** to **-5** prior to each test.

4.4.9 Retests

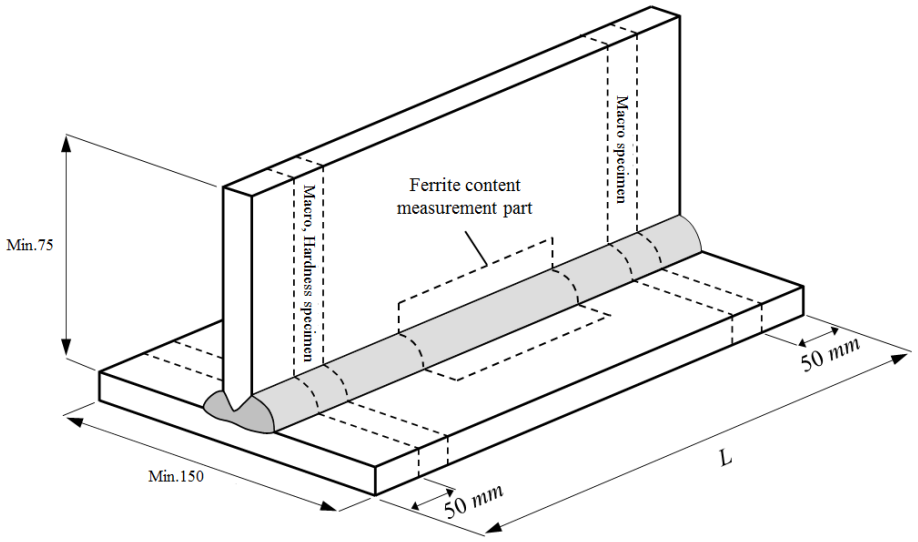
1 Where visual inspection, macro-structure inspection or non-destructive inspection test fails, the new test specimens welded under the same welding conditions, are to be subject to retest, and all of these test specimens are to pass the test items specified.

2 Where the hardness test fails, the retest may be correspondingly applied to the requirement in **4.2.12-4**.

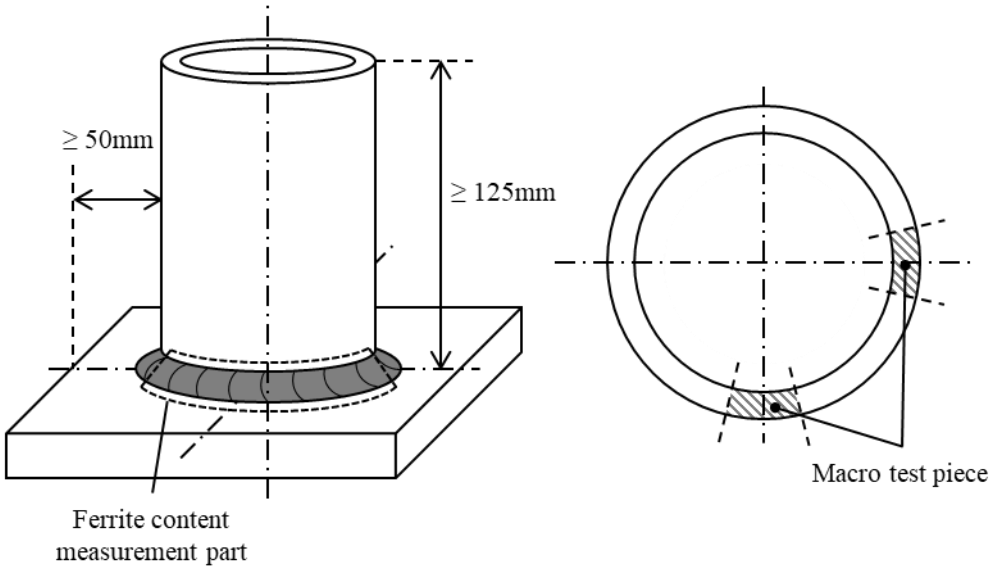
3 Where the measurement of the ferrite content at the weld surface fails to meet the requirements, a retest may be carried out by correspondingly applying the requirement in **4.2.12-5**.

Fig. M4.8 Test Assembly for T-joints with Full Penetration

(a) Plate[(1)(2)(3)(4)(7)]



(b) Pipe (or Tube)[(2)(3)(4)(5)(6)(7)]



Notes:

(1) The length of test specimen, L is not less than 350 *mm* for manual welding and semi-automatic welding and not less than 1,000 *mm* for automatic welding.

(2) Measurement of ferrite content at the weld surface (including weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in **Table M4.6**.

(3) The part measured for ferrite content may be an arbitrary selected part of the weld, excluding any discards.

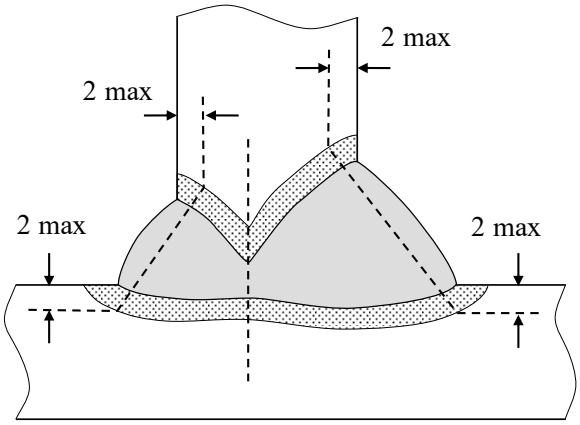
(4) The thickness of a plate (or pipe) and the thicknesses of a flange may be different.

(5) The dimensions of flange material are arbitrary. However, the distance between the outer circle of a pipe (or tube) and the end of flange is not to be less than 50 *mm* at the surface of the flange.

(6) For the upper welding and downward welding horizontally fixed pipe (or tube) positions, macro-structure specimens are to be taken from the bottoms and sides of test assemblies.

(7) Hardness tests may be carried out using one of the macro-structure specimens. In the case of the upward welding horizontally fixed pipe (or tube) position, macro-structure specimens are to be taken from the bottoms of test assemblies; however, in the case of the downward welding horizontally fixed pipe (or tube) position, macro-structure specimens are to be taken from sides of the test assemblies.

Fig. M4.9 Hardness Test (Unit: *mm*)



Notes:

(1) For each row of indentations there is to 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 1 *mm* on the basis of the bond.

(3) Test force is to be 98.07 *N*.

4.5 Tests for T-joints with Partial Penetration

4.5.1 Application

1 The requirements in 4.5 apply to the T-joints with partial penetration of materials prescribed in Table M4.6 or equivalent materials welded by a manual, semi-automatic or automatic welding method, etc.

2 The requirements for branch connections in 4.6 are applicable in cases where the angles of the pipe (or tube) fittings of test assemblies are less than 90 degrees.

4.5.2 Kinds of Test

T-joints with partial penetration are to be subjected to finished inspection, macro-structure inspection, fracture test, hardness test, non-destructive inspection and measurement of ferrite content at the weld surface. Additional tests may be required if found necessary by the Society.

4.5.3 Test Assemblies and Welding

1 Test assemblies are to be prepared with the same or equivalent material used in the actual work.

2 The dimensions and type of test assemblies are to be as indicated in Fig. M4.10.

3 Test assemblies are to be welded in the general conditions specified in welding procedure specifications.

4 The tack welds of test assemblies are to be the same procedure as the actual work.

4.5.4 Finished Inspection

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

4.5.5 Macro-structure Inspection

1 Macro specimens are to be taken from the position indicated in Fig. M4.10.

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

3 Macro examination is to include about 10 *mm* unaffected base metal.

4.5.6 Hardness Test

1 Vickers hardness is to be measured at the position shown in Fig. M4.11. The kinds of specimens for Vickers hardness are to be in accordance with the requirements specified given in Table M4.12.

2 The number of specimens for hardness test is to be in accordance with the requirements specified given in Table M4.6.

4.5.7 Fracture Tests

1 In cases where the test assembly is a plate, two test specimens are to be taken from the remaining test assembly after the macro-structure specimens have been taken.

2 In cases where the test assembly is a pipe (or tube), an appropriate number of test specimens is to be taken from the remainder of the test assembly after the macro-structure specimen has been removed.

3 Test specimens are to be broken by pressing as shown in Fig. M4.12, and be without cracks, poor penetrations, blow holes and injurious defects in the fractured surface. However, in cases where , the sum of lengths having blow holes (include poor penetrations), except at both ends of the specimen (only for plate test assemblies), is not greater than 10% of the total welded length, the test may be regarded as satisfactory.

4.5.8 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 is to be performed after heat treatment.

3 High strength rolled steels for offshore structures is to be delayed for minimum of 48 hours, unless heat treatment has been carried out.

4.5.9 Measurement of ferrite content at weld surface

1 Measurement of ferrite content at the weld surface (including weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in Table M4.6.

2 The ferrite content at the weld surface is to be measured for the part specified in Fig. M4.10 in accordance with the requirement in 4.2.11-3 to -5 prior to each test.

4.5.10 Retests

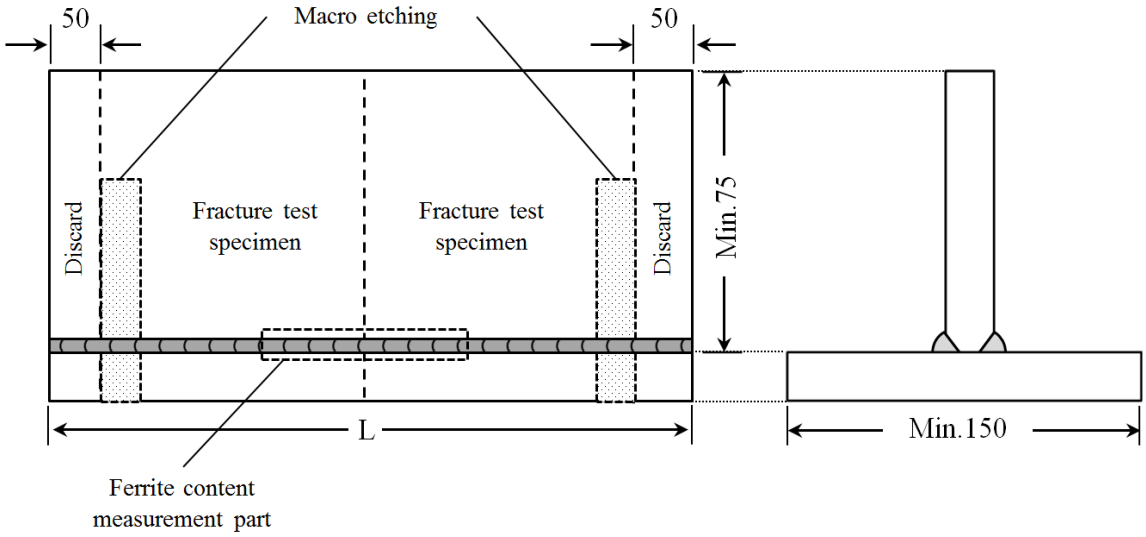
1 Where finished inspection, macro-structure inspection, fracture test or non-destructive inspection fails, the new test specimens welded under the same welding conditions, are to be subject to retest, and all of these test specimens are to pass the test items specified.

2 Where the hardness test fails, the retest may be correspondingly applied to the requirement in 4.2.12-4.

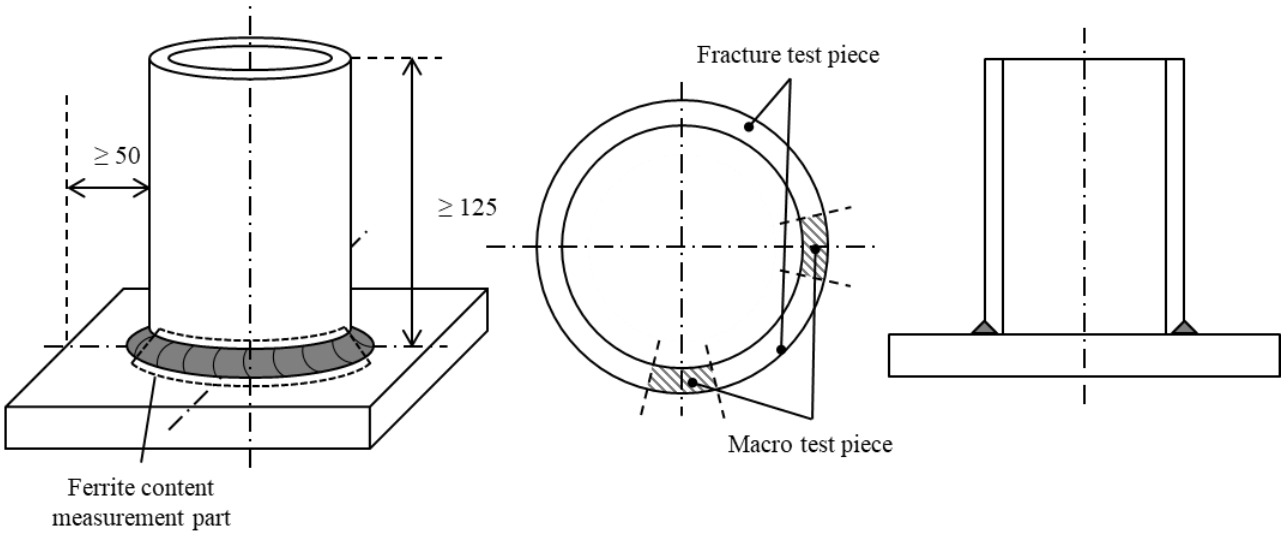
3 Where the measurement of the ferrite content at the weld surface fails to meet the requirements, a retest may be carried out by correspondingly applying the requirement in 4.2.12-5.

Fig. M4.10 Test Assemblies for T-joints with Partial Penetration (Unit: *mm*)

(a) Plate(1)(3)(4)(5)(6)



(b) Pipe (or Tube)(2)(3)(5)(6)(7)(8)



Notes:

(1) The length of test assemblies, *L* is not less than 350 *mm* for manual welding and semi-automatic welding (including gravity welding) and not less than 1,000 *mm* for automatic welding.

(2) For the upward welding and downward welding horizontally fixed pipe (or tube) positions, macro-structure specimens are to be taken from the bottoms and sides of test assemblies.

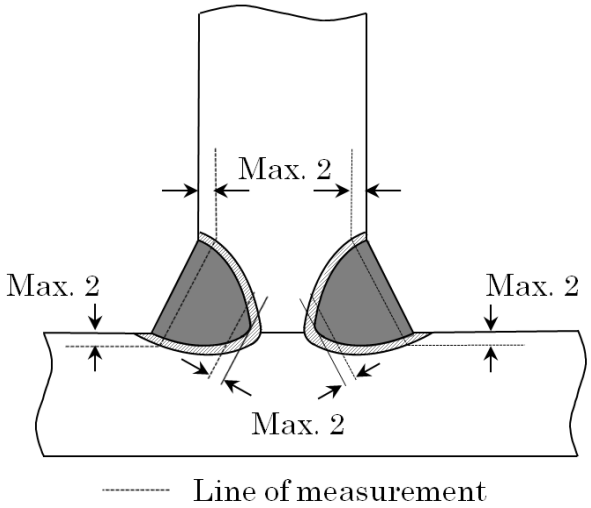
(3) Hardness tests may be carried out using one of the macro-structure specimens. In the case of the upward welding horizontally fixed pipe (or tube) position, macro-structure specimens are to be taken from the bottoms of test assemblies; however, in the case of the downward welding horizontally fixed pipe (or tube) position, macro-structure specimens are to be taken from the sides of test assemblies.

(4) Fracture test specimens are, as far as possible, to be taken in equal lengths in the direction of welding direction.

(5) Measurement of ferrite content at the weld surface (including weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in Table M4.6.

(6) The part measured for ferrite content may be an arbitrarily selected part of the weld, excluding any discards.
(7) The thickness of a plate (or pipe) and the thickness of a flange may be different.
(8) The dimensions of flange material are arbitrary. However, the distance between the outer circle of a pipe (or tube) and the end of a flange is not to be less than 50 *mm* at the surface of the flange.

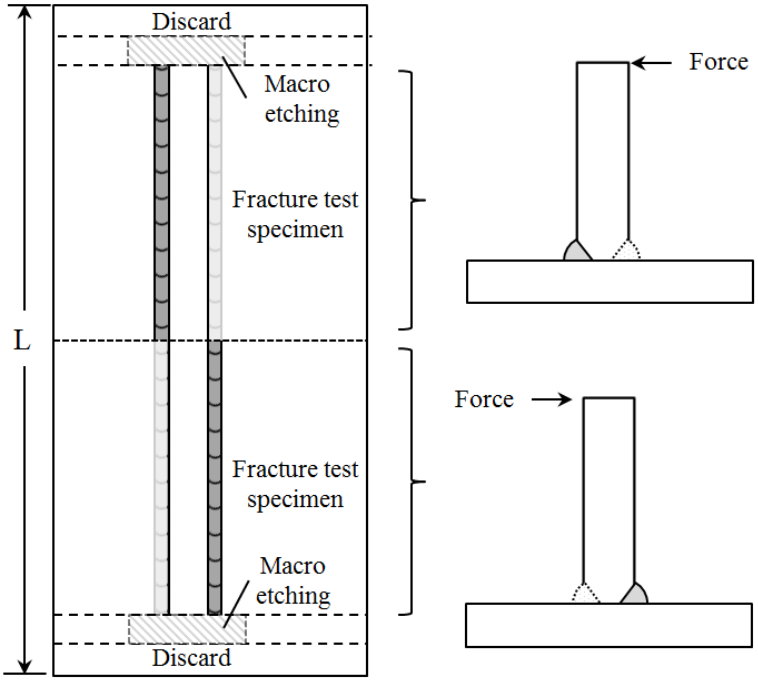
Fig. M4.11 Hardness Test (Unit: *mm*)



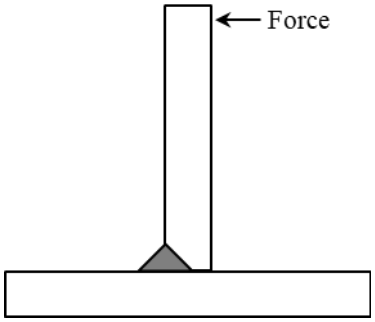
Notes:
(1) For each row of indentations there is to be a minimum of 3 individual indentations in the weld metal, the heat affected zones (both side) and the base metal (both sides).
(2) Measuring intervals are to be 1 *mm* on the basis of the bond.
(3) Test force is to be 98.07 *N*.

Fig. M4.12 Fracture Test (Unit: *mm*)

(a) Plate(1)



(b) Pipe (or Tube)



Note:

(1) Welding is to be removed from the side where force is applied.

4.6 Tests for branch connection

4.6.1 Application

The requirements in 4.6 apply to the branch connections of the materials prescribed in Table M4.6 or equivalent materials welded by a manual, semi-automatic or automatic welding method, etc. in cases where the angles of pipe (or tube) fittings are less than 90 degrees, as prescribed in 4.3.1-2, 4.4.1-2 and 4.5.1-2.

4.6.2 Kinds of Test

Branch connections are to be subjected to finished inspections, macro-structure inspections, fracture tests, hardness tests, non-destructive inspections and measurements of ferrite content at the weld surface.

4.6.3 Test Assemblies and Welding

1 Test assemblies are to be prepared with the same or equivalent material used in the actual work.

2 The dimensions and types of test assemblies are to be as indicated in Fig. M4.13.

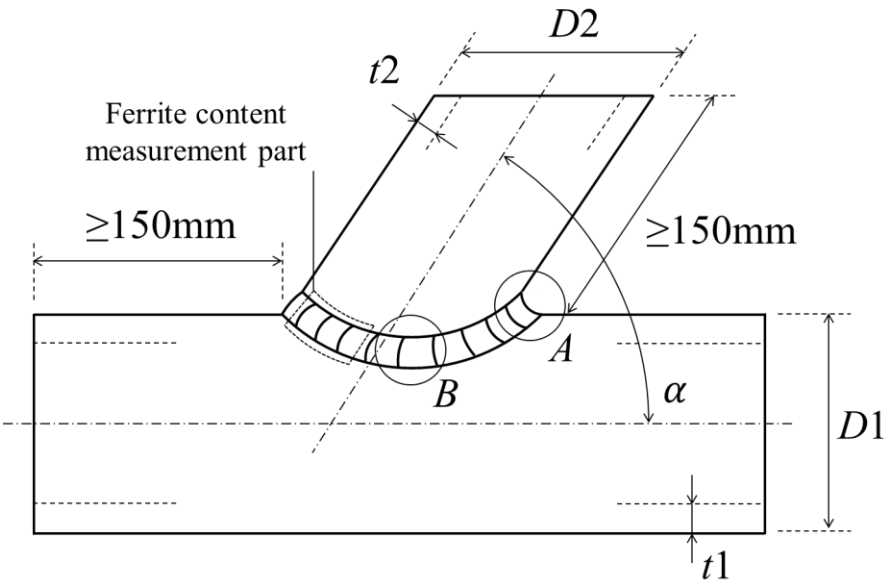
3 The joints of test assemblies are to be welded by as T-joints with partial penetration, T-joints with full penetration or fillet weld joints, whichever is used in the actual work.

4 The kinds of joint assemblies of test assemblies are to be Set-on, Set-in or Set-through, whichever is used in the actual work.

5 Test assemblies are to be welded in accordance with the general conditions specified in the welding procedure specifications.

6 The tack welds of test assemblies are to be of the same procedure as the actual work.

Fig. M4.13 Branch connection



Notes:

(1) The angle of a pipe (or tube) fitting in "α" degrees is the minimum value in the actual work.

(2) Measurement of ferrite content at the weld surface (including the weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in Table M4.6.

(3) The part measured for ferrite content may be an arbitrary selected part of the weld.

(4) *D*1 and *D*2 may be different.

(5) *t*1 and *t*2 may be different.

(6) The distance between the outer circle of a pipe (or tube) and the end of another pipe (or tube) is not to be less than 150 *mm*.

(7) Macro-structure specimens are to be taken from parts *A* and *B*.

(8) Hardness tests may be carried out using macro-structure specimens taken from part *A*.

4.6.4 Finished Inspection

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

4.6.5 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 examinations are to include about 10 *mm* of unaffected base metal.

4.6.6 Hardness Test

1 Vickers hardness is to be measured at the positions shown in **Fig. M4.7**, **Fig. M4.9** or **Fig. M4.11**. The kinds of specimens for Vickers hardness are to be in accordance with the requirements specified in **Table M4.12**.

2 The number of specimens for hardness tests is to be in accordance with the requirements specified in **Table M4.6**.

4.6.7 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 the whole length of the welding. The results of non-destructive inspections are to show that there are no cracks, poor penetration, lack of fusion and other injurious defects. For T-joints with partial penetration and fillet weld joints, fracture tests may be accepted instead of radiographic examination or ultrasonic examination. In such cases, the fracture test may be carried out by correspondingly applying the requirements in **4.3.7** or **4.5.7**.

2 In cases where post-weld heat treatment is required or specified, non-destructive inspections are to be performed after the heat treatment.

4.6.8 Measurement of Ferrite Content at Weld Surface

1 Measurement of ferrite content at the weld surface (including the weld metal and heat affected zone) is to be carried out in accordance with kind and grade of test assembly specified in **Table M4.6**.

2 The ferrite content at the weld surface is to be measured prior to each test for the parts specified in **Fig. M4.13** in accordance with the requirements in **4.2.11-3** to **-5**.

4.6.9 Retests

1 Where finished inspections, macro-structure inspections, non-destructive inspections (or fracture tests) fail, new test specimens welded under the same welding conditions are to be subject to retests, and all of these test specimens are to pass the test items specified.

2 Where hardness tests fail, retests may be carried out by correspondingly applying the requirements in **4.2.12-4**.

3 Where the measurement of the ferrite content at the weld surface fails to meet the requirements, retests may be carried out by correspondingly applying the requirements in **4.2.12-5**.

Chapter 5 WELDERS AND WELDERS QUALIFICATION TESTS

5.1 General

5.1.1 Welders

1 Each welder and welding operator (hereinafter referred to as "welder") to be engaged in the welding work specified in this part is to pass the qualification tests (including initial and renewal tests, except in cases where otherwise specified) with respect to each welder qualification (hereinafter referred to as "qualification") required depending on the applicable welding process and materials to be welded, and to obtain the qualification certificate issued by the Society.

2 This chapter specifies the qualification test requirements for manual, semi-automatic, *TIG* (tungsten inert gas), gas, automatic (hereinafter including welding with auto-carriage) and tack welding process. The term "semi-automatic welding" means that the welding is carried out manually by a welder holding a gun through which only the wire is fed automatically.

3 Each welder responsible for setting up and/or adjusting the automatic welding equipment is to obtain the qualification certificate for automatic welding process or one which includes automatic welding in the range of qualification issued by the Society regardless of whether the welder operates the equipment or not. A welding operator who solely operates the equipment and is not responsible for any setting up and/or adjusting, however, does not need said qualification provided that the operator is experienced in the specific welding work concerned.

4 Each welder engaged in tack welding is to obtain the qualification certificate for the tack welding process or one which includes tack welding in the range of qualification issued by the Society.

5 This chapter specifies the qualification test requirements for the welding work of carbon steels, stainless steels aluminium alloy and nickel steel.

6 The qualification test requirements for each welder to be engaged in special welding work or the welding of special materials not specified in this chapter are to be as deemed appropriate by the Society.

7 Notwithstanding the requirements in this chapter, welders qualified in accordance with national or international welder qualification standards may also engage in the welding work at the discretion of the Society provided that the qualification testing, range of qualification and revalidation requirements, etc. are considered equivalent to this chapter. Alternative national or international welder qualification standards, however, are to be applied in full and the cross-mixing of requirements from standards is not permitted.

5.1.2 Qualification Test Applications*

In the case of applications for qualification tests, the shipyard or manufacturer (hereinafter referred to as "applicant") to which the welder taking the qualification tests belongs is to submit an application form (Form-WE(E)) along with a photograph of the welder to the Society (relevant branch office or service site).

5.1.3 Welder Qualification Certificates*

1 Qualification certificates are to be issued to the applicant by the Society for welders who have passed qualification tests. Qualification certificates are to include the following items:

(1) Essential variables (welding process, product, type of welded joint, base metal, welding consumable, base metal thickness, outside diameter, welding positions and detail of welded joint.)

(2) Range of qualification for **(1)** above.

(3) Period of validity for the qualification certificate.

(4) Name, date of birth and photograph of the welder.

(5) Name of the applicant.

(6) Welder's ID.

(7) Renewal methods of qualification in accordance with 5.1.6.

2 The qualification certificate is to be shown to the Surveyor at any time if required.

3 The applicant is to request without delay that the Society reissue or rewrite any qualification certificates which are lost, soiled, or in which there has been a change in the items specified on them.

4 The reissuance or rewriting of qualification certificates is to be done in accordance with **-3** above, and the applicant is to submit an application for the reissuance or rewriting of the qualification certificate (any format acceptable, but the application is to include the welder's ID as well as the welder's name and date of birth) and a photograph of welder to the Society (relevant branch office or service site).

5.1.4 Period of Validity for Qualification Certificates*

A qualification certificate is to be valid from the date on which the welder passed the qualification test to a date not exceeding the period corresponding to the renewal methods selected in accordance with **5.1.6**.

5.1.5 Verification of the Validity of Qualification Certificates*

1 The person responsible for production weld quality is to verify the following items for each welder who has a qualification certificate at least once every six months. The results of this verification are to be recorded on the relevant qualification certificate or in any relevant documents, and then submitted for verification by a Society surveyor.

(1) The welder has engaged with reasonable continuity in the concerned welding work.

(2) The welder's work has been carried out within the qualified range specified in certificates.

(3) There is no specific reason to question the welder's skill and knowledge.

2 In cases where the results of verification do not fulfill any of the items in **-1** above, the person responsible for production weld quality is to apply for the cancelation of the welder's qualification certificates, except in cases related to **-1(1)** and **-1(2)** above where deemed appropriately by the Society.

5.1.6 Continuation of Qualification

1 The period of validity for a qualification certificate is to be renewed in accordance with one of the following **(1)** to **(3)** methods.

(1) The method in cases where the welder welds a test assembly covered in the qualification test (renewal) in accordance with **5.3** (however, excluding the requirements for ultrasonic testing in **5.3.5-7**, **5.3.6-5** and **5.3.7-2**) within six months before the expiry date of the existing certificate, and satisfies either requirement **(a)** or **(b)** as well as **(c)** below, the period of validity for the renewed qualification certificate is to be until three years from the day after the expiry date of the existing certificate.

(a) The welder passes the qualification test (renewal) or retest before the expiry date of the existing certificate.

(b) The welder passes the retest for qualification test (renewal) after the expiry date of the existing certificate.

(c) In cases where the verification of the validity of qualification certificate specified in **5.1.5** is carried out, and the results of said verification are deemed satisfactory by the Surveyor.

(2) The method in cases where the welder welds a test assembly covered in the qualification test (renewal) in accordance with **5.3** within six months before the expiry date of the existing certificate, and satisfies either requirement **(b)** or **(c)** as well as **(a)** and **(d)** below, the period of validity for the renewed qualification certificate is to be until two years from the day after the expiry date of the existing certificate.

(a) Two welds made to reproduce the initial test conditions except for the thickness are to be tested by one of the radiographic tests, ultrasonic tests, bend tests, fracture tests, notch tensile tests or macro-structure inspections and the results of said verification are deemed satisfactory by the Surveyor. In such a cases, the test results are to be recorded.

(b) The welder passes the qualification test (renewal) or retest before the expiry date of the existing certificate.

(c) The welder passes the retest for qualification test (renewal) after the expiry date of the existing certificate.

(d) In cases where the verification of the validity of qualification certificate specified in **5.1.5** is carried out, and the results of said verification are deemed satisfactory by the Surveyor.

(3) The method in cases where the results of the requirements **(a)** to **(d)** are verified and are deemed satisfactory by the Surveyor, the period of validity for the renewed qualification certificate is to be until the date of the next verification from the day after the completion of verification. The frequency of verification is to be no longer than three years and is to be agreed upon by the Society in advance.

(a) The welder is working for the same shipyard or manufacturer that is responsible for production weld quality as indicated on his or her qualification certificate.

(b) The welder quality management system of the shipyard or manufacturer including the following items at a minimum is verified by the Society in advance.

i) A designated person responsible for the coordination of the welder quality management system.

ii) List of welders and welding supervisors in shipyard or manufacturer.

iii) List of subcontracted welders (if applicable).

iv) Qualification certificates of welders and a description of the associated management system.

v) Training requirements for the welder qualification programme.

vi) Identification system for welders and welding procedure and related specifications used on welds.

vii) The criteria permitting the maintenance of welder qualification without retesting (e.g. repair rate).

viii) Procedure describing the system in place to monitor each welder performance based on results of welds examination records.

(c) The shipyard or manufacturer is to document at least once a year that the welder has produced acceptable welds in accordance with construction quality standards and the welder qualification certificate by the system. Which documents are required and how to document the evidences are to be verified by the Society in advance.

(d) The validity of qualification certificate is verified in accordance with **5.1.5**.

2 Notwithstanding **-1(1)** above, in cases where the welder welds a test assembly covered on the qualification test (renewal) prior to six months before the expiry date of the existing certificate, passes the qualification test (renewal), and fulfills the requirement **-1(1)(c)** above, the new qualification certificate is to be valid from the date on which the welder passed the qualification test to a date not exceeding three years from the said date.

3 In the case of continuation of a qualification, the applicant to which the welder taking the qualification tests belongs to is to submit a completed welder qualification tests application (**Form WE(E)**) along with a photograph of the welder and the existing qualification certificate (copy) to the Society (relevant branch office or service site).

4 A qualification test (renewal) is, in principle, to be carried out under test conditions in accordance with the essential variables of the qualification test (initial) by each the qualification applying for continuation.

5 In cases where the Society approves the application of alternative national or international welder qualification standards in accordance with **5.1.1-7**, the renewal of qualification is to be in accordance with this paragraph.

5.1.7 Revocation of Qualification Certificates

1 The Society will cancel a qualification certificates and notify the applicant of such in the following cases:

(1) The verification of the validity of qualification certificates specified in **5.1.5-1** is incomplete.

(2) An application for the cancelation of a qualification certificate according to the requirement specified in **5.1.5-2** is received.

(3) There is specific reason to question a welder's ability.

2 In cases where a welder whose qualification certificate has been cancelled applies to take the qualification tests once again, they are to apply to take the qualification tests (initial).

5.2 Qualifications

5.2.1 Kind of Qualification*

1 The kind of qualification is to be classified according to the welding process as follows:

(1) The qualification for manual, semi-automatic and *TIG*, gas welding process is to consist of the essential variables specified in following **(a)** through **(i)**:

(a) The variables of the welding process are to be classified as given in **Table M5.1** according to the welding process applied for the test assembly.

(b) The variables of the product are to be classified as given in **Table M5.3** according to the product used for test assembly.

(c) The variables of the type of welded joint are to be classified as given in **Table M5.4** according to the type of welded joint applied in test assembly. In addition, T-joints with partial or full penetration welds are to be included in the variables for butt welding.

(d) The variables of the base metal are to be classified as given in **Table M5.5** according to the kind of base metal used for the test assembly.

(e) The kind of welding consumable is to comply with requirements specified in **5.3.2** according to the kind of base metal used for the test assembly.

(f) The range of qualification for base metal thickness is to be classified as given in **Table M5.6** according to the base metal thickness of the test assembly.

(g) The range of qualification for outside diameter is to be classified as given in **Table M5.7** according to the outside diameter of the test assembly.

(h) The variables of the welding positions are to be classified as given in **Table M5.8** and **Table M5.9** according to the welding positions applied for the test assembly. The symbols used in the table are to be as indicated in **Table M5.10** and **Table M5.11**

(i) The variables of the detail of welded joint are to be classified as given in **Table M5.12** according to details of the welded joints applied in the test assembly.

(2) The qualification for automatic welding process is to consist of the essential variables specified in the following **(a)** through **(c)** notwithstanding the variables for product, type of joint, base metal thickness, outside diameter, welding position and detail of welded joint:

(a) The variables of the welding process are to be classified as given in **Table M5.2** according to the welding process applied for the test assembly. However, variables other than those specified in the table may be used in cases where deemed necessary by the Society.

(b) The variables of the base metal are to be classified as given in **Table M5.5** according to the kind of base metal used for the test assembly.

(c) The kind of welding consumable is to comply with requirements specified in **5.3.2** according to the kind of base metal used for the test assembly.

(3) The qualification for tack welding process is to consist of the essential variables specified in following **(a)** through **(f)** notwithstanding the variables for base metal thickness, outside diameter and detail of welded joint:

(a) The variables of the welding process are to be classified as given in **Table M5.1** according to the welding process applied for the test assembly.

(b) The variables of the product are to be classified as given in **Table M5.3** according to the product used for test assembly.

(c) The variables of the type of welded joint are to be classified as given in **Table M5.4** according to the type of welded joint applied in the test assembly. In addition, T-joints with partial or full penetration welds are to be included in the variables for butt welding.

(d) The variables of the base metal are to be classified as given in **Table M5.5** according to the base metal used in the test assembly.

(e) The kind of welding consumable is to comply with the requirement specified in **5.3.2** according to the kind of base metal used in the test assembly.

(f) The variables of the welding positions are to be classified as given in **Table M5.8** and **Table M5.9** according to the welding positions applied for the test assembly. The symbols in the table are to be as indicated in **Table M5.10** and **Table M5.11**

2 The necessary qualification for actual welding work using different processes (combination welding) is to be as deemed appropriate by the Society.

Table M5.1 Essential Variables of Welding Process

Welding process applied for test assembly	Symbol	Welding process applicable to actual welding work
Manual welding	*MW*	*MW*
Semi-automatic welding	*SW*	*SW*
TIG welding	*TW*	*TW*
Gas welding	*GW*	*GW*

Table M5.2 Essential Variables of Automatic Welding Process

Welding process applied for test assembly	Symbol	Welding process applicable to actual welding work
Submerged arc welding	*SAW*	*SAW*
Automatic gas-shielded metal arc welding	*AGMAW*	*AGMAW*
Automatic *TIG* welding	*AGTAW*	*AGTAW*
Automatic self-shielded arc welding	*ASSAW*	*ASSAW*
Electrogas welding	*EGW*	*EGW*
Electroslag welding	*ESW*	*ESW*
Gravity welding	*GRW*	*GRW*
Other automatic welding	*ETC*(1)	*ETC*(1)

Note:

(1) In cases where classified as *ETC*, qualification tests are to be carried out for each welding process for which qualification is desired.

Table M5.3 Essential Variables of Product

Product used for test assembly	Symbol	Product applicable to actual welding work
Plate	*P*	*P*
Tube	*T*	*T*

Table M5.4 Essential Variables of Type of Welded Joint

Type of welded joint applied for test assembly	Symbol	Type of welded joint applicable to actual welding work
Butt welding	*B*	*B, F*
Fillet welding	*F*	*F*

Table M5.5 Essential Variables of Base Metal

Base metal used for test assembly	Symbol	Classification of base metal		Base metal applicable to actual welding work
		Plate	Tube	
Carbon steel	*CS*	・Rolled steels for hulls ・Rolled steel plates for boilers ・Rolled steel plates for pressure vessels ・Rolled steels for low temperature service (except *KL2N*30, *KL3N*32, *KL5N*43, *KL9N*53 and *KL9N*60) ・Rolled steel bars for machine structures ・High strength rolled steels for offshore structures ・Steel castings ・Steel castings for low temperature service (except *KLC*2 and *KLC*3) ・Steel forgings ・Steel forgings for low temperature service (except *KLF*3 and *KLF*9)	・Steel tubes for boilers and heat exchangers ・Steel pipes for pressure piping ・Headers ・Steel pipes for low temperature service (except *KLP*2, *KLP*3 and *KLP*9)	*CS*
Stainless steel	*SU*	・Rolled stainless steels ・Stainless steel castings ・Stainless steel forgings ・Stainless steel propeller castings	・Stainless steel pipes	*SU*
Aluminium alloy	*AL*	・Aluminium alloy plates and extruded shapes	・Aluminium alloy pipes and tubes	*AL*
Nickel steel	*NI*	・Rolled steels for low temperature service (*KL2N*30, *KL3N*32, *KL5N*43, *KL9N*53 and *KL9N*60) ・Steel castings for low temperature service (*KLC*2 and *KLC*3) ・Steel forgings for low temperature service (*KLF*3 and *KLF*9)	・Steel pipes for low temperature service (*KLP*2, *KLP*3 and *KLP*9)	*NI*
Other metal	*ET*	・Plates and tubes not listed above		*ET*

Table M5.6 Range of Qualification for Base Metal Thickness

Base metal thickness t of test assembly (*mm*)	Range of base metal thickness T applicable to actual welding work (*mm*)
$t < 3$	$t \leqq T \leqq 2t$
$3 \leqq t < 12$	$3 \leqq T \leqq 2t$
$12 \leqq t$	$3 \leqq T$

Table M5.7 Range of Qualification for Outside Diameter (Tubes only)

Outside diameter D (1) of test assembly (*mm*)	Range of outside diameter d applicable toin actual welding work (*mm*)
$D \leqq 25$	$D \leqq d \leqq 2D$
$25 < D$	$0.5D$ (2) $\leqq d$

Notes:

(1) For non-circular sections, D is the dimension of the smaller side.

(2) Lower limit of "0.5 D" is not to be less than 25 *mm*.

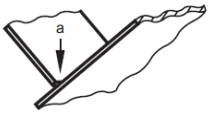
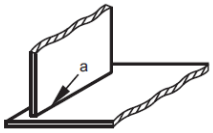
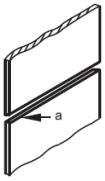
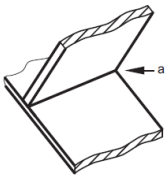
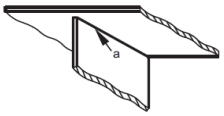
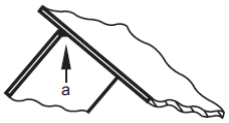
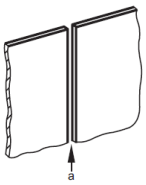
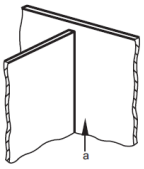
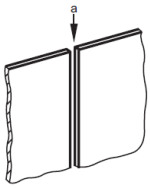
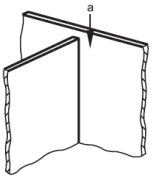
Table M5.8 Essential Variables of Welding Positions for Plates

Welding position applied for test assembly			Welding position applicable to actual welding work	
			Butt welding	Fillet welding
Plate	Butt welding	*PA*	*PA*	*PA*, *PB*
		PC	*PA*, *PC*	*PA*, *PB*, *PC*
		PE	*PA*, *PC*, *PE*	*PA*, *PB*, *PC*, *PD*, *PE*
		PF	*PA*, *PF*	*PA*, *PB*, *PF*
		PG	*PG*	*PG*
	Fillet welding	*PA*	-	*PA*
		PB	-	*PA*, *PB*
		PC	-	*PA*, *PB*, *PC*
		PD	-	*PA*, *PB*, *PC*, *PD*, *PE*
		PE	-	*PA*, *PB*, *PC*, *PD*, *PE*
		PF	-	*PA*, *PB*, *PF*
		PG	-	*PG*

Table M5.9 Variables of Welding Positions for Tubes

Welding position applied for test assembly			Welding position applicable to actual welding work	
			Butt welding	Fillet welding
Tube	Butt welding	*PA*	*PA*	*PA*, *PB*
		PC	*PA*, *PC*	*PA*, *PB*
		PH	*PA*, *PH*	*PA*, *PB*, *PD*, *PH*
		PJ	*PA*, *PJ*	*PA*, *PB*, *PD*, *PJ*
	Fillet welding	*PA*	-	*PA*
		PB	-	*PA*, *PB*
		PD	-	*PA*, *PB*, *PD*
		PH	-	*PA*, *PB*, *PD*, *PH*
		PJ	-	*PA*, *PB*, *PD*, *PJ*

Table M5.10 Symbols for Welding Positions for Plates

Welding position	Symbol	Plate	
		Butt welding	Fillet welding
Flat	*PA*		
Horizontal vertical	*PB*	—	
Horizontal	*PC*		
Horizontal overhead	*PD*	—	
Overhead	*PE*		
Vertical up	*PF*		
Vertical down	*PG*		

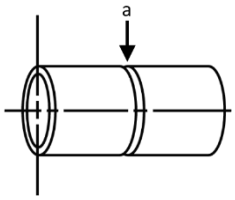
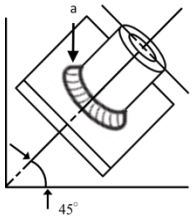
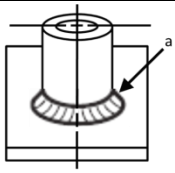
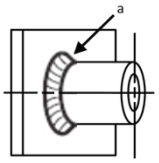
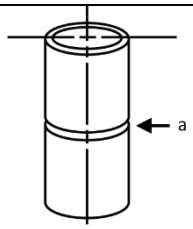
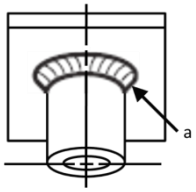
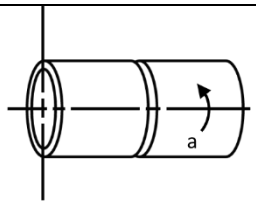
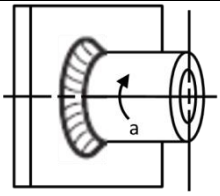
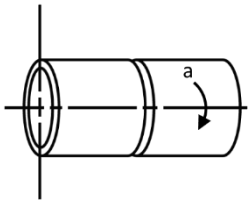
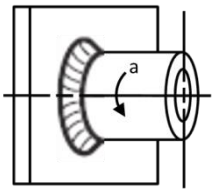
Note:

(1) The symbol “a” in this table indicates the following:

PA, *PB*, *PC*, *PD*, *PE*: welding position

PF, *PG*: weld progression or direction

Table M5.11 Symbols for Welding Positions for Tubes

Welding position	Symbol	Tube	
		Butt welding	Fillet welding
Flat	*PA*	 (tube rotating)	 (tube rotating)
Horizontal vertical	*PB*	—	 (tube rotating or fixed)  (tube rotating)
Horizontal	*PC*	 (tube rotating or fixed)	—
Horizontal overhead	*PD*	—	 (tube rotating or fixed)
Tube position for welding upwards	*PH*	 (tube fixed)	 (tube fixed)
Tube position for welding downwards	*PJ*	 (tube fixed)	 (tube fixed)

Note:

(1) The symbol "a" in this table indicates the following:

PA, *PB*, *PC*, *PD*, *PE*: welding position

PF, *PG*: weld progression or direction

Table M5.12 Variables of Detail of Welded Joint

Detail of welded joint applied for test assembles			Symbol	Detail of welded joint applicable to actual welding work
Butt welding	Single side	With backing	*ss mb*	*ss mb,* *bs mb,* *sl, ml*
		Without backing	*ss nb*	*ss mb, ss nb, ss gb, bs mb, bs nb, sl, ml*
		Gas backing	*ss gb*	*ss mb,* *ss gb, bs mb,* *sl, ml*
	Both side	With gouging	*bs mb*	*ss mb,* *bs mb,* *sl, ml*
		Without gouging	*bs nb*	*ss mb,* *bs mb, bs nb, sl, ml*
Fillet welding	Single layer		*sl*	*sl*
	Multi-layer		*ml*	*sl, ml*

Notes:

Backing materials other than backing strips may be used.

5.2.2 Range of Qualification*

1 The range of qualification included in the qualification is to be the applicable range for the actual welding work specified in **Table M5.1** through **Table M5.9**, **Table M5.12** and is to be the one in accordance with the essential variables included in the qualifications which a welder acquires.

2 The range of qualification for a welding position, in cases where multiple welding positions are used in welding the test assembly, is to be all applicable welding positions.

3 Welders who have passed qualification tests for manual welding processes may be similarly regard as the welder responsible for setting up and/or adjusting of the gravity welding process within the range of qualification they qualified.

4 Welders who have passed qualification tests for semi-automatic welding, *TIG* welding or gas welding may be similarly regard as the welder responsible for setting up and/or adjusting of the welding process using an auto-carriage in the range of qualification for the qualification they qualified.

5 Welders who have passed qualification tests for manual welding, semi-automatic welding, *TIG* welding or gas welding, may be engaged in the actual welding work using the tack welding process within the range of qualification for the welding process, kind of joint, base metal and welding position they qualified.

6 Welders who have passed qualification tests for manual welding, semi-automatic welding, *TIG* welding or gas welding may be engaged in welding work for both plates and tubes to the extent deemed appropriate by to the Society.

7 Welders who have passed qualification tests for tack welding may be engaged in welding work for tubes within the range of qualification they qualified.

5.3 Qualification Tests

5.3.1 Kinds and Procedures of Qualification Tests*

1 Test assemblies are to be welded according to welding procedure specifications, etc. which include essential variables corresponding to the qualification for which the welder will be tested. In cases where the acceptance criteria specified in requirement in **5.3.6** is fulfilled as a result of the qualification test, the qualification is to be considered acquired.

2 Qualification tests and the welding of test assemblies are to be carried out in the presence of a surveyor.

3 Qualification tests for automatic welding processes are to be as deemed appropriate by the Society.

4 Test items for each qualification test are to be as indicated in **Table M5.13**.

5 The welding of test assemblies is to comply with the requirements specified in **Table M5.1** through **Table M5.9,** corresponding to the essential variables for the qualification for which the welder will be tested.

Table M5.13 Test Items for Qualification Tests

Test assembly	Test item
Butt welding	Visual inspection
	Bend test (1) (2) (3) (4)
Fillet welding	Visual inspection
	Fracture test (5)
Tack welding	Visual inspection
	Fracture test

Notes:

(1) Radiographic tests or fracture tests may be carried out instead of bend tests except in the case of gas-shielded welding processes using solid wires or metal core wires.

(2) For nickel steel in plates, longitudinal bend test specimens may be used.

(3) For nickel steel in tubes, radiographic tests or fracture tests may be carried out instead of bend tests not withstanding **(1)** above.

(4) For the test assemblies for tubes whose outside diameter D is not more than 25 mm, notch tensile tests may be carried out.

(5) Macro-structure inspections may be carried out instead of fracture tests.

5.3.2 Testing Materials and Welding Consumables*

1 Base metals and welding consumables for test assemblies are to conform to one of the following requirements or to be of equivalent quality approved by the Society:

(1) Test assemblies for plates

Plates listed in **Table M5.5** and comply with the requirements specified in **Part K**

(2) Test assemblies for tubes

Tubes listed in **Table M5.5** and comply with the requirements specified in **Part K**

Tube fabricated with the plates specified in **(1)**

(3) Welding consumables

Welding consumables approved by the Society

2 Gas welding rods are to be those for mild steel complying with a recognized standard or those considered appropriate by the Society.

5.3.3 Test Assemblies

1 The dimensions of butt welding test assemblies for plates are to be as specified in **Fig. M5.1** through **M5.3**.

2 The dimensions of fillet welding test assemblies for plates are to be as specified in **Fig. M5.4**.

3 The dimensions of butt welding test assemblies for tubes are to be as specified in **Fig. M5.5** and **Fig. M5.6**.

4 The dimensions of test assemblies for tubes are to be as specified in **Fig. M5.7**.

5 The dimensions of tack welding test assemblies for butt joint of plates are to be as specified in **Fig. M5.8**.

6 The dimensions of tack welding test assemblies for fillet joint of plates are to be as specified in **Fig. M5.9**.

7 The dimensions of grooves for test assemblies are to comply with the welding procedure specifications, etc. referred to during the welding of test assemblies, unless otherwise specified.

8 One welding position is to be used per test assembly.

9 The welding of tube test assemblies applied with tube positions for welding upwards or that for welding downwards during qualification tests is to be as specified in **Fig. M5.10**. For qualification tests for tubes, arcs AB and AC indicated in **Fig M5.11** may be welded in welding position PH or PJ respectively, and arc BC may be welded in welding position PC notwithstanding the requirement in **-8** above.

10 Test assemblies for qualification tests for gas welding are to be of without backing.

11 One root run and one capping run included in the surface welding of the test assembly is to have a least one stop and restart respectively, except in cases where automatic welding procedures are applied.

12 Welders are allowed to remove minor imperfections by grinding only in the stop location and only before the restart of welding.

13 Test assemblies are not to change their up-and-down or right-to-left positions throughout the welding operation.

14 In principle, test assemblies for plates are to be so restrained or prestrained that any warping due to the welding does not exceed an angular distortion of 5 degrees.

15 Test assemblies are not to be subjected to peening or heat treatment throughout the period before, during and after the welding.

5.3.4 Test Specimens

1 The test specimens are to be finished to the sizes and dimensions shown in **Table M3.3**.

(1) Face bend and root bend test specimens from plate test assemblies are to be of the type *B*-9, and side bend test specimens from plate test assemblies are to be of the type *B*-11.

(2) Longitudinal bend test specimens are to be of type *B*-10.

(3) Face bend and root bend test specimens from tube test assemblies are to be of the type *B*-12, and side bend tests specimens from pipe test assemblies are to be of the type *B*-13.

2 In cases where a test specimen does not comply with dimensional specifications due to poor machining, a replaced test assembly is to be welded and tested.

5.3.5 Test Procedures

1 Visual inspections

Welds are to be visually examined prior to the cutting of test specimens for bend tests, radiographic tests, fracture tests and macro-structure inspections.

2 Bend tests

(1) The number of bend test specimens is to comply with the requirement specified in **Table M5.14**.

(2) Selection of test specimens is to comply with the requirements specified in **Fig. M5.1**, **Fig. M5.2**, and **Fig. M5.6**. At least one bend test specimen is to include one stop and restart in the bending parts for root runs or for cap runs.

(3) Selection of longitudinal bend test specimens is to comply with the requirements specified in **M5.2**.

(4) The test is to be a bend test either using the guided bend test jig specified in **Fig M3.1**, **Fig M3.2** or the equivalent or the roller bend test jig specified in **Fig M3.3**. The test specimens are to be bent through 180 degrees under the test conditions specified in **Table M5.15**. In the case of aluminium alloys, the method of bend testing using a roller specified in **Fig M3.4** may be carried out.

(5) With respect to qualification tests for gas welding, the radii of the plunger of the jig and support roller are to be 10 *mm*, and the roller span is to be 53 *mm* for roller bend tests.

(6) The test specimen, including stop and restart, is to be bended that the stop and restart are the tensile side.

3 Fracture tests

(1) For butt welding

(a) In the case of plate test assemblies, test specimens are to be the whole of test assembly, excluding the edges, in length and are to be tested in accordance with *ISO* 9017:2017.

(b) In the case of tube test assemblies, test specimens are to be the whole of test assembly specified in **Table M5.5** and are to be selected in accordance with the requirements specified in **Fig. M5.6**. The test method is to be in accordance with *ISO* 9017:2017.

(c) The widths of fracture test specimens for plates and tubes are to comply with **Table M5.16**.

(2) For fillet welding

(a) In the case of plate test assemblies, test specimens are to comply with the requirements specified in **Fig. M5.4** and be tested in accordance with *ISO* 9017:2017.

(b) In the case of tube test assemblies, test specimens are to be the full test specimen specified in **Fig M 5.5** and are to be divided into at least four specimens. The test method is to be in accordance with *ISO* 9017:2017.

(c) The widths of fracture test specimens for plates and tubes are to comply with **Table M5.16**.

4 Notch tensile tests

Test specimens are to comply with the requirements in **Fig. M5.12**.

5 Macro-structure inspections

(1) Two test specimens are to be prepared from different positions, and at least one macro-examination specimen is to be cut at the one stop and restart for either root runs or cap runs.

(2) Test specimens are to be etched on one side to clearly reveal the weld metal, fusion line, root penetration and the heat affected zone.

(3) Macro-sections are to include at least 10 *mm* of unaffected base metal.

6 Radiographic tests

Test specimens are to be whole of test assemblies. In the case of plate test assemblies, test specimens are to exclude the edges of test assemblies. The test is to be carried out in accordance with internal or international standers deemed appropriate by the Society.

Table M5.14 Number of Bend Test Specimens

Kind of bend test (1)	Number of bend test specimens	
	Qualification test (Initial)	Qualification test (Renewal)(2)
Face bend test	2	1
Root bend test	2	1
Longitudinal bend test	4	2

Notes:

(1) In cases where the base metal thickness of the test assembly is not less than 12 *mm*, a side bend specimen with a thickness of 10 *mm* may be used.

(2) Selection of test specimens for tube test assemblies applied tube positions for welding upwards or that for welding downwards is to comply with the requirements given in **Fig M5.6**.

(3) In accordance with requirements in **5.3.3-9**, the number of bend test specimens for qualification tests (renewal) is to be the same as the number for qualification tests (initial) for test assembly welding in two welding position at a time.

Table M5.15 Conditions for Bend Tests

Kind of base metal used for test assembly		Radius of plunger (t: thickness of test specimen)
Carbon steel	*KE*47	$\frac{5}{2}t$
	*KA*420, *KD*420, *KE*420, *KF*420, *KA*460, *KD*460, *KE*460, *KF*460, *KA*500, *KD*500, *KE*500, *KF*500	$\frac{5}{2}t$
	*KA*550, *KD*550, *KE*550, *KF*550, *KA*620, *KD*620, *KE*620, *KF*620, *KA*690, *KD*690, *KE*690, *KF*690	3.0t
	Other than the above(1)	2.0t
Stainless steel(1)		2.0t
Aluminium alloy		$(\frac{100 \times t}{A} - t) \times 0.5$
Nickel steel	9% *Ni* steel	$\frac{10}{3}t$
	Except above(1)	2.0t

Note:

(1) The radius of the plunger is to be calculated from the following formula, where the elongation A of the base metal is less than 20%

$$(\frac{100 \times t}{A} - t) \times 0.5$$

A: Minimum elongation (%) specified in **Part K**.

Table M5.16 Widths of Fracture Test Specimens(1)

Plate	Width of fracture test specimen (mm)	
	150 min.	
Tube	Outside diameter D of test assembly (mm)	Width of fracture test specimen (mm)
	$25 < D < 50$	10 min.
	$50 \leq D < 100$	20 min.
	$100 \leq D$	35 min.

Note:

(1) The width of a fracture test specimen indicates the length in the direction parallel to the welding direction.

Fig. M5.1 Dimensions of Plate Test Assemblies for Butt Welding

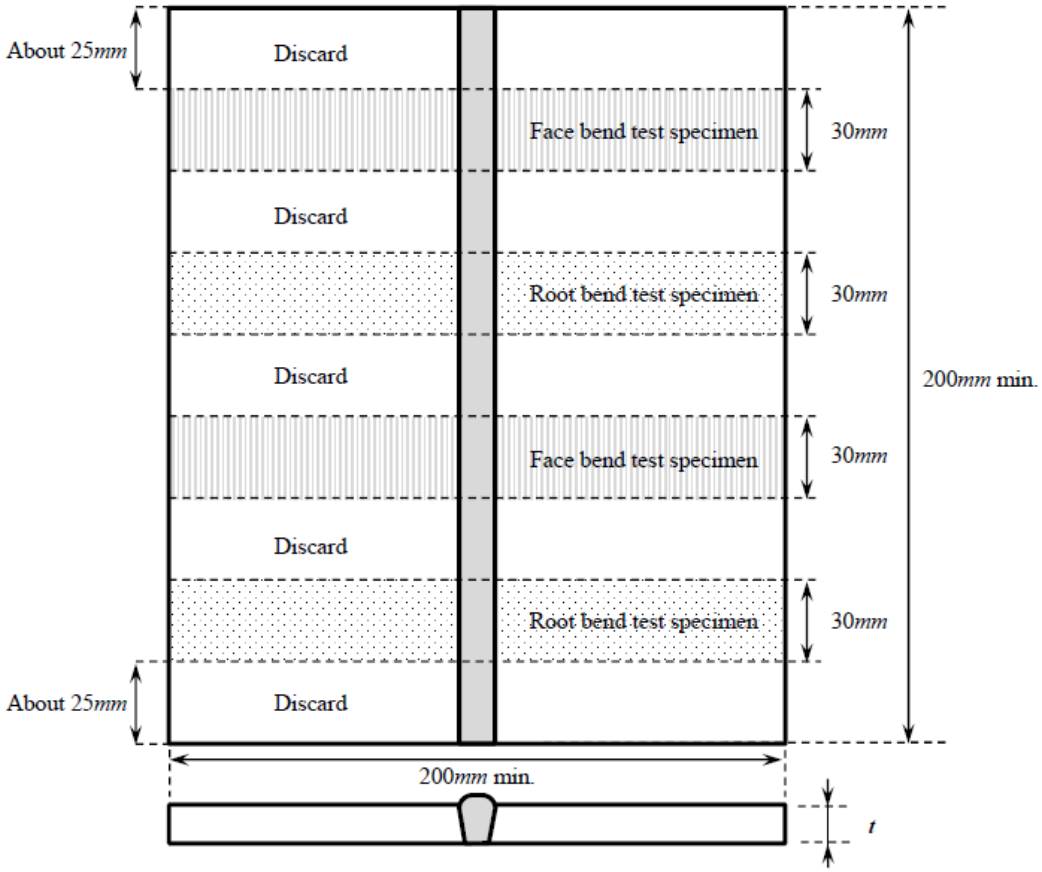


Fig. M5.2 Dimensions of Plate Test Assemblies for Butt Welding
(in cases where side bend specimens are taken)

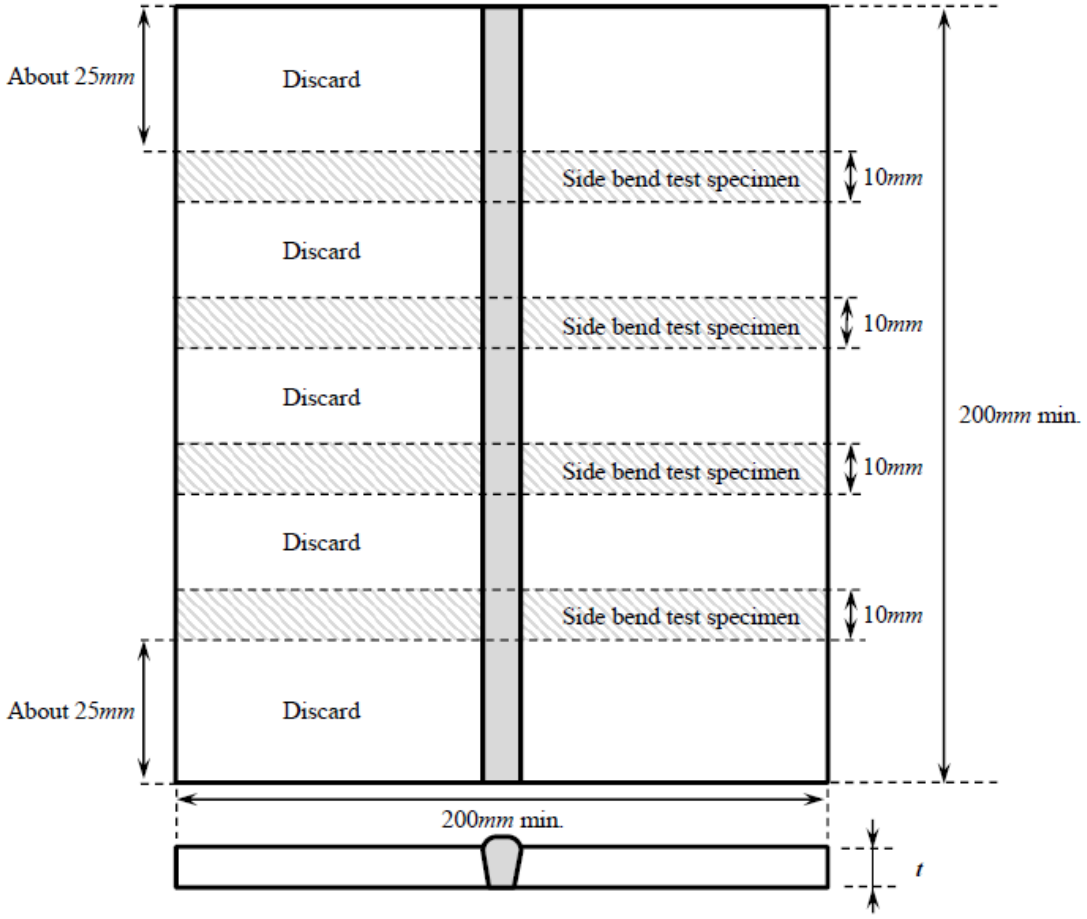
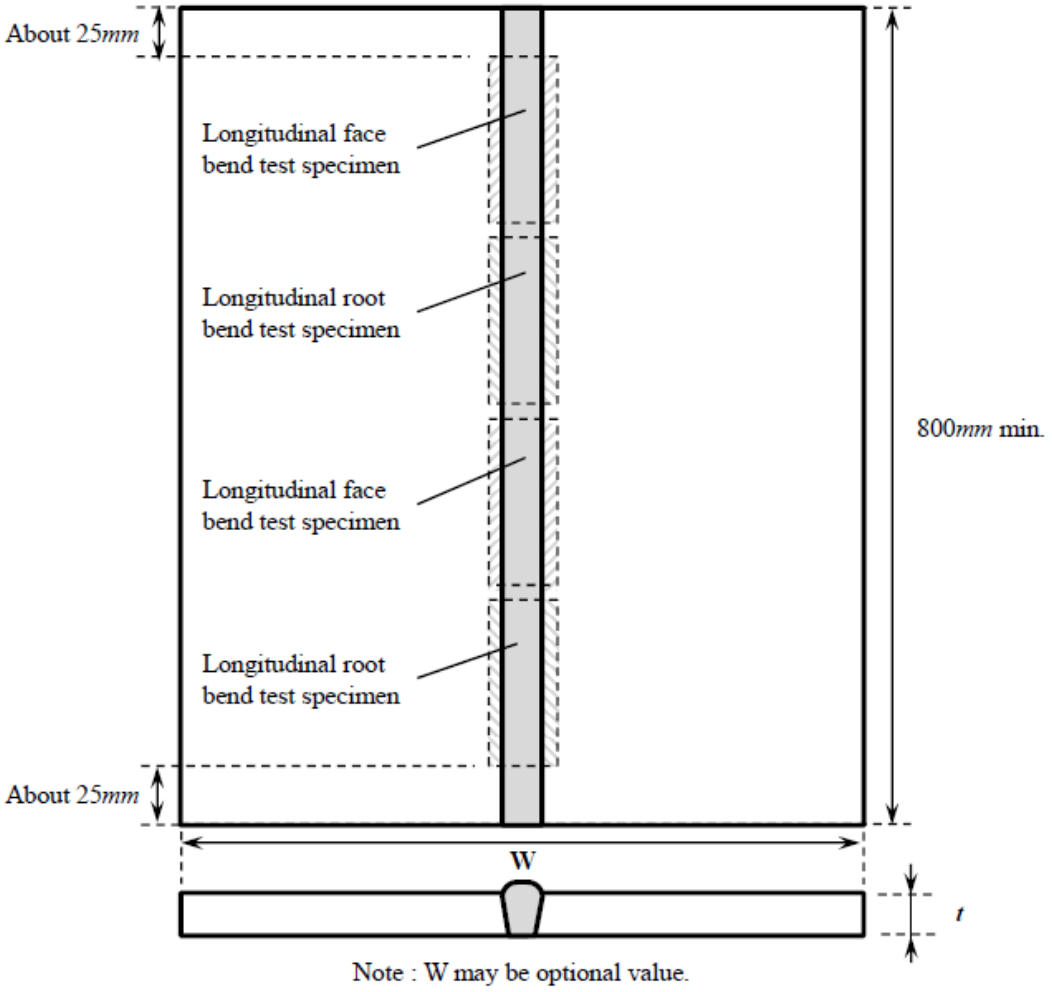


Fig. M5.3 Dimensions of Plate Test Assemblies for Butt Welding
(in cases where longitudinal bend specimens are taken for nickel steel)



Note : W may be optional value.

Fig. M5.4 Dimensions of Plate Test Assemblies for Filet Welding

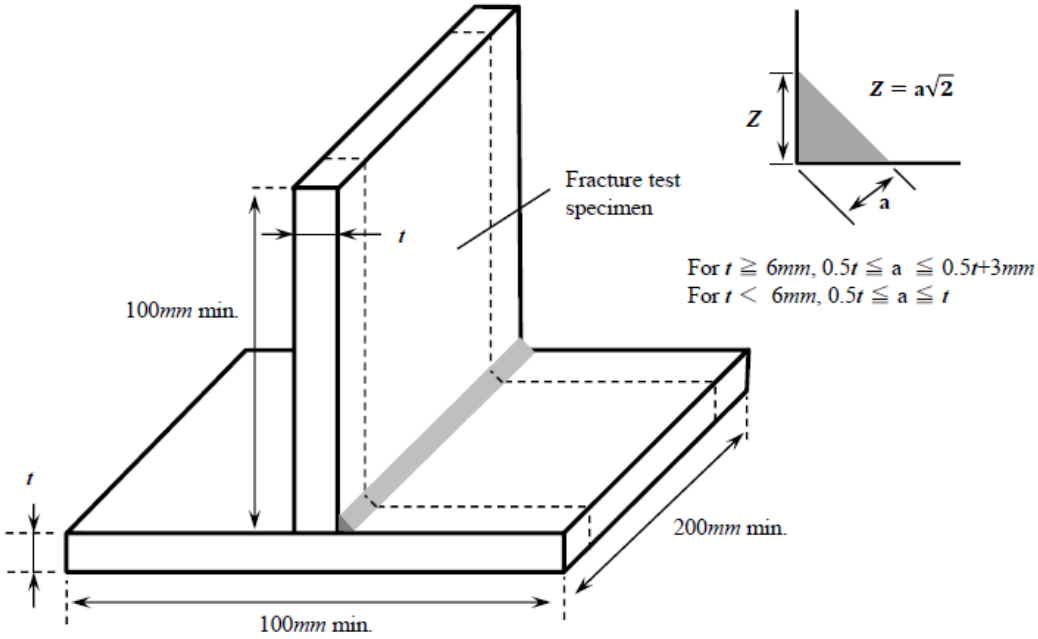


Fig. M5.5 Dimensions of Tube Test Assemblies for Butt Welding

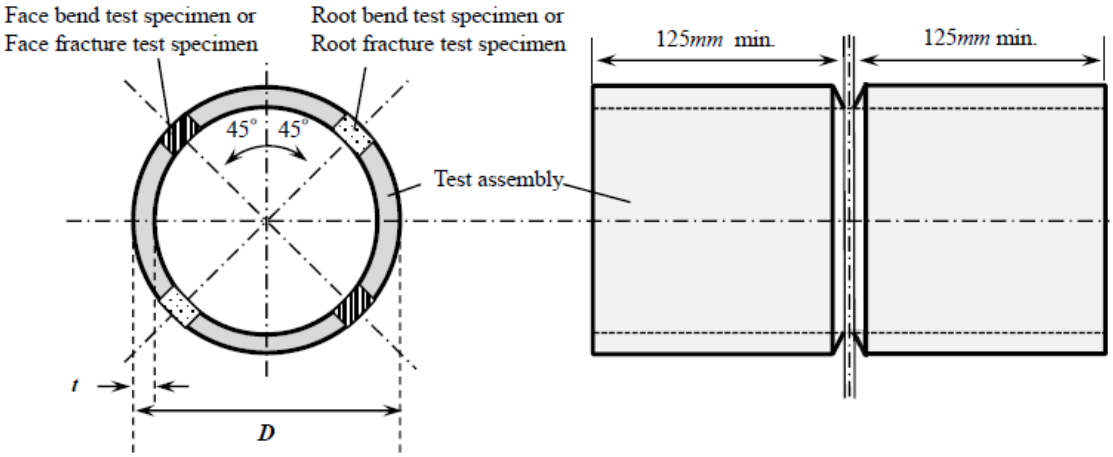
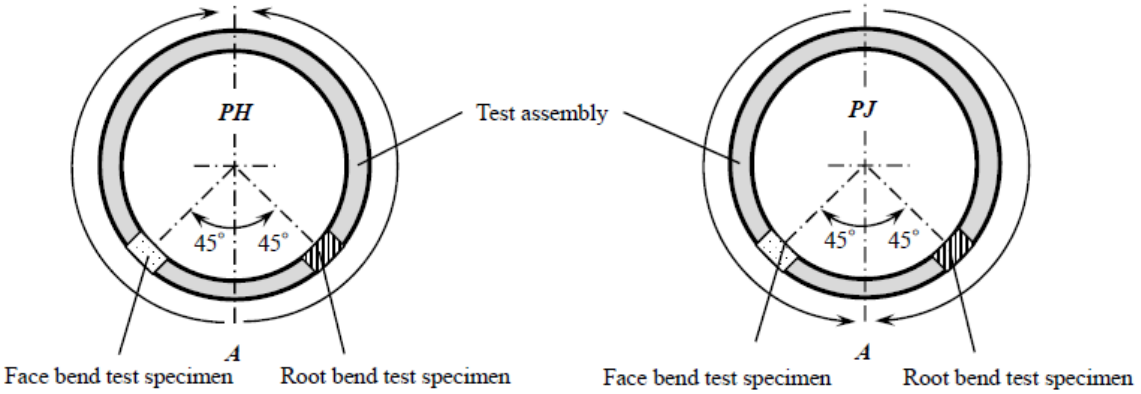
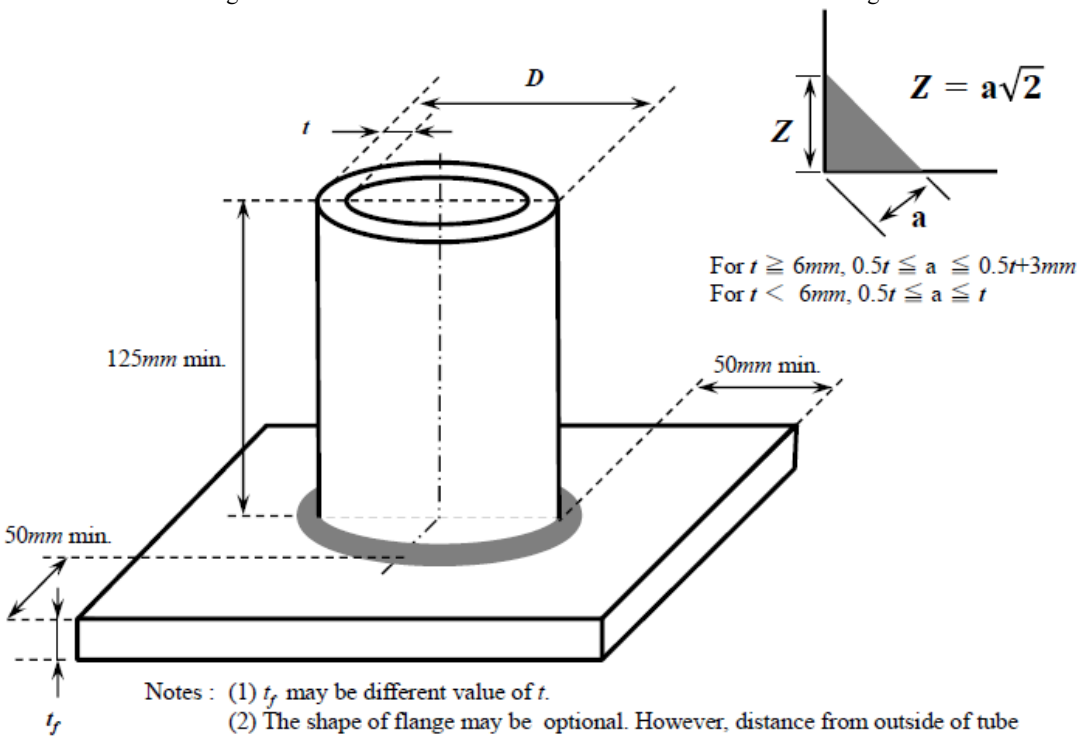


Fig. M5.6 Selection of Test Specimen for Tube Test Assemblies Applied with Tube Positions for Welding Upwards or That for Welding downwards in Qualification Tests (Renewal)



Notes : (1) A is to just under the horizontal axis.
(2) Arrows in the figure indicates the welding direction.

Fig. M5.7 Dimensions of Tube Test Assemblies for Fillet Welding



Notes : (1) t_f may be different value of t.
(2) The shape of flange may be optional. However, distance from outside of tube assembly to edge of flange is not less than 50mm on the flange plate surface.

Fig. M5.8 Dimensions of Plate Test Assemblies for Butt Welding Using Tack Welding

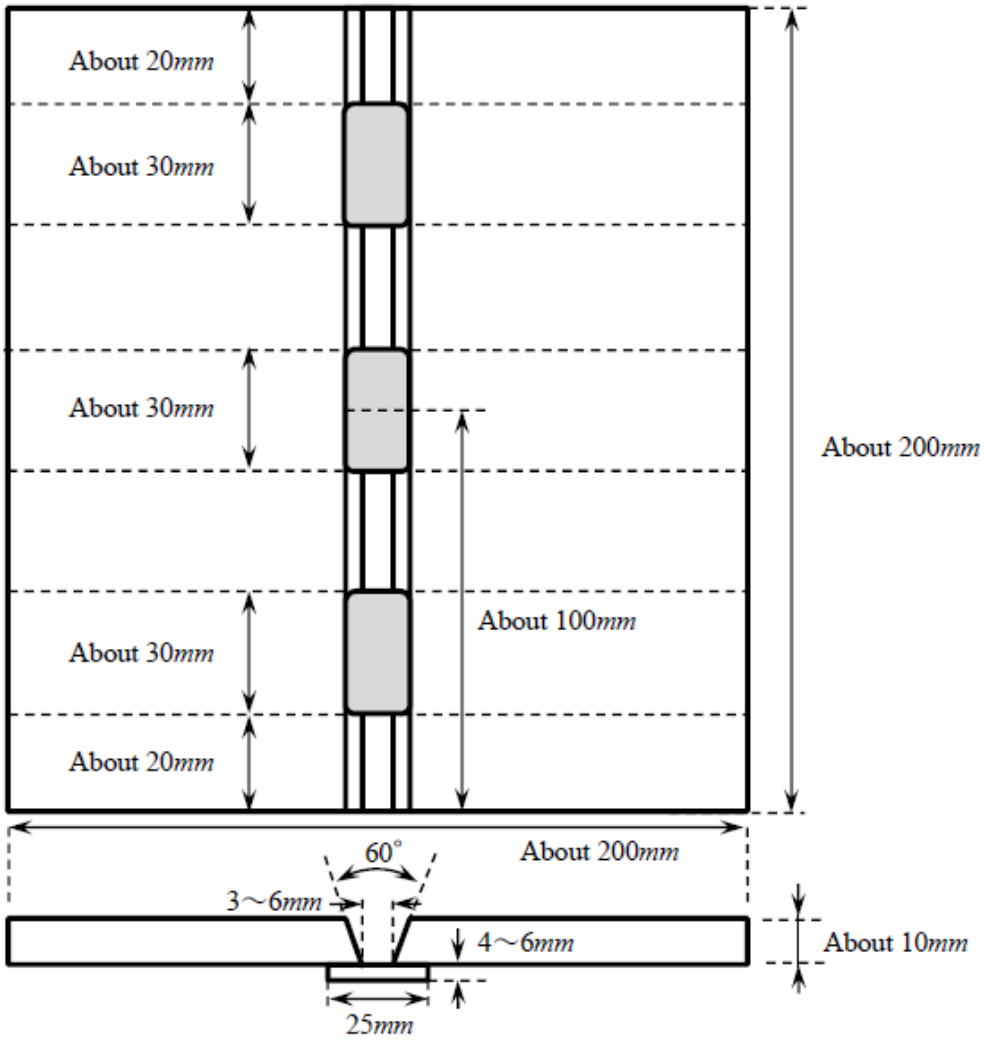


Fig. M5.9 Dimensions of Plate Test Assemblies for Fillet Welding Using Tack Welding

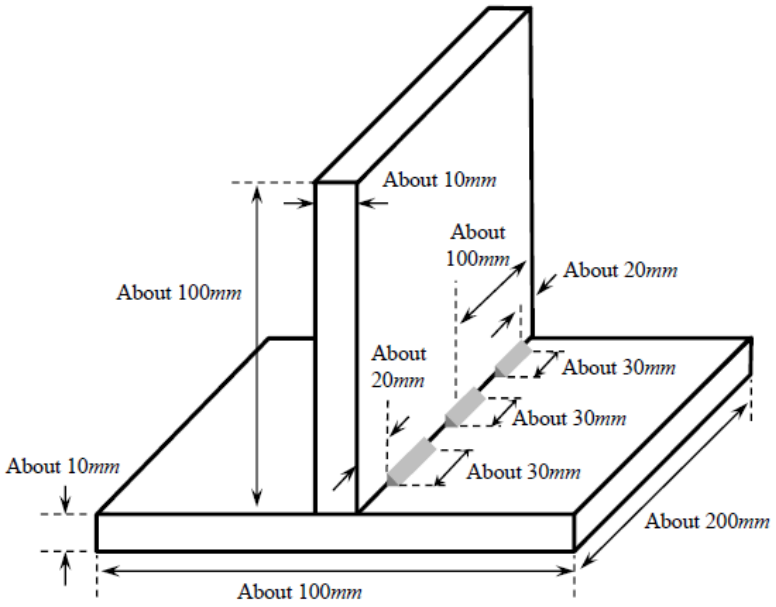
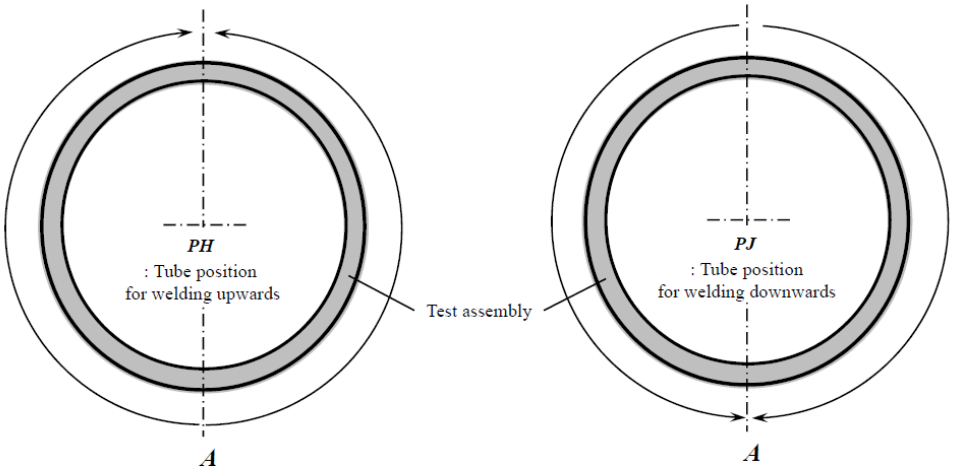
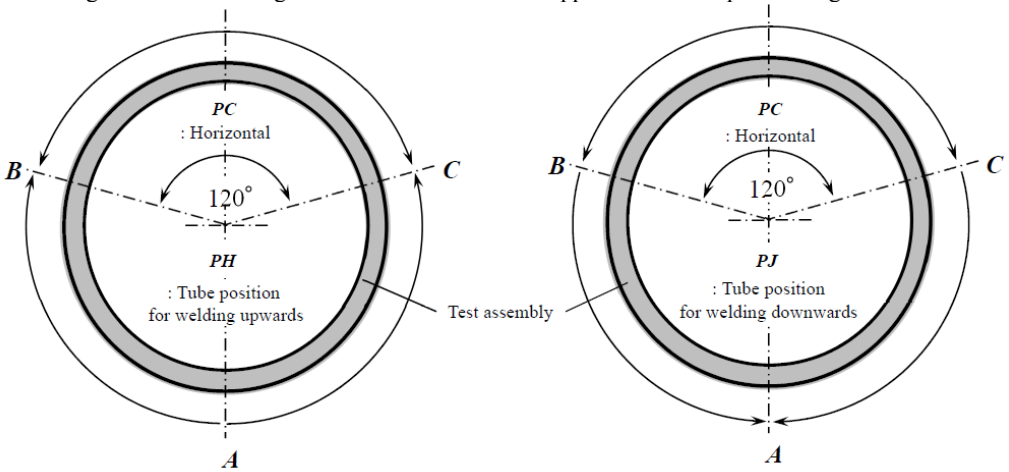


Fig. M5.10 Welding for Tube Test Assemblies Applied with Tube Positions for Welding Upwards or That for Welding Downwards



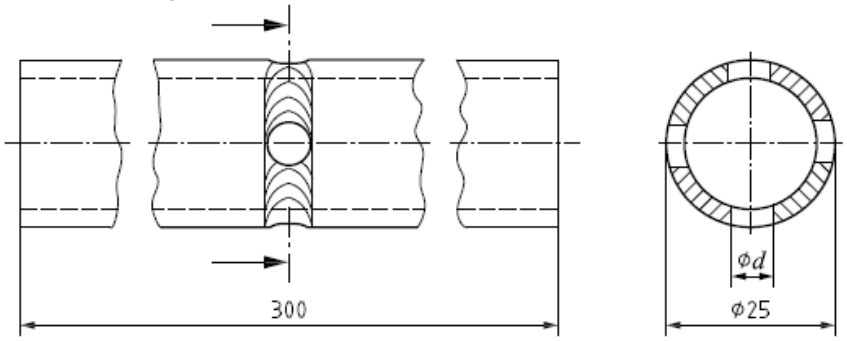
Notes : (1) In welding on the arc *BAC*, *A* is to just under the horizontal axis.
(2) Arrows in the figure indicates the welding direction.

Fig. M5.11 Welding for Tube Test Assemblies Applied with Multiple Welding Positions



Notes : (1) In welding on the arc *BAC*, *A* is to just under the horizontal axis.
(2) Arrows in the figure indicates the welding direction. In arc *BC*, whichever direction is acceptable.

Fig. M5.12 Notch Tensile Tests for Tube Test Assemblies



d: Diameter of the hole in weld (*mm*)

T: Base metal thickness (*mm*)

For $T \geq 1.8$ *mm*, $d = 4.5$

For $T < 1.8$ *mm*, $d = 3.5$

Note:

(1) Holes are not allowed in the stop and restart

7 Ultrasonic testing

The test is to be carried out on the entire weld of the test assemblies. In the case of plate test assemblies, however, the edges of test assemblies is excluded. Tests are to be carried out in accordance with *ISO* 17460:2018. However, this requirement only applied where the renewal method in **5.1.6-1(2)** is selected.

5.3.6 Acceptance Criteria

1 Visual inspections

Imperfections detected are to be assessed in accordance with quality level *B* of *ISO* 5817:2014, except in cases where level *C* applies such as for excess weld metal, excess penetration, excessive convexity and excessive throat thickness.

2 Bend tests

(1) The specimens are to show neither cracks nor other serious defects greater than 3 *mm* in length in any direction on the outside surface due to the bending.

(2) Continuous blow holes and cracks found on the surface of welds are to be regarded as the length of the crack including the blow hole.

(3) The total length of the visible cracks each having a length less than 3 *mm* is not to exceed 10 *mm*.

(4) The total combined number of visible blow holes and visible small cracks are not to exceed 10.

(5) Any cracks on the side surface of test specimens are to be outside the scope of the qualification judgment. In cases where a crack extends continuously from the face to side surfaces, the length of the crack is not to include that of the crack on the side surface.

(6) In cases where a crack occurs in the base metal, it is to be outside the scope of the qualification judgment, and the test assembly is to be welded again.

3 Fracture tests, notch tensile tests and radiographic tests

Imperfections which detected are to be assessed in accordance with quality level *B* of *ISO* 5817:2014.

4 Macro-structure inspections

Test specimens are to show no cracks, poor penetration, lack of fusion and other serious defects.

5 Ultrasonic testing

Imperfections which detected are to be assessed in accordance with quality level *B* of *ISO* 11666:2018. However, this requirement only applies in cases where the renewal method in **5.1.6-1(2)** is selected.

5.3.7 Retests

1 Welders who fail to meet the requirements for certain parts of bend tests, fracture tests or macro-structure inspections, may take retests for the failed part using duplicate test specimens taken from test assemblies welded within one month from the date of failure.

2 Welders who fail to meet the requirements for all parts of visual inspections, bend tests, fracture tests, macro-structure inspections, radiographic tests, ultrasonic testing (only in cases where the renewal method in **5.1.6-1(2)** is applied) or notch tensile tests

or in the retest prescribed in **-1** above are not allowed to retest within one month from the date of failure.

3 In cases where a welder takes tests according to the requirement specified in **-2** above, the welder is to submit (relevant branch office or service site) a new welder qualification test application form (**Form WE(E)**) to the Society. In such cases, a photograph of the welder does not need to be submitted.

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 tests 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 inspections 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 six 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 M6.1**.

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 M6.9** are to be added the grade marks (after the *U* in the case of the preceding **-2**) of the said electrodes (Example : *KMW*53*UH*10).

Table M6.1 Grades and Marks

For mild steel	For high tensile steel			For steel for low temperature service	
*KMW*1	*KMW*52	*KMW*52*Y*40	*KMW*63*Y*47	*KMWL*1	*KMWL*91
*KMW*2	*KMW*53	*KMW*53*Y*40		*KMWL*2	*KMWL*92
*KMW*3	*KMW*54	*KMW*54*Y*40		*KMWL*3	
		*KMW*55*Y*40			

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 Tests*

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 M6.2. 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 M6.3.

3 The test for electrodes given in 6.2.1(2) is 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 M6.3 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 M6.2 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 M6.4.

Table M6.2 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[9] (*mm*)	
Deposited metal test	Flat	4	1[1]	Fig. M6.1	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	Fig. M6.2	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[2]			
	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. M6.3	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 diameters 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.

(9) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

Table M6.3 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[4] (*mm*)	
Deposited metal test	Flat	4	1	Fig. M6.1	20	Tensile test specimen : 1
		max. diameter	1			Impact test specimen : 3
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.

(4) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

Table M6.4 Grades of Steel Used for Test Assembly

Grade of electrode	Grade of steel used for test assembly[1] [2]
*KMW*1	*KA*
*KMW*2	*KA*, *KB* or *KD*
*KMW*3	*KA*, *KB*, *KD* or *KE*
*KMW*52	*KA*32, *KA*36, *KD*32 or *KD*36
*KMW*53	*KA*32, *KA*36, *KD*32, *KD*36, *KE*32 or *KE36*
*KMW*54	*KA*32, *KA*36, *KD*32, *KD*36, *KE*32, *KE*36, *KF*32 or *KF*36
*KMW*52*Y*40	*KA*40 or *KD*40
*KMW*53*Y*40	*KA*40, *KD*40 or *KE*40
*KMW*54*Y*40, *KMW*55*Y*40	*KA*40, *KD*40, *KE*40 or *KF*40
*KMW*63*Y*47	*KE*47
*KMWL*1	*KE* or *KL*24*A*
*KMWL*2	*KE*, *KL*24*A*, *KL*24*B*, *KL*27 or *KL*33
*KMWL*3	*KL*27, *KL*33 or *KL*37
*KMWL*91	*KL*9*N*53 or *KL*9*N*60
*KMWL*92	*KL*9*N*53 or *KL*9*N*60

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 *KMWL*91 and *KMWL*92.

(2) The tensile strength of high tensile steels *KA*32, *KD*32, *KE*32 and *KF*32 used in the butt weld test assemblies are to be greater than 490 N/mm^2.

6.2.5 Welding Procedure of Test Assemblies*

1 Deposited Metal Test Assemblies (Fig. M6.1)

(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℃ but not below 100℃, the temperature being taken at the centre of weld on the surface of seam.

2 Butt Weld Test Assemblies (**Fig. M6.2**)

(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℃ but not below 100℃ 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 4 *mm* 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. M6.3**)

(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. M6.1 Deposited Metal Test Assembly (Unit: *mm*)

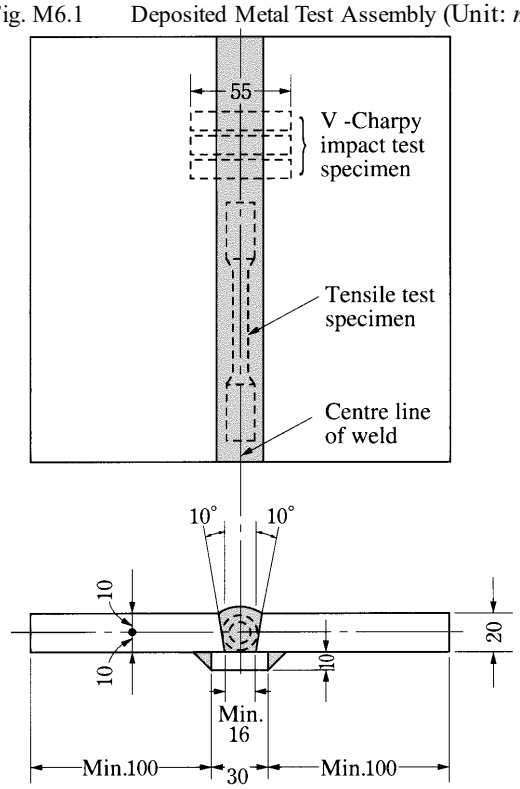
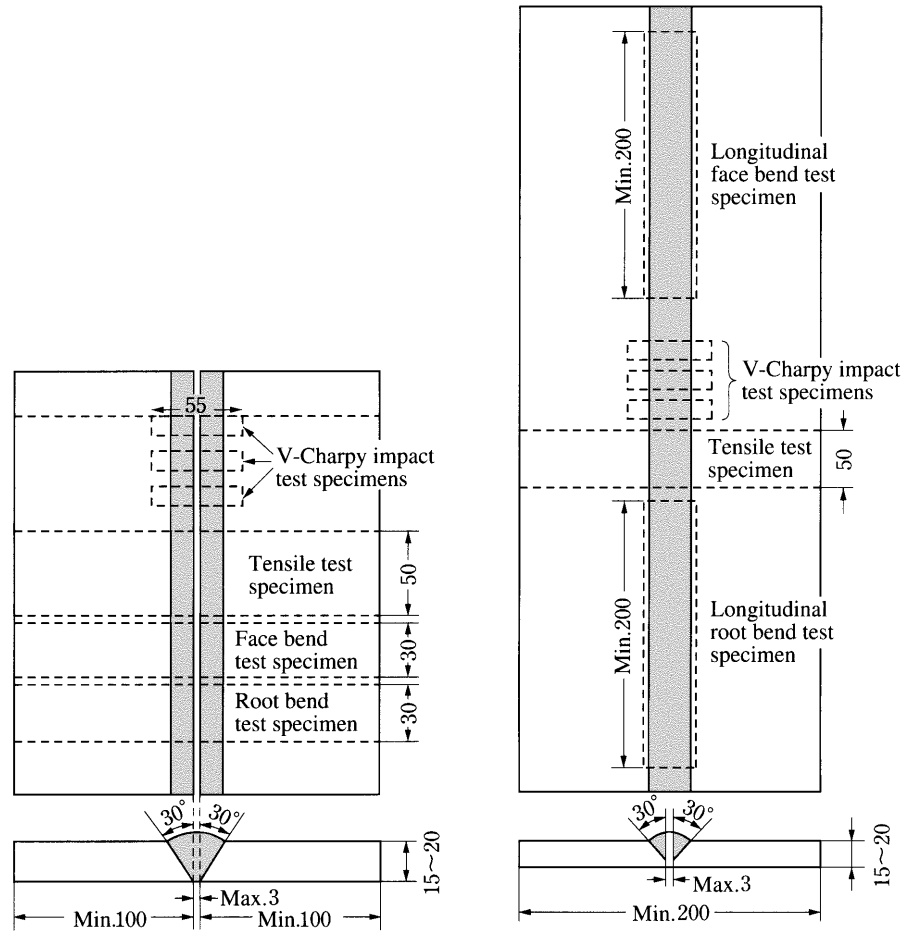
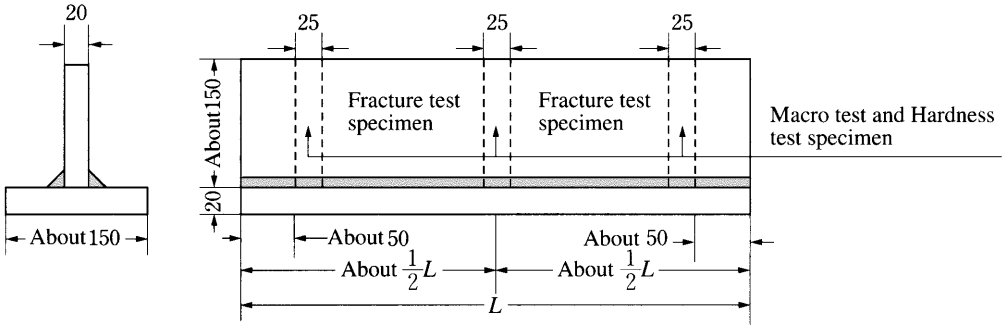


Fig. M6.2 Butt Weld Test Assembly (Unit: *mm*)



(a) For Electrodes except (b) **(b) For Electrodes of Grade *KMWL*91 or *KMWL*92**

Fig. M6.3 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 *U*1*A* specimen shown in Table M3.1, 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℃ 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 M6.5 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 M6.5 Tensile Test Requirements for Deposited Metal

Grade of electrode	Tensile Strength (N/mm^2)	Yield point (N/mm^2)	Elongation (%)
*KMW*1	400～560	305 min.	22 min.
*KMW*2			
*KMW*3			
*KMW*52	490～660	375 min.	
*KMW*53			
*KMW*54			
*KMW*52*Y*40	510～690	400 min.	
*KMW*53*Y*40			
*KMW*54*Y*40			
*KMW*55*Y*40			
*KMW*63*Y*47	570～720	460 min.	19 min.
*KMWL*1	400～560	305 min.	22 min.
*KMWL*2	440～610	345 min.	
*KMWL*3	490～660	375 min.	21 min.
*KMWL*91	590 min.	375(1)min.	25 min.
*KMWL*92	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 *U*4 specimens shown in **Table K2.5**, 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. M6.4**.

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 M6.6** 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. M6.4 Position of Impact Test Specimen (Unit: *mm*, *t*: Plate thickness)

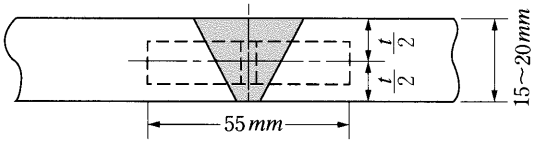


Table M6.6 Impact Test Requirements for Deposited Metal

Grade of electrode	Testing temperature (℃)	Minimum mean absorbed energy (*J*)
*KMW*1	20	47
*KMW*2	0	
*KMW*3	-20	
*KMW*52	0	
*KMW*53	-20	
*KMW*54	-40	
*KMW*52*Y*40	0	
*KMW*53*Y*40	-20	
*KMW*54*Y*40	-40	
*KMW*55*Y*40	-60	
*KMW*63*Y*47	-20	64
*KMWL*1	-40	34
*KMWL*2	-60	
*KMWL*3	-60	
*KMWL*91	-196	27
*KMWL*92	-196	

6.2.8 Butt Weld Tensile Test

1 The tensile test specimen is to be *U*2*A* or *U*2*B* specimen shown in **Table M3.1**, 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 M6.7**.

Table M6.7 Tensile Test Requirements for Butt Weld

Grade of electrode	Tensile Strength (N/mm^2)
*KMW*1, *KMW*2, *KMW*3	400 min.
*KMW*52, *KMW*53, *KMW*54	490 min.
*KMW*52*Y*40, *KMW*53*Y*40, *KMW*54*Y*40, *KMW*55*Y*40	510 min.
*KMW*63*Y*47	570 min.
*KMWL*1	400 min.
*KMWL*2	440 min.
*KMWL*3	490 min.
*KMWL*91	630 min.
*KMWL*92	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 M3.2**, and the test specimens are to be taken from each test assembly. However, for *KMWL*91 or *KMWL*92, the face bend and root bent specimens are to be *B*-7 specimen shown in **Table M3.2**, 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 3 *mm* 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 *KMWL*91 and *KMWL*92, 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 *U*4 specimen shown in **Table K2.5**, 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 coincide with the mid-thickness of the plates.

2 Testing temperature and minimum mean absorbed energy are to comply with the requirements given in **Table M6.8** 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 M6.8 Impact Test Requirements for Butt Weld

Grade of electrode	Testing temperature (℃)	Minimum mean absorbed energy (*J*)	
		Flat, Horizontal, Overhead	Vertical upward, Vertical downward
*KMW*1	20	47	34
*KMW*2	0		
*KMW*3	-20		
*KMW*52	0		
*KMW*53	-20		
*KMW*54	-40		
*KMW*52*Y*40	0		39
*KMW*53*Y*40	-20		
*KMW*54*Y*40	-40		
*KMW*55*Y*40	-60		
*KMW*63*Y*47	-20	64	
*KMWL*1	-40	27	27
*KMWL*2	-60		
*KMWL*3	-60		
*KMWL*91	-196		
*KMWL*92	-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 M6.9** according to the test procedures specified in preceding **-1** or the type of suffixes to be added to the grade marks.

Table M6.9 Requirements for Hydrogen Contents

Mark	Requirements for Hydrogen Contents (cm^3/g)		
	Glycerine method	Mercury method(1)	Gas chromatographic method(1)
*H*15	0.10 max.	0.15 max.	0.15 max.
*H*10	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 25 *mm* are selected from three places shown in **Fig. M6.3**.

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. M6.5** 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. M6.6**, 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. M6.5 Hardness Test(Unit: *mm*)

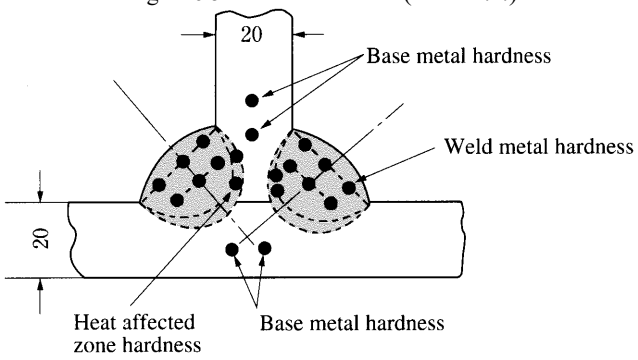
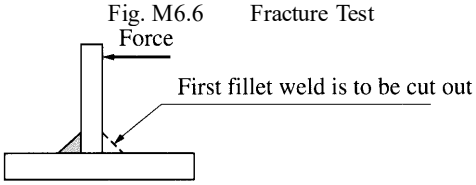


Fig. M6.6 Fracture Test



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 M6.10**.

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 M6.11**.

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 M6.10 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(2) (*mm*)	
Deposited metal test	Flat	4(1)	1	**Fig. M6.1**	20	Tensile test specimen : 1 Impact test specimen : 3
		exceeding 4, 8 max.	1			

Notes:

(1) Where deemed necessary by the Society, butt weld tests in the flat or vertical (either upward or downward) welding position specified in **Table M6.2** of **6.2.4-1** may be requested in place of deposited metal tests of 4 *mm* diameter electrodes. In this case, impact test specimens (one set of three) are to be selected.

(2) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

Table M6.11 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. M6.1**	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 M6.12**.

2 Automatic welding consumables which have passed the tests for each welding process given in **Table M6.15** are appended with suffixes shown in **Table M6.13** 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 M6.14** and the suffix given in **Table M6.14** will be added after the suffix *G*. (Example: *KAW53TMG* (*M*1))

Table M6.12 Grades and Marks

For mild steel	For high tensile steel			For steel for low temperature service	
*KAW*1	*KAW*51	*KAW*52*Y*40	*KAW*63*Y*47	*KAWL*1	*KAWL*91
*KAW*2	*KAW*52	*KAW*53*Y*40		*KAWL*2	*KAWL*92
*KAW*3	*KAW*53	*KAW*54*Y*40			*KAWL*3
	*KAW*54	*KAW*55*Y*40			

Table M6.13 Marks

Welding technique	Mark
Multi-run technique (1)	*M*
Two-run technique (2)	*T*
Multi-run and Two-run technique	*TM*

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 M6.14 Gas types

Group	Type	Gas composition (Vol. %)			
		CO_2	O_2	H_2	*Ar*
*M*1	*M*1-1	1~5	-	1~5	Rest
	*M*1-2	1~5	-	-	Rest
	*M*1-3	-	1~3	-	Rest
	*M*1-4	1~5	1~3	-	Rest
*M*2	*M*2-1	6~25	-	-	Rest
	*M*2-2	-	4~10	-	Rest

	*M*2-3	6~25	1~8	-	Rest
*M*3	*M*3-1	26~50	-	-	Rest
	*M*3-2	-	11~15	-	Rest
	*M*3-3	6~50	9~15	-	Rest
I	*I*-1	-	-	-	100
C	*C*-1	100	-	-	-
	C-2	Rest	1~30	-	-
E	*E*-1	Except above			

Table M6.15 Kind of Test of Automatic Welding Consumables

Welding process	Kinds of test[8]		Grade of welding consumable	Test assembly			Kind and number of test specimens taken from test assembly
				Number	Dimension	Thickness (*mm*)[3][9]	
Multi-run technique	Deposited metal test		*KAW*1, *KAWL*1 *KAW*2, *KAWL*2 *KAW*3, *KAWL*3 *KAW*51, *KAWL*91 *KAW*52, *KAWL*92 *KAW*53, *KAW*54, *KAW*52*Y*40 *KAW*53*Y*40 *KAW*54*Y*40 *KAW*55*Y*40 *KAW*63*Y*47	1	Fig. M6.7	20	Tensile test specimen : 2 Impact test specimen : 3
	Butt weld test			1[4]	Fig. M6.8	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	*KAW*1, *KAW*51	1	Fig. M6.9	12～15	Tensile test specimen : 2 Longitudinal tensile test specimen : 1[5] Face bend test specimen : 1 Root bend test specimen : 1 Impact test specimen : 3
				1		20～25	
			*KAW*2, *KAW*52*Y*40 *KAW*3, *KAW*53*Y*40 *KAW*52, *KAW*54*Y*40 *KAW*53, *KAW*55*Y*40 *KAW*54,*KAW*63*Y*47	1		20～25	
				1		30～35	
		Gas shielded arc and self-shielded arc welding	*KAW*1, *KAW*2 *KAW*3 *KAW*51, *KAW*52 *KAW*53, *KAW*54 *KAW*52*Y*40 *KAW*53*Y*40 *KAW*54*Y*40 *KAW*55*Y*40 *KAW*63*Y*47	1		12～15[1]	Tensile test specimen : 2 Longitudinal tensile test specimen : 1[5] Face bend test specimen : 1 Root bend test specimen : 1 Impact test specimen : 3
						20[2]	
				1		20～25[1]	
						30～35[2]	
	Butt weld test		*KAWL*1, *KAWL*2 *KAWL*3, *KAWL*91 *KAWL*92	1		12～15	Tensile test specimen : 2 Longitudinal tensile test specimen : 1[5] Face bend test specimen : 1 Root bend test specimen : 1 Impact test specimen : 3
				1		20～25	
Multi-run and two-run technique	Deposited metal test		*KAW*1, *KAWL*1 *KAW*2, *KAWL*2 *KAW*3, *KAWL*3 *KAW*51, *KAWL*91 *KAW*52, *KAWL*92 *KAW*53 *KAW*54 *KAW*52*Y*40 *KAW*53*Y*40 *KAW*54*Y*40 *KAW*55*Y*40 *KAW*63*Y*47	[7]			
	Butt weld test						

Notes:

(1) Thickness of test assemblies where applied maximum plate thickness is not more than 25 *mm*.

(2) Thickness of test assemblies where applied maximum plate thickness is more than 25 *mm*.

(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 *KAWL*91 and *KAWL*92 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.

(9) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

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 M6.14**. Although, when the manufacturer of the consumables recommends gas types of the group of *M*1, *M*2, *M*3 or *C* in **Table M6.14**, 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 *M*1, *M*2 and *M*3, the test is allowed to limit any one of the gas type of *M*1, *M*2 or *M*3 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 M6.15**.

2 Grades of steel to be used in preparation of test assemblies are to be as given in **Table M6.16**.

Table M6.16 Grades of Steel Used for Test Assembly

Grade of welding consumable	Grade of steel used for test assembly(1)(2)
*KAW*1	*KA*
*KAW*2	*KA*, *KB* or *KD*
*KAW*3	*KA*, *KB*, *KD* or *KE*
*KAW*51	*KA*32 or *KA*36
*KAW*52	*KA*32, *KA*36, *KD*32 or *KD*36
*KAW*53	*KA*32, *KA*36, *KD*32, *KD*36, *KE*32 or *KE*36
*KAW*54	*KA*32, *KA*36, *KD*32, *KD*36, *KE*32, *KE*36, *KF*32 or *KF*36
*KAW*52*Y*40	*KA*40 or *KD*40
*KAW*53*Y*40	*KA*40, *KD*40 or *KE*40
*KAW*54*Y*40, *KAW*55*Y*40	*KA*40, *KD*40, *KE*40 or *KF*40
*KAW*63*Y*47	*KE*47
*KAWL*1	*KE* or *KL*24*A*
*KAWL*2	*KE*, *KL*24*A*, *KL*24B, *KL*27 or *KL*33
*KAWL*3	*KL*27, *KL*33 or *KL*37
*KAWL*91	*KL*9*N*53 or *KL*9*N*60
*KAWL*92	*KL*9*N*53 or *KL*9*N*60

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 *KAWL*91 and *KAWL*92.

(2) The tensile strength of high tensile steels *KA*32, *KD*32, *KE*32 and *KF*32 used in the butt weld test assemblies is to be greater than 490 N/mm^2.

6.3.5 Welding Sequence of Test Assemblies

1 Deposited Metal Test Assemblies with Multi-run Technique (**Fig. M6.7**)

(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 4 *mm* 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 3 *mm*.

(2) After each run, the assembly is to be left in still air until it has cooled to less than 250℃ but not below 100℃, the temperature being taken at the centre of weld on the surface of seam.

2 Butt Weld Test Assemblies with Multi-run Technique (**Fig. M6.8**)

(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. M6.9**)

(1) The maximum diameter of wire and edge preparation are to be in accordance with **Fig. M6.10**, 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℃ 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. M6.7 Deposited Metal Test Assembly with Multi-run Technique (Unit: *mm*)

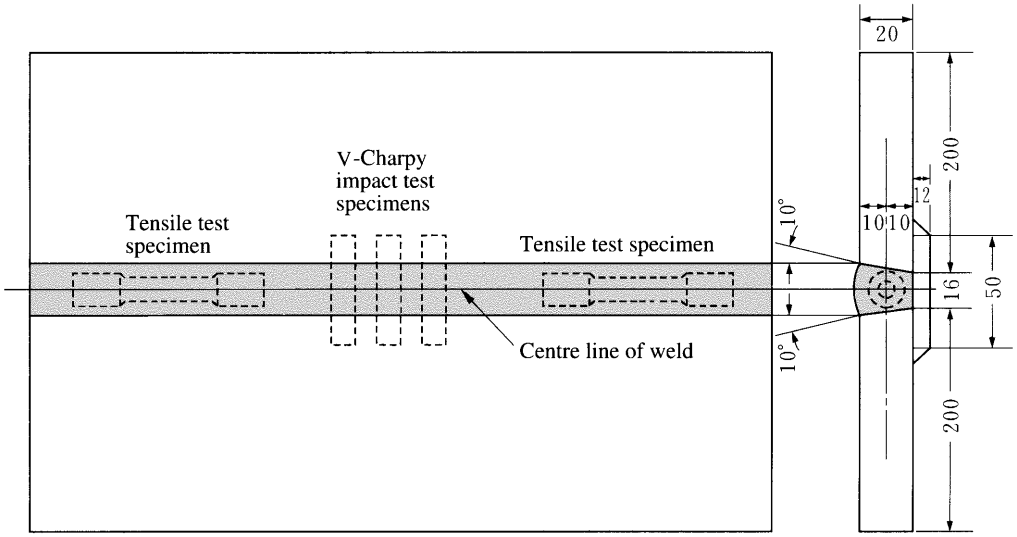
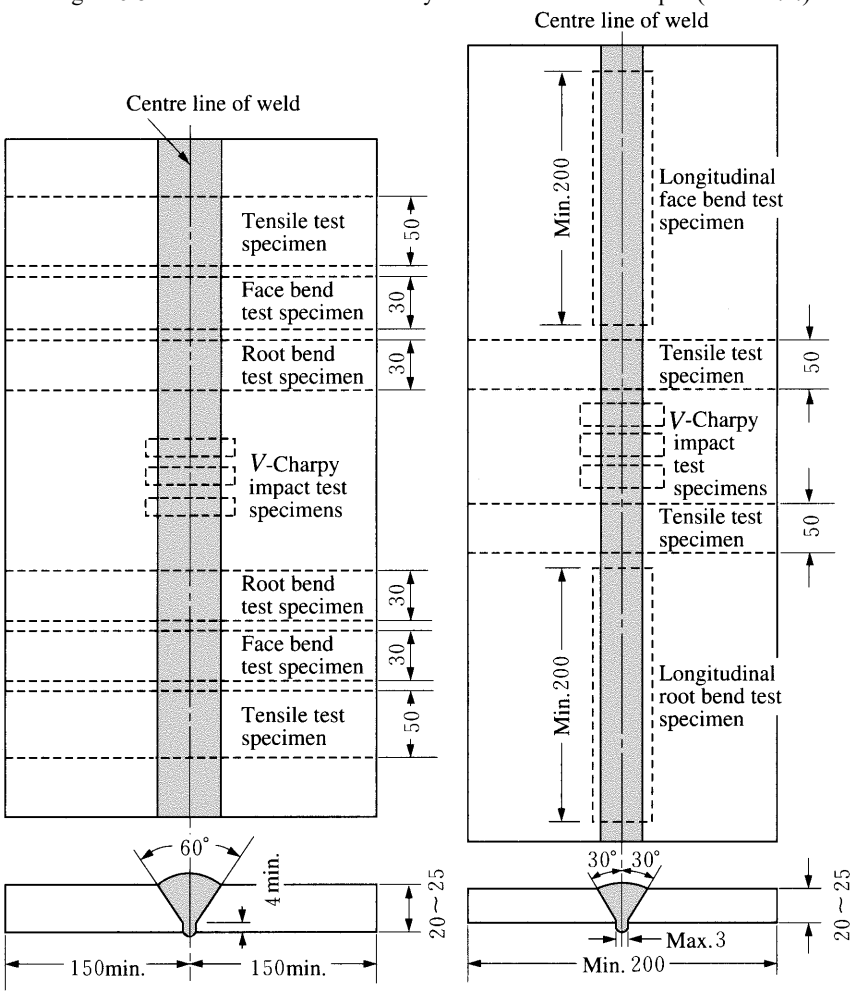


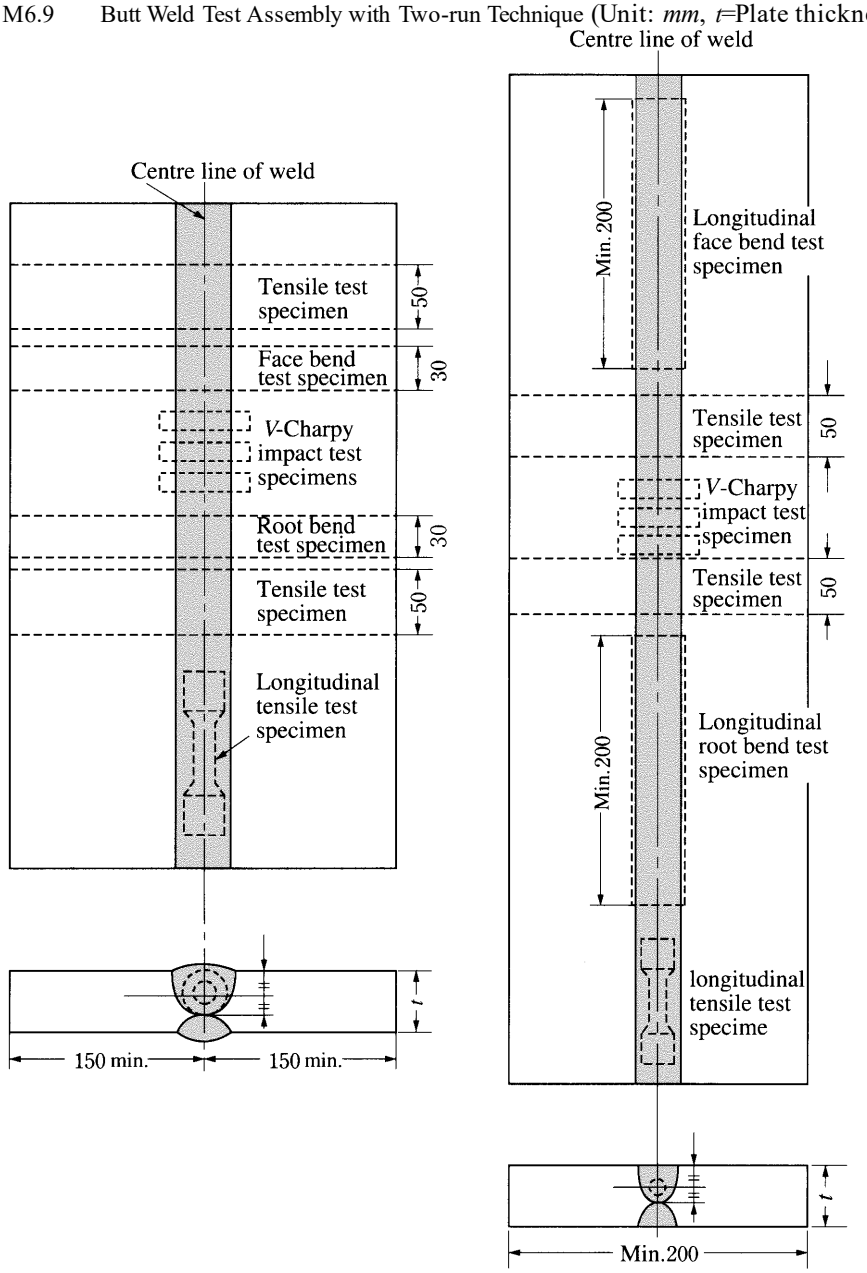
Fig. M6.8 Butt Weld Test Assembly with Multi-run Technique (Unit: *mm*)



(a) For Other Grades than (b)

(b) For *KAWL* 91 or *KAWL* 92

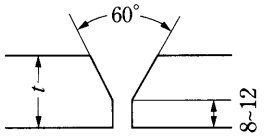
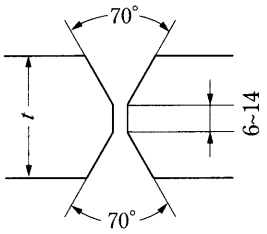
Fig. M6.9 Butt Weld Test Assembly with Two-run Technique (Unit: *mm*, *t*=Plate thickness)



(a) For Other Grades than (b) (b) For *KAWL*91 or *KAWL*92

Fig. M6.10 Edge Preparation of Butt Weld Test Assembly with Two-run Technique (Unit: *mm*, *t*=Plate thickness)

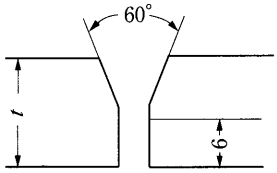
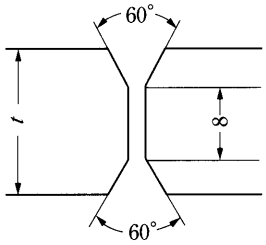
(a) Submerged Arc Welding Consumables

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

Note :

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 *U*1*A* specimen shown in **Table M3.1** and two specimens are to be taken from test assembly with 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 M6.17** 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 M6.17 Tensile Test Requirements for Deposited Metal

Grade of welding consumable	Tensile strength (N/mm^2)	Yield point (N/mm^2)	Elongation (%)
*KAW*1	400～560	305 min.	22 min.
*KAW*2			
*KAW*3			
*KAW*51	490～660	375 min.	
*KAW*52			
*KAW*53			
*KAW*54			
*KAW*52*Y*40	510～690	400 min.	
*KAW*53*Y*40			
*KAW*54*Y*40			
*KAW*55*Y*40			
*KAW*63*Y*47	570～720	460 min.	19 min.
*KAWL*1	400～560	305 min.	
*KAWL*2	440～610	345 min.	
*KAWL*3	490～660	375 min.	21 min.
*KAWL*91	590 min.	375(1) min.	25 min.
*KAWL*92	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 *U*4 specimen shown in **Table K2.5** 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 M6.4** of the preceding **6.2.7**.

2 Testing temperature and minimum mean absorbed energy are to meet the requirements of **Table M6.18** 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 M6.18 Impact Test Requirements for Deposited Metal

Grade of Welding consumable	Testing temperature (℃)	Minimum mean absorbed energy (*J*)
*KAW*1	20	34
*KAW*2	0	
*KAW*3	-20	
*KAW*51	20	
*KAW*52	0	
*KAW*53	-20	
*KAW*54	-40	
*KAW*52*Y*40	0	39
*KAW*53*Y*40	-20	
*KAW*54*Y*40	-40	
*KAW*55*Y*40	-60	
*KAW*63*Y*47	-20	64
*KAWL*1	-40	27
*KAWL*2	-60	
*KAWL*3	-60	
*KAWL*91	-196	
*KAWL*92	-196	

6.3.8 Butt Weld Tensile Test with Multi-run Technique

1 The tensile test specimens are to be *U*2*A* or *U*2*B* specimen shown in **Table M3.1** and two specimens are to be taken from each test assembly.

2 The tensile strength obtained from the tensile tests is to meet the requirements of **Table M6.19**, according to the grades of the automatic welding consumables.

Table M6.19 Tensile Test Requirements for Butt Weld

Grade of welding consumable	Tensile Strength (N/mm^2)
*KAW*1, *KAW*2, *KAW*3	400 min.
*KAW*51, *KAW*52, *KAW*53, *KAW*54	490 min.
*KAW*52*Y*40, *KAW*53*Y*40, *KAW*54*Y*40, *KAW*55*Y*40	510 min.
*KAW*63*Y*47	570 min.
*KAWL*1	400 min.
*KAWL*2	440 min.
*KAWL*3	490 min.
*KAWL*91	630 min.
*KAWL*92	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 M3.2** and two test specimens are to be taken from each test assembly. For *KAWL*91 or *KAWL*92 face and root bend test specimen are to be *B*-7 test specimens shown in **Table M3.2**, 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 3 *mm* on the outer surface of bending or any other defects is not to develop. However, the inner radius and bending angle of *KAWL*92 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 *U*4 specimen shown in **Table K2.5** 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 M6.4** of the preceding **6.2.7**.

2 Testing temperature and the minimum mean absorbed energy are to meet the requirements of **Table M6.18** 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 M3.1** and two specimens are to be taken from each assembly.

2 The tensile strength obtained from the tensile tests is to meet the requirements of **Table M6.19**, 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 M3.1** is to be machined from the thicker test assembly and the longitudinal axis is to coincide with the centre of weld about 7 *mm* 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℃ 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 M6.17** 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 M3.2** and test specimens are to be taken from each test assembly. However, for *KAWL*91 and *KAWL*92, 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.

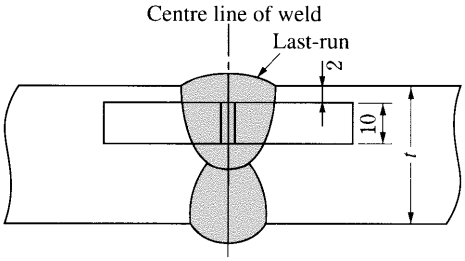
6.3.13 Butt Weld Impact Test with Two-run Technique

1 The impact test specimens are to be *U*4 specimen shown in **Table K2.5** 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 2 *mm* depth position of the test assembly as given in **Table M6.4** of the preceding **6.2.7**.

2 Test temperature and the minimum mean absorbed energy are to meet the requirements of **Table M6.18** 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. M6.11 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 M6.20**.

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 M6.15** 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 M6.20 Kind of Test for Annual Inspection

Grade of welding consumable	Welding process	Kinds of test		Test assembly			Kind and number of test specimens taken from test assembly
				Number	Dimension	Thickness(2) (*mm*)	
*KAW*1 *KAW*2 *KAW*3 *KAW*51 *KAW*52 *KAW*53 *KAW*54 *KAW*52*Y*40 *KAW*53*Y*40 *KAW*54*Y*40 *KAW*55*Y*40 *KAW*63*Y*47 *KAWL*1 *KAWL*2 *KAWL*3 *KAWL*91 *KAWL*92	Multi-run technique	Deposited metal test		1	**Fig. M6.7**	20	Tensile test specimen : 1 Impact test specimen : 3
	Two-run technique	Butt weld test	Submerged arc welding	1	**Fig. M6.9**	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 shield 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. M6.7**	20	Tensile test specimen : 1 Impact test specimen : 3
		Butt(1) weld test	Submerged arc welding	1	**Fig. M6.9**	20	Tensile test specimen : 1 Face bend test specimen : 1 Root bend test specimen : 1 Impact test specimen : 3
			Gas shielded arc and shield arc welding	1		20～25	Tensile test specimen : 1 Face bend test specimen : 1 Root bend test specimen : 1 Impact test specimen : 3

Notes:

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

(2) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

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 M6.21**.

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 M6.14** of **6.3.2-3**, and the suffix given in Table will be added after suffix *G*. (Example : *KSW*53*G* (*M*1))

Table M6.21 Grades and Marks

For mild steel	For high tensile steel			For steel for low temperature service	
*KSW*1	*KSW*51	*KSW*52*Y*40	*KSW*63*Y*47	*KSWL*1	*KSWL*91
*KSW*2	*KSW*52	*KSW*53*Y*40		*KSWL*2	*KSWL*92
*KSW*3	*KSW*53	*KSW*54*Y*40		*KSWL*3	
	*KSW*54	*KSW*55*Y*40			

6.4.3 Approval Test

1 For the approval of semi-automatic welding consumables, the test specified in **6.4.4-1** is 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 M6.14**. Although, when the manufacturer of the consumables recommends gas types of the group of *M*1, *M*2, *M*3 or *C*, in **Table M6.14**, 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 *M*1, *M*2 or *M*3, the test is allowed to limit any one of the gas types of *M*1, *M*2 or *M*3 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 M6.22**.

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 M6.23**, appropriate to the kind of semi-automatic welding consumables.

Table M6.22 Kind of Test for Semi-Automatic Welding Consumable

Kinds of test[6]	Test assembly					Kind and number of test specimens taken from test assembly
	Welding position	Wire diameter (*mm*)	Number	Dimensions	Thickness[7] (*mm*)	
Deposited metal test	Flat	maximum diameter	1[1]	**Fig. M6.1**	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. M6.2**	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. M6.3**	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.

(7) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

Table M6.23 Grades of Steel Used for Test Assembly

Grade of welding consumable	Grade of steel used for test assembly(1)(2)
*KSW*1	*KA*
*KSW*2	*KA*, *KB* or *KD*
*KSW*3	*KA*, *KB*, *KD* or *KE*
*KSW*51	*KA*32 or *KA*36
*KSW*52	*KA*32, *KA*36, *KD*32 or *KD*36
*KSW*53	*KA*32, *KA*36, *KD*32, *KD*36, *KE*32 or *KE*36
*KSW*54	*KA*32, *KA*36, *KD*32, *KD*36, *KE*32, *KE*36, *KF*32 or *KF*36
*KSW*52*Y*40	*KA*40 or *KD*40
*KSW*53*Y*40	*KA*40, *KD*40 or *KE*40
*KSW*54*Y*40, *KSW*55*Y*40	*KA*40, *KD*40, *KE*40 or *KF*40
*KSW*63*Y*47	*KE*47
*KSWL*1	*KE* or *KL*24*A*
*KSWL*2	*KE*, *KL*24*A*, *KL*24*B*, *KL*27 or *KL*33
*KSWL*3	*KL*27, *KL*33 or *KL*37
*KSWL*91	*KL*9*N*53 or *KL*9*N*60
*KSWL*92	*KL*9*N*53 or *KL*9*N*60

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 *KSWL*91 and *KSWL*92.

(2) The tensile strength of high tensile steels *KA*32, *KD*32, *KE*32 and *KF*32 used in the test assemble is to be greater than 490 N/mm^2.

6.4.5 Welding Sequence of Test Assemblies

1 Deposited Metal Test Assemblies (**Fig. M6.1**)

(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 2 *mm* to 6 *mm*.

(2) After each run, the assembly is to be left in still air until it has cooled to less than 250℃ but not below 100℃, the temperature being taken at the centre of weld on the surface of seam.

2 Butt Weld Test Assemblies (**Fig. M6.2**)

(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℃, but not below 100℃, the temperature being taken at the centre of weld on the surface of seam.

3 Fillet Weld Test Assemblies (**Fig. M6.3**)

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 may 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 *U*1*A* specimen shown in **Table M3.1** and one specimen 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 M6.24** 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 M6.24 Tensile Test Requirements for Deposited Metal

Grade of welding consumable	Tensile Strength (N/mm^2)	Yield point (N/mm^2)	Elongation (%)
*KSW*1	400～560	305 min.	22 min.
*KSW*2			
*KSW*3			
*KSW*51	490～660	375 min.	
*KSW*52			
*KSW*53			
*KSW*54			
*KSW*52*Y*40	510～690	400 min.	
*KSW*53*Y*40			
*KSW*54*Y*40			
*KSW*55*Y*40			
*KSW*63*Y*47	570～720	460 min.	19 min.
*KSWL*1	400～560	305 min.	22 min.
*KSWL*2	440～610	345 min.	
*KSWL*3	490～660	375 min.	21 min.
*KSWL*91	590 min.	375(1) min.	25 min.
*KSWL*92	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 *U*4 specimens as shown in **Table K2.5** 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 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 M6.25** 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 M6.25 Impact Test Requirements for Deposited Metal

Grade of welding consumable	Testing temperature (℃)	Minimum mean absorbed energy (*J*)
*KSW*1	20	47
*KSW*2	0	
*KSW*3	-20	
*KSW*51	20	
*KSW*52	0	
*KSW*53	-20	
*KSW*54	-40	
*KSW*52*Y*40	0	
*KSW*53*Y*40	-20	
*KSW*54*Y*40	-40	
*KSW*55*Y*40	-60	
*KSW*63*Y*47	-20	64
*KSWL*1	-40	34
*KSWL*2	-60	
*KSWL*3	-60	
*KSWL*91	-196	27
*KSWL*92	-196	

6.4.8 Butt Weld Tensile Test

1 The tensile test specimens are to be *U*2*A* or *U*2*B* specimen shown in **Table M3.2** 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 M6.26**.

Table M6.26 Tensile Test Requirements for Butt Weld

Grade of welding consumable	Tensile Strength (N/mm^2)
*KSW*1, *KSW*2, *KSW*3	400 min.
*KSW*51, *KSW*52, *KSW*53, *KSW*54	490 min.
*KSW*52*Y*40, *KSW*53*Y*40, *KSW*54*Y*40, *KSW*55*Y*40	510 min.
*KSW*63*Y*47	570 min.
*KSWL*1	400 min.
*KSWL*2	440 min.
*KSWL*3	490 min.
*KSWL*91	630 min.
*KSWL*92	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 M3.2** and one specimen is to be taken from each test assembly. However, for *KSWL*91 and *KSWL*92, the face and root bend specimens are to be *UB*-7 specimen shown in **Table M3.2** and specimen is to be taken longitudinally from each test assembly.

2 The test specimens are to be capable of withstanding, without crack exceeding 3 *mm* 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 *KMWL*91 and *KMWL*92, 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 *U*4 specimen as shown in **Table K2.5** 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 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 M6.27** 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 M6.28**.

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 M6.27 Impact Test Requirements for Butt Weld

<table>
<tr><th rowspan="2">Grade of welding consumable</th><th rowspan="2">Testing temperature (℃)</th><th colspan="2">Minimum mean absorbed energy (J)</th></tr>
<tr><th>Flat, Horizontal, Overhead</th><th>Vertical upward, Vertical downward</th></tr>
<tr><td>KSW1</td><td>20</td><td rowspan="10">47</td><td rowspan="6">34</td></tr>
<tr><td>KSW2</td><td>0</td></tr>
<tr><td>KSW3</td><td>-20</td></tr>
<tr><td>KSW51</td><td>20</td></tr>
<tr><td>KSW52</td><td>0</td></tr>
<tr><td>KSW53</td><td>-20</td></tr>
<tr><td>KSW54</td><td>-40</td><td rowspan="4">39</td></tr>
<tr><td>KSW52Y40</td><td>0</td></tr>
<tr><td>KSW53Y40</td><td>-20</td></tr>
<tr><td>KSW54Y40</td><td>-40</td></tr>
<tr><td>KSW55Y40</td><td>-60</td></tr>
<tr><td>KSW63Y47</td><td>-20</td><td colspan="2">64</td></tr>
<tr><td>KSWL1</td><td>-40</td><td rowspan="5">27</td><td rowspan="5">27</td></tr>
<tr><td>KSWL2</td><td>-60</td></tr>
<tr><td>KSWL3</td><td>-60</td></tr>
<tr><td>KSWL91</td><td>-196</td></tr>
<tr><td>KSWL92</td><td>-196</td></tr>
</table>

Table M6.28 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(2) (*mm*)	
Deposited metal test	Flat	(1)	1	Fig. M6.1	20	Tensile test specimen : 1 Impact test specimen : 3

Notes:

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

(2) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

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 refered 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 M6.29**.

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 M6.29 Grades and Marks

For mild steel	For high tensile steel		
*KEW*1	*KEW*51	*KEW*52*Y*40	*KEW*63*Y*47
*KEW*2	*KEW*52	*KEW*53*Y*40	
*KEW*3	*KEW*53	*KEW*54*Y*40	
	*KEW*54	*KEW*55*Y*40	

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 M6.30**.

2 Grades of steel to be used for test assemblies are to be as given in **Table M6.31**.

Table M6.30 Kind of Test for Electro-slag and Electro-gas Welding Consumables

Kind of test	Test assembly			Kinds and no. of test specimens taken from test assembly
	Number	Dimensions	Thickness(1)(2) (*mm*)	
Butt weld test	1	Fig.M6.12	20～25	Tensile test specimen : 2 Longitudinal tensile test specimen : 2 Side bend test specimen : 2 Impact test specimen : 6 Macro test specimen : 2
	1		35～45	

Notes:

(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.

(2) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

Table M6.31 Grades of Steel Used for Test Assembly

Grade of welding consumable	Grade of steel used for test assembly(1)
*KEW*1	*KA*
*KEW*2	*KA*, *KB* or *KD*
*KEW*3	*KA*, *KB*, *KD* or *KE*
*KEW*51	*KA*32 or *KA*36
*KEW*52	*KA*32, *KA*36, *KD*32 or *KD*36
*KEW*53	*KA*32, *KA*36, *KD*32, *KD*36, *KE*32 or *KE*36
*KEW*54	*KA*32, *KA*36, *KD*32, *KD*36, *KE*32, *KE*36, *KF*32 or *KF*36
*KEW*52*Y*40	*KA*40 or *KD*40
*KEW*53*Y*40	*KA*40, *KD*40 or *KE*40
*KEW*54*Y*40, *KEW*55*Y*40	*KA*40, *KD*40, *KE*40 or *KF*40
*KEW*63*Y*47	*KE*47

Note:

(1) The tensile strength of high tensile steels *KA*32, *KD*32, *KE*32 and *KF*32 used in the test assemble is to be greater than 490 N/mm^2.

6.5.5 Welding Sequence of Test Assemblies

1 Butt weld test assemblies (**Fig. M6.12**)

(1) The edge preparation is to be in accordance with the recommendations by the manufacturer.

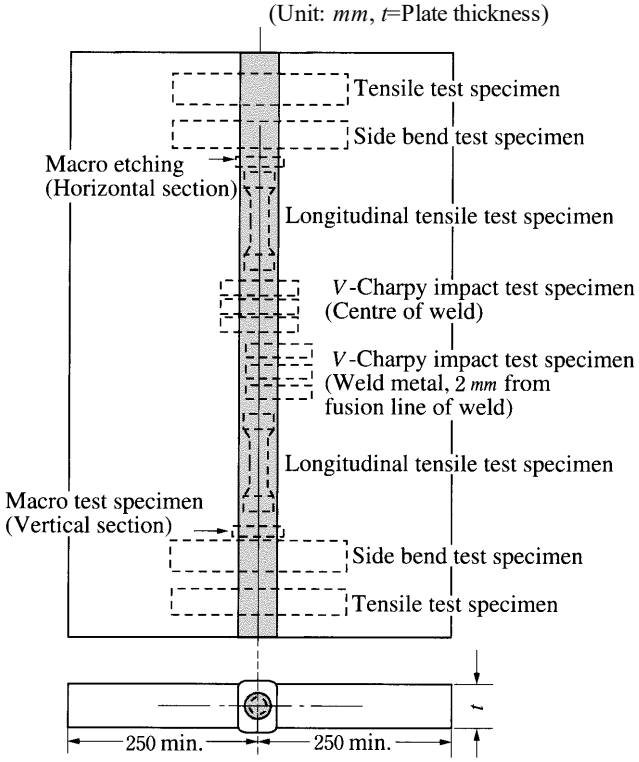
(2) Test assemblies are to be welded upward in vertical position in one pass, generally, and in accordance with the practice recommended by the manufacturer.

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. M6.12 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 M3.1** to be taken from each test assembly.

2 Longitudinal tensile test specimens may be subjected to the heat treatment not exceeding 250℃ 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 M6.32** 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 M6.33** 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 M6.32 Tensile Test Requirement

Grade of welding consumable	Tensile Strength (N/mm^2)
*KEW*1 *KEW*2 *KEW*3	400 min.
*KEW*51 *KEW*52 *KEW*53 *KEW*54	490 min.
*KEW*52*Y*40 *KEW*53*Y*40 *KEW*54*Y*40 *KEW*55*Y*40	510 min.
*KEW*63*Y*47	570 min.

Table M6.33 Longitudinal Tensile Test Requirement

Grade of welding consumable	Tensile Strength (N/mm^2)	Yield point (N/mm^2)	Elongation (%)
*KEW*1 *KEW*2 *KEW*3	400～560	305 min.	22 min.
*KEW*51 *KEW*52 *KEW*53 *KEW*54	490～660	375 min.	
*KEW*52*Y*40 *KEW*53*Y*40 *KEW*54*Y*40 *KEW*55*Y*40	510～690	400 min.	
*KEW*63*Y*47	570～720	460 min.	19 min.

6.5.7 Bend Test

1 Two pieces of side bend test specimen *UB*-8 shown in **Table M3.2** 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 3 *mm* can be seen on the outer surface of the test specimen.

6.5.8 Impact Test

1 The impact test specimens are to be *U*4 specimen as shown in **Table K2.5**, 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 2 *mm* apart from the surface of test assembly as specified in **Fig. M6.13**.

2 The position of the notch is to be in accordance with **Fig. M6.13(a)** and **(b)** respectively, and its longitudinal direction is to be perpendicular to the surface of the test assembly.

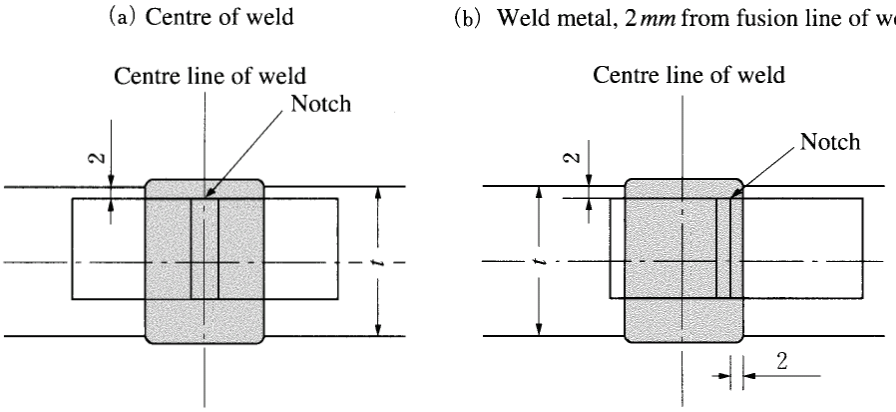
3 Testing temperature and each value of minimum mean absorbed energy is to be in accordance with the requirements in **Table M6.34** according to grade of welding consumable.

4 The requirements in **6.2.7-4**. are to be applied to this clause.

Table M6.34 Impact Test Requirement

Grade of welding consumable	Testing temperature (℃)	Minimum mean absorbed energy (*J*)
*KEW*1	20	34
*KEW*2	0	
*KEW*3	-20	
*KEW*51	20	
*KEW*52	0	
*KEW*53	-20	
*KEW*54	-40	
*KEW*52*Y*40	0	39
*KEW*53*Y*40	-20	
*KEW*54*Y*40	-40	
*KEW*55*Y*40	-60	
*KEW*63*Y*47	-20	64

Fig. M6.13 Position of Impact Specimen (Unit: *mm*, *t*= Plate thickness)



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 M6.35**.

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 M6.35 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) (3) (4) (*mm*)	
Butt weld test	1	**Fig. M6.12**	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.

(3) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

(4) In cases where testing is difficult to carry out under the applied welding process, the specified value in this table may be changed.

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 M6.12**.

2 One side automatic welding consumables which have passed the tests for each welding process given in **Table M6.37** are to be appended with suffixes given in **Table M6.36** 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 M6.14** of **6.3.2-3**, and the suffix given in **Table M6.14** will be added after the suffix *G*. (Example : *KAW*53*SMPG* (M1))

Table M6.36 Suffix

Welding technique	Suffixes
One-run technique(1)	*SP*
Multi-run technique(2)	*MP*
One-run and multi-run technique	*SMP*

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 M6.37 Kinds of Test for One-side Automatic Welding Consumable

Grade of welding consumable	Welding process	Kinds of test[5]	Test assembly			Kind and number of test specimens taken from test assembly
			Number	Dimension	Thickness[1][8] (*mm*)	
*KAW*1 *KAW*2 *KAW*3 *KAW*51 *KAW*52	One-run technique	Butt weld test	1	Fig. M6.14	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	
*KAW*53 *KAW*54 *KAW*52*Y*40 *KAW*53*Y*40 *KAW*54*Y*40 *KAW*55*Y*40 *KAW*63*Y*47	Multi-run technique		1		12～15[2]	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
					20～25[3]	
			1		20～25[2]	
					30～35[3]	
*KAWL*1 *KAWL*2 *KAWL*3 *KAWL*91 *KAWL*92	One-run and Multi-run technique		1		12～15[6]	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][7]	
					30～35[3][7]	

Notes:

(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 restrictions is to be taken as the maximum applicable thickness, and is to be certified.

(2) Thickness of test assemblies corresponding to single electrodes.

(3) Thickness of test assemblies corresponding to multiple electrodes.

(4) Where thickness of test assemblies ranges between 12～15 *mm*, the test specimens are to be 1 set of 3 impact test specimens given in Fig. M6.15(b).

(5) The hydrogen test may be carried out at the request of the manufacturer.

(6) Thickness of test assembly for one-run technique.

(7) Thickness of test assembly for multi-run technique.

(8) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

6.6.3 Approval Test

1 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 M6.14. Although, when the manufacturer of the consumables recommends gas types of the group of *M*1, *M*2, *M*3 or *C* in Table M6.14, 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 *M*1, *M*2 and *M*3, the test is allowed to limit any one of the gas types of *M*1, *M*2 or *M*3 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 M6.37**.

2 Grades of steel to be used in preparation of test assemblies are to be as given in **Table M6.38**.

Table M6.38 Grades of Steel Used for Test Assembly

Grade of welding consumable	Grade of steel used for test assembly(1)
*KAW*1	*KA*
*KAW*2	*KA*, *KB* or *KD*
*KAW*3	*KA*, *KB*, *KD* or *KE*
*KAW*51	*KA*32 or *KA*36
*KAW*52	*KA*32, *KA*36, *KD*32 or *KD*36
*KAW*53	*KA*32, *KA*36, *KD*32, *KD*36, *KE*32 or *KE*36
*KAW*54	*KA*32, *KA*36, *KD*32, *KD*36, *KE*32, *KE*36, *KF*32 or *KF*36
*KAW*52*Y*40	*KA*40 or *KD*40
*KAW*53*Y*40	*KA*40, *KD*40 or *KE*40
*KAW*54*Y*40, *KAW*55*Y*40	*KA*40, *KD*40, *KE*40 or *KF*40
*KAW*63*Y*47	*KE*47
*KAWL*1	*KE* or *KL*24*A*
*KAWL*2	*KE*, *KL*24*A*, *KL*24*B*, *KL*27 or *KL*33
*KAWL*3	*KL*27, *KL*33 or *KL*37
*KAWL*91	*KL*9*N*53 or *KL*9*N*60
*KAWL*92	*KL*9*N*53 or *KL*9*N*60

Note:

(1) The tensile strength of high tensile steels *KA*32, *KD*32, *KE*32 and *KF*32 used in the test assemble is to be greater than 490 N/mm^2.

6.6.5 Welding Sequence of Test Assemblies

1 Butt Weld Test Assemblies with One-run and Multi-run Technique (**Fig. M6.14**)

(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.

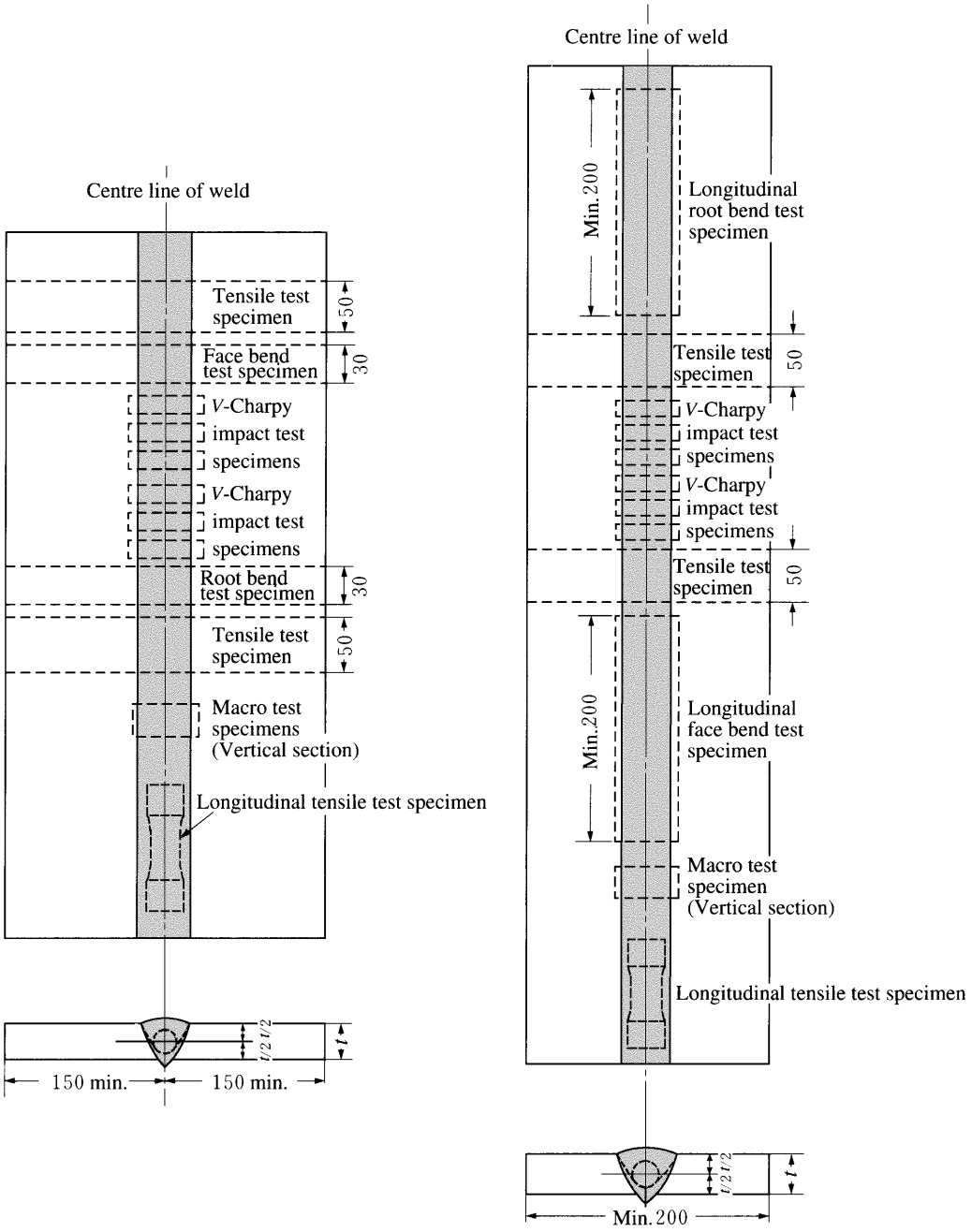
(2) Test assemblies are to be welded in flat position by one-run technique or multi-run technique according to the procedures specified by the manufacturer. However, for gas shielded arc and self-shielded arc one side automatic welding consumables, the welding position is to be specified by the manufacturer.

(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℃ but not below 100℃, 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 may be subjected to radiographic examination prior to taking specimen from the assembly.

Fig. M6.14 Butt Weld Test Assembly with One-run and Multi-run Technique (Unit: *mm*, *t*=Plate thickness)



(a) For Other Grade than (b) (b) For *KAWL* 91 or *KAWL* 92

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

1 Two tensile test specimens to be *U*2*A* or *U*2*B* as shown in **Table M3.1** and one longitudinal tensile test specimen to be *U*1*A* are to be taken from each test assembly with 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℃ for a period not exceeding 16 hours for hydrogen removal prior to testing.

3 Tensile strength of *U*2*A* or *U*2*B* test specimen is to be as given in **Table M6.19** of **6.3.8** according to the grades of one side automatic welding consumables. Tensile strength, yielding point and elongation of *U*1*A* longitudinal tensile test specimens are to be as given in **Table M6.17** 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

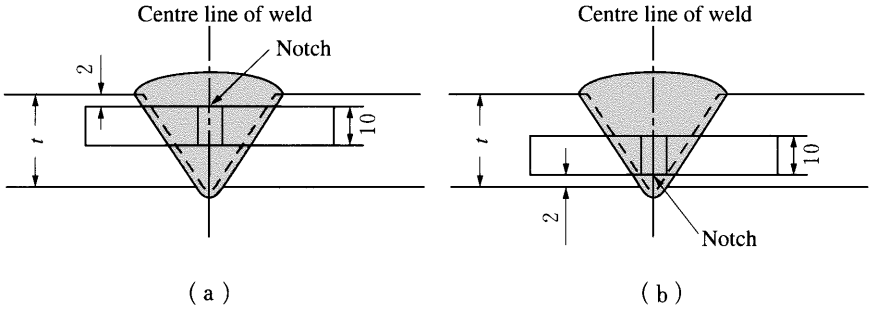
1 Two sets of impact test specimens to be *U*4 test specimens as shown in Table K2.5 are to be taken from each test assembly. Longitudinal direction of the test specimen is to be perpendicular to the weld line and each position from which the test specimens are taken is to be **(a)** and **(b)** as shown in Fig. M6.15.

2 Testing temperature and the value of minimum mean absorbed energy are to meet the requirements of Table M6.18 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. M6.15 Position of Impact Test Specimen for Butt Weld with One-run and Multi-run Technique

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



(a) (b)

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. M6.14. 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 M6.39.

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 M6.39 Kinds of Test at Annual Inspection

Grade of welding consumable	Welding process	Kinds of test	Test assembly			Kind and number of test specimens taken from test assembly
			Number	Dimension	Thickness[3] (*mm*)	
*KAW*1 *KAW*2 *KAW*3 *KAW*51 *KAW*52	One-run technique	Butt weld[2] test	1	Fig. M6.14	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]
*KAW*53 *KAW*54 *KAW*52*Y*40 *KAW*53*Y*40 *KAW*54*Y*40 *KAW*55*Y*40	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]
*KAW*63*Y*47 *KAWL*1 *KAWL*2 *KAWL*3 *KAWL*91 *KAWL*92	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. M6.15(b)**.

(2) The butt weld tests for one-run and multi-run technique are to be carried out by one-run technique.

(3) Thicknesses of *KE*47 steel used as test specimens may be reduced to the thicknesses in the table by machining before welding.

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 M6.40**.

2 Submerged arc welding consumables which have passed the tests for each welding process given in **Table M6.42** are appended with suffixes shown in **Table M6.41** 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 M6.14** of **6.3.2-3**, and the suffix given in the table will be added after suffix *G*. (Example: *KW*308*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: *KW*308*G(C)*-315M)

Table M6.40 Grades and Marks of Welding Consumables

Electrode for manual arc welding	Consumable for *TIG* and *MIG* welding	Flux wire semi-automatic welding	Consumable for submerged arc welding
*KD*308	*KY*308	*KW*308	*KU*308
*KD*308*L*	*KY*308*L*	*KW*308*L*	*KU*308*L*
*KD*308*N2*	*KY*308*N2*	*KW*308*N2*	-
*KD*309	*KY*309	*KW*309	*KU*309
*KD*309*L*	*KY*309*L*	*KW*309*L*	*KU*309*L*
*KD*309*Mo*	*KY*309*Mo*	*KW*309*Mo*	*KU*309*Mo*
*KD*309*MoL*	-	*KW*309*MoL*	-
*KD*310	*KY*310	*KW*310	*KU*310
-	*KY*310*S*	-	-
*KD*310*Mo*	-	-	-
*KD*316	*KY*316	*KW*316	*KU*316
*KD*316*L*	*KY*316*L*	*KW*316*L*	*KU*316*L*
*KD*317	*KY*317	*KW*317	*KU*317
*KD*317*L*	*KY*317*L*	*KW*317*L*	*KU*317*L*
-	*KY*321	-	-
*KD*329*J*1	-	-	-
*KD*329*J*4*L*	*KY*329*J*4*L*	*KW*329*J*4*L*	-
*KD*2209	*KY*2209	*KW*2209	-
*KD*347	*KY*347	*KW*347	*KU*347

Table M6.41 Suffix

Welding process	Suffix
Multi-run technique	*M*
Two-run technique	*T*
Multi-run and Two-run technique	*TM*

Table M6.42 Kinds of Test of Welding Consumables for Stainless Steel

Kind of welding consumables	Kind of test	Test assembly					Kind and number of test specimens taken from test assembly
		Welding position	Dia. of electrode or wire[1] (*mm*)	No.	Dimension	Thickness (*mm*)	
Electrode for manual arc welding	Deposited metal test	Flat	3.2	1	Fig. M6.16	12	Tensile test specimen : 1
			4.0			19	
	Butt weld test	Flat	3.2 or 4.0	1	Fig. M6.17	9~12	Tensile test specimen : 1 Face bend test specimen : 1 Root bend test specimen : 1
		Horizontal		1			
		Vertical upward		1			
		Vertical downward		1			
		Overhead		1			
Consumables for *TIG* welding	Deposited metal test	Flat	2.4	1	Fig. M6.16	12	Tensile test specimen : 1
			3.2	1		19	
	Butt weld test	Flat	2.0~3.2	1	Fig. M6.17	9~12	Tensile test specimen : 1 Face bend test specimen : 1 Root bend test specimen : 1
		Horizontal		1			
		Vertical upward		1			
		Vertical downward		1			
		Overhead		1			
Consumables for *MIG* welding	Deposited metal test	Flat	1.2	1	Fig. M6.16	12	Tensile test specimen : 1
			1.6	1		19	
	Butt weld test	Flat	1.2~2.0	1	Fig. M6.17	9~12	Tensile test specimen : 1 Face bend test specimen : 1 Root bend test specimen : 1
		Horizontal		1			
		Vertical upward		1			
		Vertical downward		1			
		Overhead		1			
Flux wire for semi-automatic welding	Deposited metal test	Flat	1.2~2.4	1	Fig. M6.16	12	Tensile test specimen : 1
			3.2 or max. dia.			19	
	Butt weld test	Flat	1.2~3.2	1	Fig. M6.17	9~12	Tensile test specimen : 1 Face bend test specimen : 1 Root bend test specimen : 1
		Horizontal		1			
		Vertical upward		1			
		Vertical downward		1			
		Overhead		1			

Kind of welding consumables		Kind of test	Test assembly					Kind and number of test specimens taken from test assembly
			Welding position	Dia. of electrode or wire[(1)] (*mm*)	No.	Dimension	Thickness (*mm*)	
Consumables for sub-merged arc welding	Multi-run technique	Deposited metal test	Flat	1.2~4.0	1	Fig. M6.16	19~25	Tensile test specimen : 1
		Butt weld test	Flat	1.2~4.0	1	Fig. M6.18(a)	19	Tensile test specimen : 1 Face bend test specimen : 1 Root bend test specimen : 1
	Two-run technique	Butt weld test	Flat	1.2~2.4	1	Fig. M6.18(b)	12	Tensile test specimen : 1 Face bend test specimen : 1 Root bend test specimen : 1
			Flat	4.0	1		19	Tensile test specimen : 1 Longitudinal tensile test specimen : 1 Face bend test specimen : 1 Root bend test specimen : 1
	Multi-run and Two-run technique	Deposited metal test	Flat	1.2~4.0	1	Fig. M6.16	19~25	Tensile test specimen : 1
		Butt weld test (Multi-run)	Flat	1.2~4.0	1	Fig. M6.18(a)	19	Tensile test specimen : 1 Face bend test specimen : 1 Root bend test specimen : 1
		Butt weld test (Two-run)	Flat	1.2~2.4	1	Fig. M6.18(b)	12	Tensile test specimen : 1 Longitudinal tensile test specimen: 1 Face bend test specimen : 1 Root bend test specimen : 1
			Flat	4.0	1		19	Tensile test specimen : 1 Longitudinal tensile test specimen: 1 Face bend test specimen : 1 Root bend test 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 M6.14**. Although, when the manufacturer of the consumables recommends gas types of the group of *M*1, *M*2 or *M*3 in **Table M6.14**, 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 *M*1, *M*2 or *M*3, the test is allowed to limit any one of the gas types of *M*1, *M*2 and *M*3 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 M6.42**. 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 steels used for tests are to be of those grades of steel specified in **Table M6.43** according to types of welding consumables, or those considered to be equivalent by the Society.

Table M6.43 Grades of Steel for Test Assembly

Grade of welding consumable	Grade of steel for test assembly
*KD*308, *KY*308, *KW*308, *KU*308	*KSUS*304, *KSUS*304*L*
*KD*308*L*, *KY*308*L*, *KW*308*L*, *KU*308*L*	
*KD*308*N2*, *KY*308*N2*, *KW*308*N2*	*KSUS*304*N2*
*KD*309, *KY*309, *KW*309, *KU*309	*KSUS*309*S*
*KD*309*L*, *KY*309*L*, *KW*309*L*, *KU*309*L*	
*KD*309*Mo*, *KY*309*Mo*, *KW*309*Mo*, *KU*309*Mo*	
*KD*309*MoL*, *KW*309*MoL*	
*KD*310, *KY*310, *KW*310, *KU*310	*KSUS*310*S*
*KY*310*S*	
*KD*310*Mo*	
*KD*316, *KY*316, *KW*316, *KU*316	*KSUS*316, *KSUS*316*L*
*KD*316*L*, *KY*316*L*, *KW*316*L*, *KU*316*L*	
*KD*317, *KY*317, *KW*317, *KU*317	*KSUS*317, *KSUS*317*L*
*KD*317*L*, *KY*317*L*, *KW*317*L*, *KU*317*L*	
*KY*321	*KSUS*321
*KD*329*J*1	*KSUS*329*J*1
*KD*329*J*4*L*, *KY*329*J*4*L*, *KW*329*J*4*L*	*KSUS*329*J*4*L*
*KD*2209, *KY*2209, *KW*2209	*KSUS*323*L*, *KSUS*329*J*3*L*, *KSUS*821*L*1
*KD*347, *KY*347, *KW*347, *KU*347	*KSUS*321, *KSUS*347

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. M6.16**)

(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℃, but not below 15℃, the temperature being taken at the centre of weld on the surface of seam.

2 Butt weld test assemblies (**Fig. M6.17** and **Fig. M6.18**)

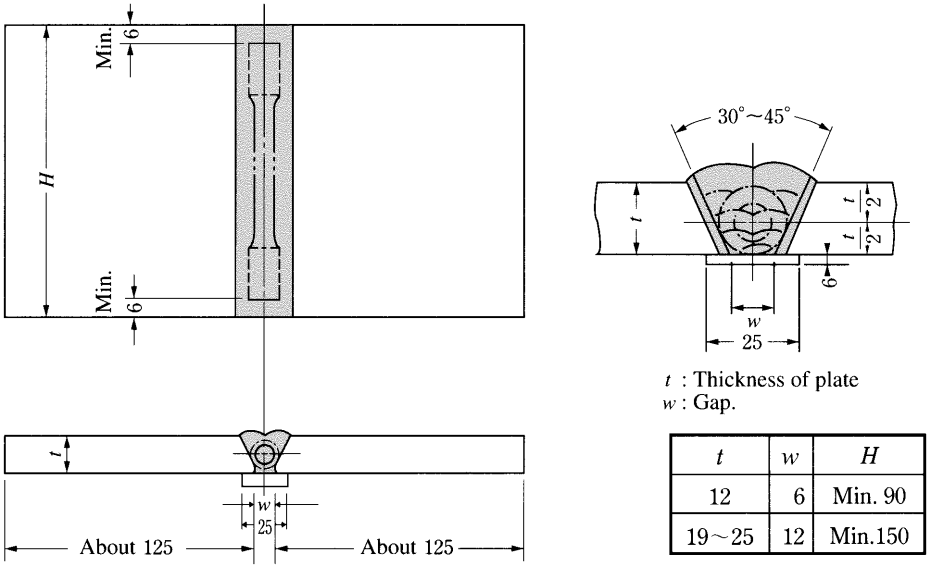
(1) Test assemblies are to be welded in each welding position (flat, horizontal, vertical upward, vertical downward and overhead) which is recommended by the manufacturer.

(2) After each run, the assembly is to be left in still air until it has cooled to less than 150℃, but not below 15℃, 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 may be subjected to radiographic examination prior to taking specimen from the assembly.

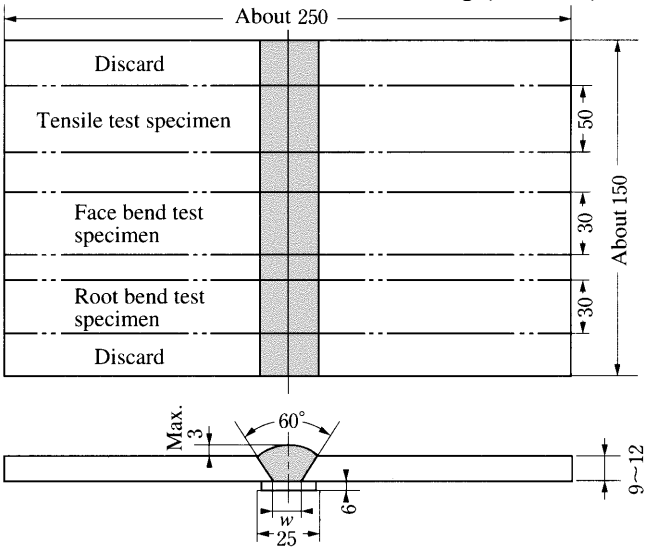
Fig. M6.16 Deposited Metal Test Assembly (Unit: *mm*)



t : Thickness of plate
w : Gap.

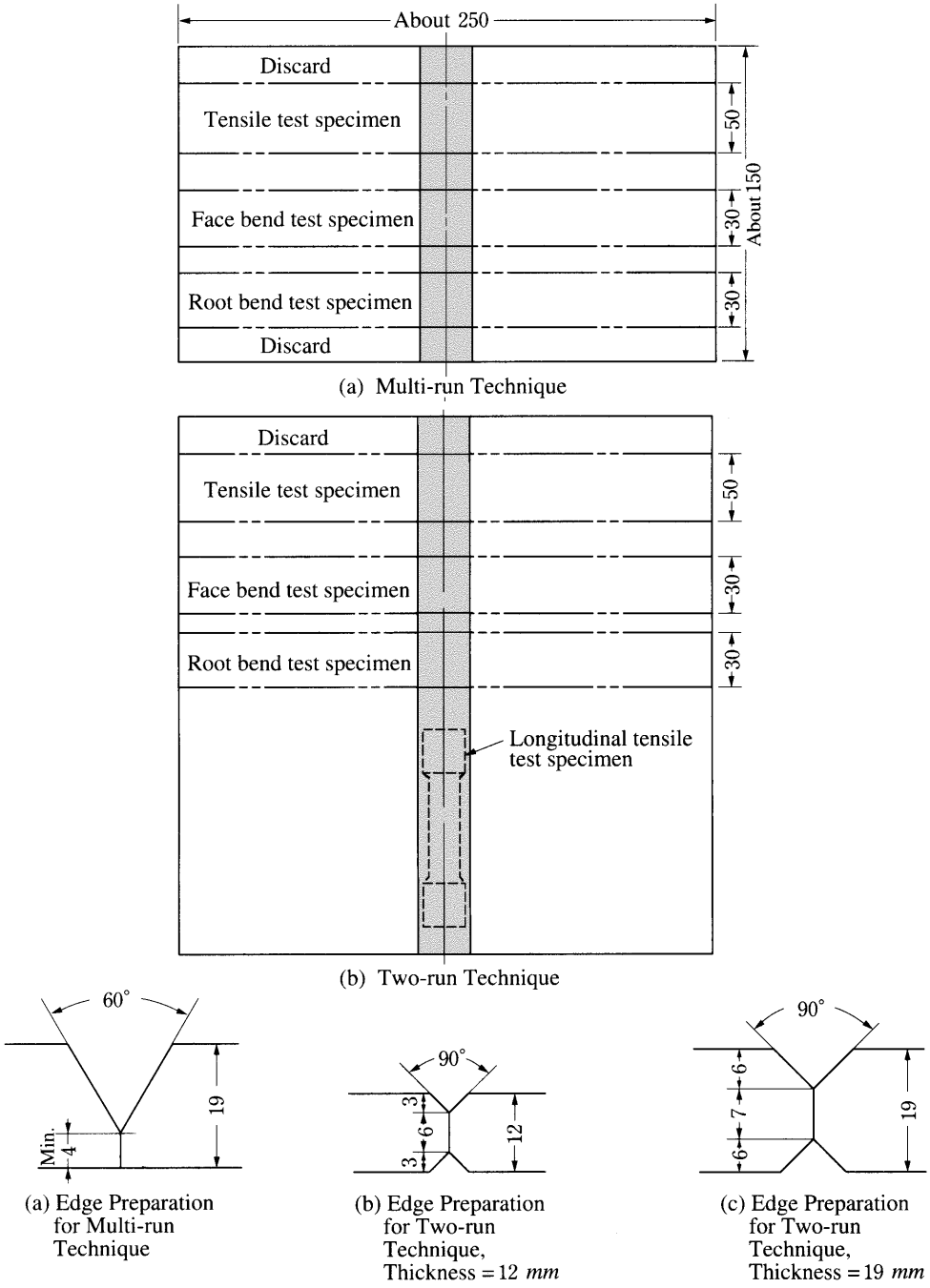
t	*w*	*H*
12	6	Min. 90
19～25	12	Min.150

Fig. M6.17 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 *TIG* welding	Consumables *MIG* welding	Flux wire for semi-automatic welding
Gap *w* (*mm*)	Max.dia.of electrode	Max. 5	Max. 5	Max. 6

Fig. M6.18 Butt Weld Test Assembly for Submerged Arc Welding (Unit: *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 M6.44**, **Table M6.46** and **Table M6.47**.

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 M6.45**.

6.7.7 Deposited Metal Tensile Test

1 The tensile test specimen is to be 1*B* or 1*C* specimen shown in **Table M3.1**, and test specimen is to be taken from each test assembly. Further, where approved by the Society, one *U*1*A* tensile test specimen may be taken, care being taken that the longitudinal axis coincides with the centre of weld and the thickness. (**Fig. M6.16**)

2 The tensile test specimens may be heated at below 250℃ 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 M6.48**, 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 M6.44 Chemical Composition of Deposited Metal for Electrodes

Grade	Chemical composition of deposited metal (%)								
	C	*Si*	*Mn*	*P*	*S*	*Ni*	*Cr*	*Mo*	Others
*KD*308	0.08 max.	0.90 max.	2.50 max.	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	-	-
*KD*308*L*	0.04 max.	0.90 max.	2.50 max.	0.04 max.	0.03 max.	9.0~12.0	18.0~21.0	-	-
*KD*308*N2*	0.10 max.	0.90 max.	1.00~4.00	0.04 max.	0.03 max.	7.0~11.0	20.0~25.0	-	*N* 0.12 ~0.30
*KD*309	0.15 max.	0.90 max.	2.50 max.	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	-	-
*KD*309*L*	0.04 max.	0.90 max.	2.50 max.	0.04 max.	0.03 max.	12.0~16.0	22.5~25.0	-	-
*KD*309*Mo*	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	-
*KD*309*MoL*	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	-
*KD*310	0.20 max.	0.75 max.	2.50 max.	0.03 max.	0.03 max.	20.0~22.0	25.0~28.0	-	-
*KD*310*Mo*	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	-
*KD*316	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	-
*KD*316*L*	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	-
*KD*317	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	-
*KD*317*L*	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	-
*KD*329*J*1	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	-
*KD*329*J4L*	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	*Cu*: 1.0 max. *N*: 0.08~0.30 *W*: 2.5 max.
*KD*2209	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	*Cu*: 0.75 max. *N*: 0.08~0.20
*KD*347	0.08 max.	0.90 max.	2.50 max.	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	-	*Nb*8×*C*(%)~1.0

Table M6.45 Chemical Composition of Deposited Metal for *TIG* Electrodes or *MIG* Wires

Grade	Chemical composition of deposited metal (%)								
	C	*Si*	*Mn*	*P*	*S*	*Ni*	*Cr*	*Mo*	Others
*KY*308	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	-	-
*KY*308*L*	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	-	-
*KY*308*N2*	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
*KY*309	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	-	-
*KY*309*L*	0.03 max.	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	12.0~14.0	23.0~25.0	-	-
*KY*309*Mo*	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	-
*KY*310	0.15 max.	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	20.0~22.5	25.0~28.0	-	-
*KY*310*S*	0.08 max.	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	20.0~22.5	25.0~28.0	-	-
*KY*316	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	-
*KY*316*L*	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	-
*KY*317	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	-
*KY*317*L*	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	-
*KY*321	0.08 max.	0.65 max.	1.0~2.5	0.03 max.	0.03 max.	9.0~10.5	18.0~20.5	-	*Ti*9× *C*(%)~1.0
*KY*329*J4L*	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
*KY*2209	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
*KY*347	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	-	*Nb*10× *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 M6.46 Chemical Composition of Deposited Metal for Semi-automatic Welding

(a)With Gas

Grade	Chemical composition of deposited metal (%)								
	C	*Si*	*Mn*	*P*	*S*	*Ni*	*Cr*	*Mo*	Others
*KW*308	0.08 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	-	-
*KW*308*L*	0.04 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~12.0	18.0~21.0	-	-
*KW*308*N2*	0.10 max.	1.0 max.	1.0~4.0	0.04 max.	0.03 max.	7.0~11.0	20.0~25.0	-	*N* 0.12 ~0.30
*KW*309	0.10 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	-	-
*KW*309*L*	0.04 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	-	-
*KW*309*Mo*	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	-
*KW*309*MoL*	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	-
*KW*310	0.20 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	20.0~22.0	25.0~28.0	-	-
*KW*316	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	-
*KW*316*L*	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	-
*KW*317	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	-
*KW*317*L*	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	-
*KW*329*J4L*	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	*Cu*: 1.0 max. *N*: 0.08~0.30
*KW*2209	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	*Cu*: 0.5 max. *N*: 0.08~0.20
*KW*347	0.08 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	-	*Nb* 8× *C* (%)~1.0

(b)Without Gas

Grade	Chemical composition of deposited metal (%)								
	C	*Si*	*Mn*	*P*	*S*	*Ni*	*Cr*	*Mo*	Others
*KW*308	0.08 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~11.0	19.5~22.0	-	-
*KW*308*L*	0.04 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~12.0	19.5~22.0	-	-
*KW*308*N2*	0.10 max.	1.0 max.	1.0~4.0	0.04 max.	0.03 max.	7.0~11.0	20.0~25.0	-	*N* 0.12 ~0.30
*KW*309	0.10 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	23.0~25.5	-	-
*KW*309*L*	0.04 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	12.0~14.0	23.0~25.5	-	-
*KW*309*Mo*	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	-
*KW*309*MoL*	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	-
*KW*310	0.20 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	20.0~22.0	25.0~28.0	-	-
*KW*316	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	-
*KW*316*L*	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	-
*KW*317	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	-
*KW*317*L*	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	-
*KW*2209	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	*Cu*: 0.5 max. *N*: 0.08~0.20
*KW*347	0.08 max.	1.0 max.	0.5~2.5	0.04 max.	0.03 max.	9.0~11.0	19.0~21.5	-	*Nb* 8× *C* (%)~1.0

Table M6.47 Chemical Composition of Deposited Metal for Submerged Arc Welding

Grade	Chemical composition of deposited metal (%)								
	C	*Si*	*Mn*	*P*	*S*	*Ni*	*Cr*	*Mo*	Others
*KU*308	0.08 max.	1.0 max.	2.5 max.	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	-	-
*KU*308*L*	0.04 max.	1.0 max.	2.5 max.	0.04 max.	0.03 max.	9.0~12.0	18.0~21.0	-	-
*KU*309	0.15 max.	1.0 max.	2.5 max.	0.04 max.	0.03 max.	12.0~14.0	22.0~25.0	-	-
*KU*309*L*	0.04 max.	1.0 max.	2.5 max.	0.04 max.	0.03 max.	12.0~14.0	22.5~25.0	-	-
*KU*309*Mo*	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	-
*KU*310	0.20 max.	1.0 max.	2.5 max.	0.04 max.	0.03 max.	20.0~22.0	25.0~28.0	-	-
*KU*316	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	-
*KU*316*L*	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	-
*KU*317	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	-
*KU*317*L*	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	-
*KU*347	0.08 max.	1.0 max.	2.5 max.	0.04 max.	0.03 max.	9.0~11.0	18.0~21.0	-	*Nb* 8× *C* (%)~1.0

Table M6.48 Tensile Test Requirements for Deposited Metal

Electrode for manual arc welding	*TIG* and *MIG* welding consumable	Flux wire for semi-automatic welding	Submerged arc welding consumable	Tensile strength (N/mm^2)	0.2%proof stress (N/mm^2)	Elongation (%)
*KD*308	*KY*308	*KW*308	*KU*308	550 min.	225 min.	35 min.
*KD*308*L*	*KY*308*L*	*KW*308*L*	*KU*308*L*	510 min.	205 min.	35 min.
*KD*308*N2*	*KY*308*N2*	*KW*308*N2*	-	690 min.	375 min.	25 min.
*KD*309	*KY*309	*KW*309	*KU*309	550 min.	225 min.	30 min.
*KD*309*L*	*KY*309*L*	*KW*309*L*	*KU*309*L*	510 min.	205 min.	30 min.
*KD*309*Mo*	*KY*309*Mo*	*KW*309*Mo*	*KU*309*Mo*	550 min.	225 min.	30 min.
*KD*309*MoL*	-	*KW*309*MoL*	-	510 min.	205 min.	30(1)min.
*KD*310	*KY*310	*KW*310	*KU*310	550 min.	225 min.	30 min.
-	*KY*310*S*	-	-	550 min.	225 min.	30 min.
*KD*310*Mo*	-	-	-	550 min.	225 min.	30 min.
*KD*316	*KY*316	*KW*316	*KU*316	550 min.	225 min.	30 min.
*KD*316*L*	*KY*316*L*	*KW*316*L*	*KU*316*L*	510 min.	205 min.	35 min.
*KD*317	*KY*317	*KW*317	*KU*317	550 min.	225 min.	30 min.
*KD*317*L*	*KY*317*L*	*KW*317*L*	*KU*317*L*	510 min.	205 min.	30 min.
-	*KY*321	-	-	550 min.	225 min.	30 min.
*KD*329*J*1	-	-	-	590 min.	390 min.	15 min.
*KD*329*J*4*L*	*KY*329*J*4*L*	*KW*329*J*4*L*	-	690 min.	450 min.	15 min.
*KD*2209	*KY*2209	*KW*2209	-	690 min.	450 min.	15 min.
*KD*347	*KY*347	*KW*347	*KU*347	550 min.	225 min.	30 min.

Note:

(1) Elongation of *KW*309*MoL* is not be less than 20(%).

6.7.8 Butt Weld Tensile Test

1 The tensile test specimen are to be *U*2*A* or *U*2*B* specimen shown in **Table M3.1**, 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 M6.49**.

3 Submerged arc welding consumables used only in the two-run technique are to be selected as *U*1*A* tensile test specimens of

Table M3.1, 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℃ 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 M6.48**. 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 M3.1**, and test specimens are to be taken from each assembly. (**Fig. M6.17** and **Fig. M6.18**)

2 The test specimens are to be capable of withstanding without crack exceeding 3*mm* 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 M6.50**.

3 The welding procedure and requirements of test assemblies specified in **6.7.5** through **6.7.9**.

Table M6.49 Tensile Test Requirements for Butt Weld

Electrode for manual arc welding	*TIG* and *MIG* welding consumable	Flux wire for semi-automatic welding	Submerged arc welding consumable	Tensile strength (N/mm^2)
*KD*308	*KY*308	*KW*308	*KU*308	520 min. (1)
*KD*308*L*	*KY*308*L*	*KW*308*L*	*KU*308*L*	520 min. (1)
*KD*308*N2*	*KY*308*N2*	*KW*308*N2*	—	690 min.
*KD*309	*KY*309	*KW*309	*KU*309	520 min.
*KD*309*L*	*KY*309*L*	*KW*309*L*	*KU*309*L*	520 min.
*KD*309*Mo*	*KY*309*Mo*	*KW*309*Mo*	*KU*309*Mo*	520 min.
*KD*309*MoL*	—	*KW*309*MoL*	—	520 min.
*KD*310	*KY*310	*KW*310	*KU*310	520 min.
—	*KY*310*S*	—	—	520 min.
*KD*310*Mo*	—	—	—	520 min.
*KD*316	*KY*316	*KW*316	*KU*316	520 min. (1)
*KD*316*L*	*KY*316*L*	*KW*316*L*	*KU*316*L*	520 min. (1)
*KD*317	*KY*317	*KW*317	*KU*317	520 min. (1)
*KD*317*L*	*KY*317*L*	*KW*317*L*	*KU*317*L*	520 min. (1)
—	*KY*321	—	—	520 min.
*KD*329*J*1	—	—	—	590 min.
*KD*329*J4L*	*KY*329*J4L*	*KW*329*J4L*	—	620 min.
*KD*2209	*KY*2209	*KW*2209	—	620 min. (2)
*KD*347	*KY*347	*KW*347	*KU*347	520 min.

Notes:

(1) Where the test assembly is made of *KSU*304*L*, *KSU*316*L* and *KSU*317*L*, the tensile strength is not to be less than 480 N/mm^2.

(2) Where the test assembly is made of *KSU*323*L* and *KSU*821*L*1, tensile strength is not to be less than 600 N/mm^2.

Table M6.50 Kinds of Test at Annual Inspections

Kind of welding consumables		Kind of test	Test assembly					Kind and number of test specimens taken from test assembly
			Welding position	Dia. of electrode or wire (*mm*)	Number	Dimensions	Thickness (*mm*)	
Electrode for manual arc welding		Deposition metal test	Flat	3.2~4.0	1	**Fig. M6.16**	12~19	Tensile test specimen : 1
TIG welding consumable		Deposition metal test	Flat	2.4~3.2	1	**Fig. M6.16**	12~19	Tensile test specimen : 1
MIG welding consumable		Deposition metal test	Flat	1.2~1.6	1	**Fig. M6.16**	12~19	Tensile test specimen : 1
Flux wire for semi-automatic welding		Deposition metal test	Flat	1.2~3.2	1	**Fig. M6.16**	12~19	Tensile test specimen : 1
Consumable for submerged arc welding	Multi-run technique	Deposition metal test	Flat	1.2~4.0	1	**Fig. M6.16**	19~25	Tensile test specimen : 1
	Two-run technique	Butt weld test	Flat	2.4~4.0	1	**Fig. M6.18 (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	Deposition metal test	Flat	1.2~4.0	1	**Fig. M6.16**	19~25	Tensile test specimen : 1
		Butt weld test	Flat	2.4~4.0	1	**Fig. M6.18 (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 M6.51**.

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 M6.52** and the kind is to be suffixed following to the mark "*G*". (e.g. *KAl5RBG*(*I*-3))

Table M6.51 Grades and Marks

Kind of Welding consumables	Grade and Mark
Electrode	*KAl5RA*, *KAl5RB*, *KAl5RC*, *KAl6RD*
Wire	*KAl5WA*, *KAl5WB*, *KAl5WC*, *KAl6WD*

Table M6.52 Kind of Gas

Group	Kind	Gas composition (%)	
		He	*Ar*
I	*I*-1	—	100
	I-2	100	—
	I-3	1～33	Rest
	I-4	34～66	Rest
	I-5	67～95	Rest
E	*E*-1	Other	

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 M6.52** by the manufacturer. However, where the manufacturer designates several kinds of gas which are classified into the group *I* in **Table M6.52** 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 M6.53**.

2 The aluminium alloys used in preparation for test assembly corresponding to welding consumables are to as given in **Table M6.54**.

Table M6.53 Kinds of Test for Welding Consumables

Kind of test	Test assembly				Kind and number of test specimens taken from test assembly
	Welding position	Number	Dimension	Thickness (*mm*)	
Deposited metal test (Chemical composition test)	Flat	1	**Fig. M6.19**	—	—
Butt weld test	Flat	1	**Fig. M6.20**	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. M6.21**	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 M6.54 Grade of Aluminium Alloys Used for Test Assembly

Grade of welding consumable	Grade of aluminium alloys used for test assembly(1)	
KAl5RA, *KAl5WA*	5000 series	5754*P-O*
KAl5RB, *KAl5WB*		5086*P-O*
KAl5RC, *KAl5WC*		5083*P-O* 5383*P-O* 5456*P-O* 5059*P-O*
KAl6RD, *KAl6WD*	6000 series(2)	6005*AS* 6061*S* 6082*S*

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 260 N/mm^2 may be used.

6.8.5 Welding Sequence of Test Assemblies

1 Deposited weld metal test assembly (**Fig. M6.19**)

(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. M6.20** and **Fig. M6.21**)

(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. M6.21** 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.

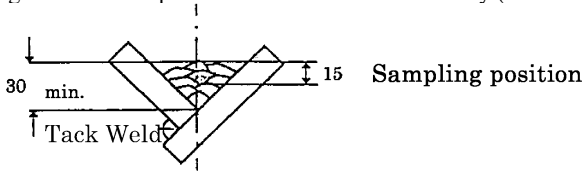
3 The test assemblies are not to be subjected to any heat treatment.

4 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. M6.19** and the results of the analysis are to comply with the limit value specified by the manufacturer.

Fig. M6.19 Deposited Weld Metal Test Assembly (Unit: *mm*)



6.8.7 Butt Weld Tensile Test

1 The tensile test specimens are to be *U2A* or *U2B* specimen shown in **Fig. M3.1** and two test specimens are to be taken from each assembly.

2 The tensile strength corresponding to the grade of welding consumables is to comply with the requirements as given in **Table M6.55**.

Table M6.55 Tensile Test Requirements

Grade of welding consumable	Tensile strength (N/mm^2)
KAl5RA, *KAl5WA*	190 min
KAl5RB, *KAl5WB*	240 min
KAl5RC, *KAl5WC*	275 min(1)
	290 min(2)
	330 min(3)
KAl6RD, *KAl6WD*	170 min

Notes:

(1) For test specimens of grade 5083*P-O*

(2) For test specimens of grade 5383*P-O* or 5456*P-O*

(3) For test specimens of grade 5059*P-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 M3.2** 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 M6.56**, without cracks exceeding 3 *mm* in length and other any defects on the outer surface.

Table M6.56 Former Diameter of Bend Test

Grade of welding consumable	Former diameter (*mm*)(1)
KAl5RA, *KAl5WA*	3 *t*
KAl5RB, *KAl5WB*	6 *t*
KAl5RC, *KAl5WC*	
KAl6RD, *KAl6WD*	

Note:

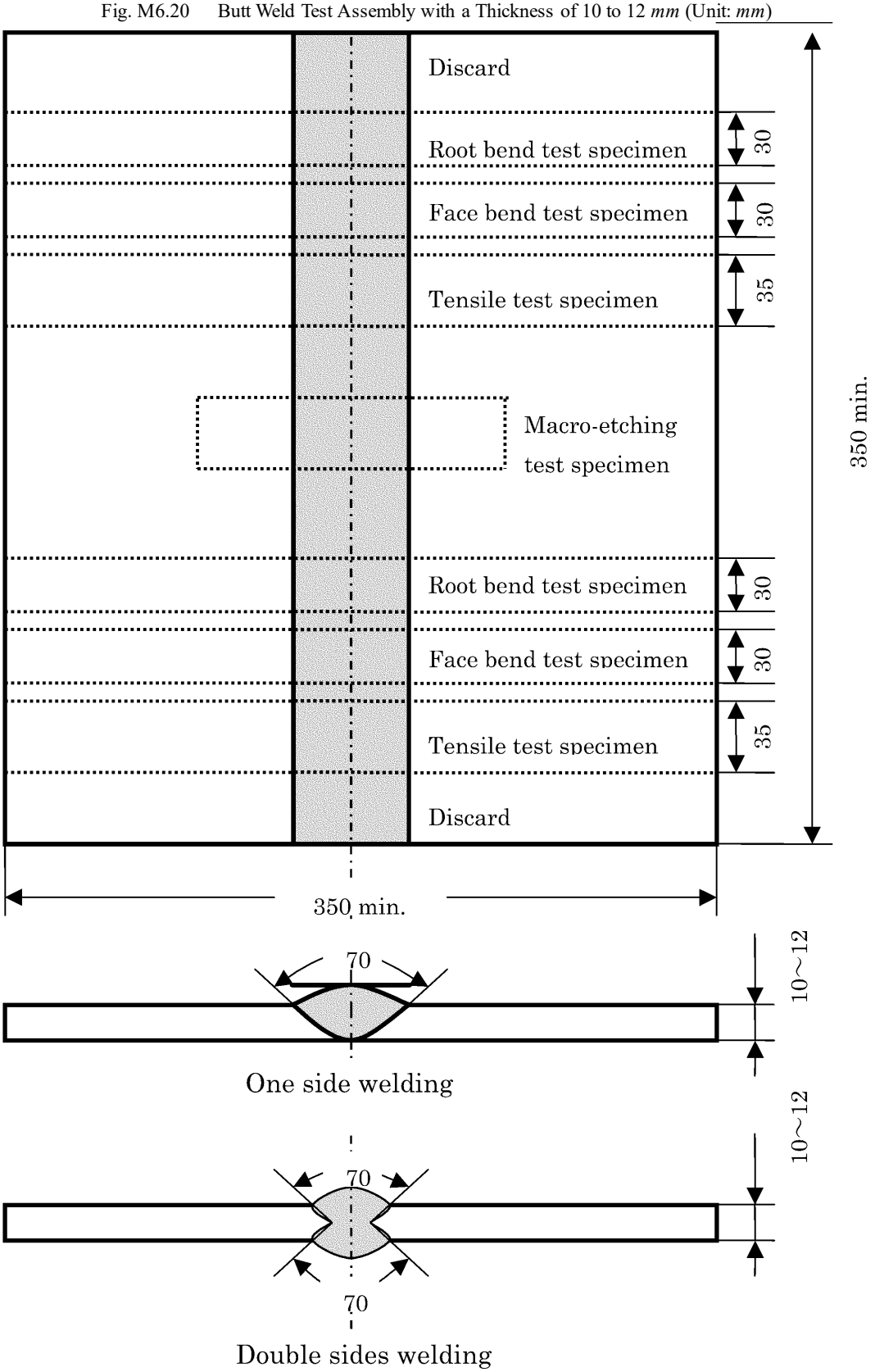
(1) *t*: Thickness of the test specimen (*mm*)

6.8.9 Butt Weld Macro-etching Test

1 One macro-etching test specimen as shown in **Fig. M6.20** and **Fig. M6.21** 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. M6.20 Butt Weld Test Assembly with a Thickness of 10 to 12 *mm* (Unit: *mm*)

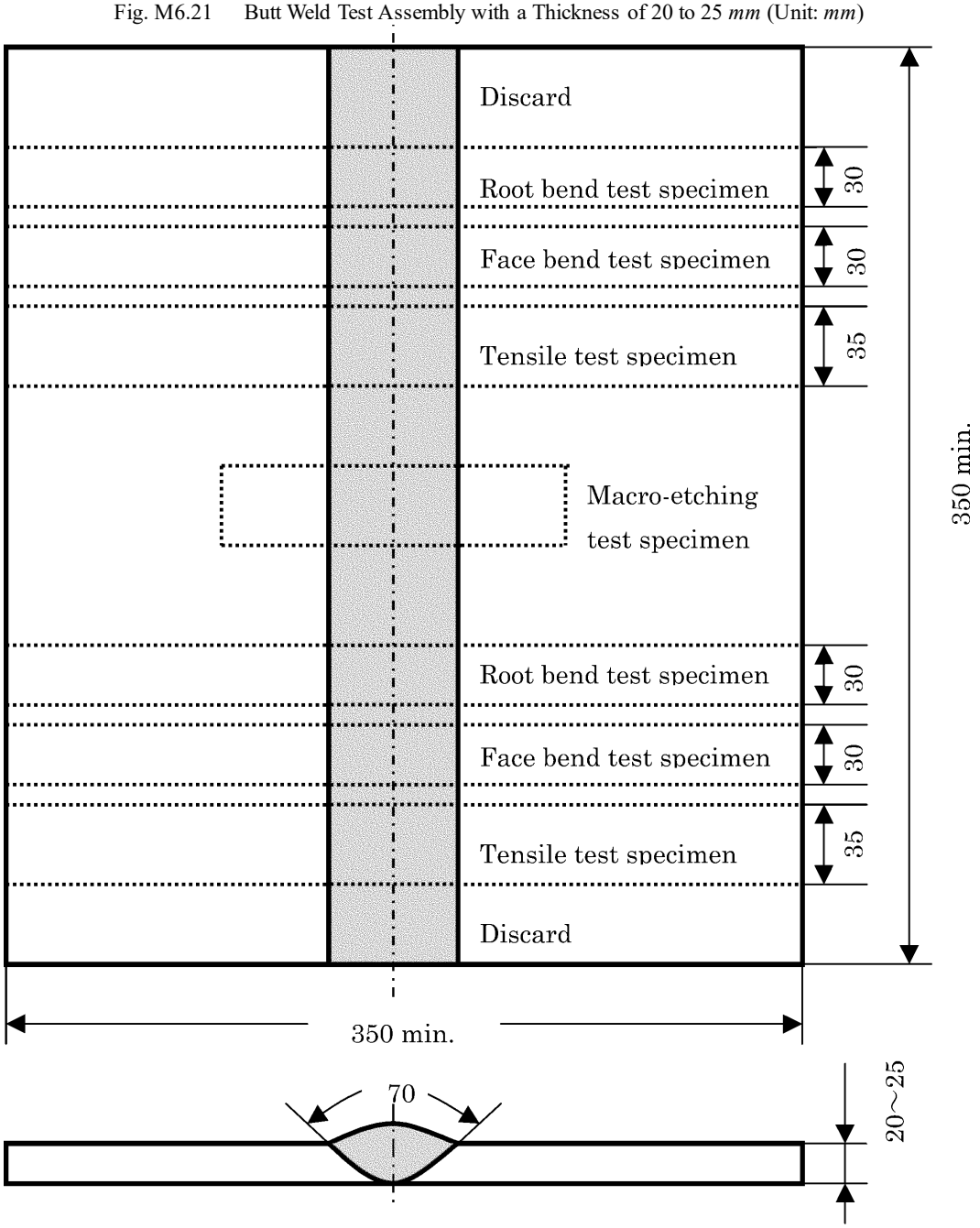


Notes:

(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. M6.21 Butt Weld Test Assembly with a Thickness of 20 to 25 *mm* (Unit: *mm*)



Note :

(1) Back sealing runs are allowed.

6.8.10 Annual Inspections

1 In the annual inspections, every approved welding consumable is 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 M6.57**.

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 High Strength Rolled Steels for Offshore Structures

6.9.1 Application

Welding consumables for high strength rolled steels for offshore 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 M6.57 Kinds of Tests in Annual Inspections

Kind of test	Test assembly				Kind and number of test specimens taken from test assembly
	Welding position	Number	Dimensions	Thickness (*mm*)	
Deposited weld metal test (Chemical composition Analysis)	Flat	1	Fig. M6.19	—	—
Butt weld test	Flat	1	Fig. M6.20	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 M6.58.

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 M6.63 are to be added to the grade marks (after the suffixes in the case of the preceding -2) of the said electrodes. (Example: *KMW*3*Y*46*H*5)

Table M6.58 Kind and Grade

High Strength Rolled Steels for Offshore Structures		
Electrode for manual arc welding	Welding consumables for Semi-automatic welding	Welding consumables for automatic welding
KMW2Y42	*KSW2Y42*	*KAW2Y42*
KMW2Y46	*KSW2Y46*	*KAW2Y46*
KMW2Y50	*KSW2Y50*	*KAW2Y50*
KMW2Y55	*KSW2Y55*	*KAW2Y55*
KMW2Y62	*KSW2Y62*	*KAW2Y62*
KMW2Y69	*KSW2Y69*	*KAW2Y69*
KMW2Y89	*KSW2Y89*	*KAW2Y89*
KMW2Y96	*KSW2Y96*	*KAW2Y96*
KMW3Y42	*KSW3Y42*	*KAW3Y42*
KMW3Y46	*KSW3Y46*	*KAW3Y46*
KMW3Y50	*KSW3Y50*	*KAW3Y50*
KMW3Y55	*KSW3Y55*	*KAW3Y55*
KMW3Y62	*KSW3Y62*	*KAW3Y62*
KMW3Y69	*KSW3Y69*	*KAW3Y69*
KMW3Y89	*KSW3Y89*	*KAW3Y89*
KMW3Y96	*KSW3Y96*	*KAW3Y96*
KMW4Y42	*KSW4Y42*	*KAW4W42*
KMW4Y46	*KSW4Y46*	*KAW4Y46*
KMW4Y50	*KSW4Y50*	*KAW4Y50*
KMW4Y55	*KSW4Y55*	*KAW4Y55*
KMW4Y62	*KSW4Y62*	*KAW4Y62*
KMW4Y69	*KSW4Y69*	*KAW4Y69*
KMW4Y89	*KSW4Y89*	*KAW4Y89*
KMW4Y96	*KSW4Y96*	*KAW4Y96*
KMW5Y42	*KSW5Y42*	*KAW5Y42*
KMW5Y46	*KSW5Y46*	*KAW5Y46*
KMW5Y50	*KSW5Y50*	*KAW5Y50*
KMW5Y55	*KSW5Y55*	*KAW5Y55*
KMW5Y62	*KSW5Y62*	*KAW5Y62*
KMW5Y69	*KSW5Y69*	*KAW5Y69*

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 assembles, 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 M6.2** and **Note(3)** of **Table M6.22** are not to be required. Provisions for automatic welding consumables are to be the requirements specified multi-run technique.

2 In addition to the test specified in **-1** above, the hydrogen test specified in **6.9.11** is to be carried out during the approval test, notwithstanding **Note(6)** of **Table M6.2**, **Note(2)** of **Table M6.3**, **Note(8)** of **Table M6.15** and **Note(6)** of **Table M6.22**.

3 The grades of steels used for tests are to be those given in **Table M6.59** in corresponding to the grades of welding consumables, or those which considered equivalent by the Society.

Table M6.59 Grades of Steel for Test Assembly

Grades of welding consumables	Grade of steel for test assembly(1) (2)
*KMW*2*Y*42 ～ 96 *KSW*2*Y*42 ～ 96 *KAW*2*Y*42 ～ 96	*KA*420～*KA*960
*KMW*3*Y*42 ～ 96 *KSW*3*Y*42 ～ 96 *KAW*3*Y*42 ～ 96	*KA*420～*KA*960 or *KD*420～*KD*960
*KMW*4*Y*42 ～ 96 *KSW*4*Y*42 ～ 96 *KAW*4*Y*42 ～ 96	*KA*420～*KA*960, *KD*420～*KD*960 or *KE*420～*KE*960
*KMW*5*Y*42 ～ 69 *KSW*5*Y*42 ～ 69 *KAW*5*Y*42 ～ 69	*KA*420～*KA*690, *KD*420～*KD*690, *KE*420～*KE*690 or *KF*420～*KF*690

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.

(2) For butt weld test assemblies, a grade of steel having the same strength as the welding consumable is to be used.

6.9.5 Welding Sequence of Test Assemblies

The welding sequence of test assemblies is 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 M6.60** 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 M6.60** 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 M6.60 Test Requirements for Deposited Metal

Grades of welding consumables	Tensile test			Impact test	
	Tensile strength (N/mm^2)	Yield point or proof stress (N/mm^2)	Elongation (%)	Test temperature (℃)	Minimum mean absorbed energy(J)
KMW2Y42,KSW2Y42,KAW2Y42	520～680	420 min.	20 min.	0	47
KMW3Y42,KSW3Y42,KAW3Y42				-20	
KMW4Y42,KSW4Y42,KAW4Y42				-40	
KMW5Y42,KSW5Y42,KAW5Y42				-60	
KMW2Y46,KSW2Y46,KAW2Y46	540～720	460 min.		0	
KMW3Y46,KSW3Y46,KAW3Y46				-20	
KMW4Y46,KSW4Y46,KAW4Y46				-40	
KMW5Y46,KSW5Y46,KAW5Y46				-60	
KMW2Y50,KSW2Y50,KAW2Y50	590～770	500 min.	18 min.	0	50
KMW3Y50,KSW3Y50,KAW3Y50				-20	
KMW4Y50,KSW4Y50,KAW4Y50				-40	
KMW5Y50,KSW5Y50,KAW5Y50				-60	
KMW2Y55,KSW2Y55,KAW2Y55	640～820	550 min.		0	55
KMW3Y55,KSW3Y55,KAW3Y55				-20	
KMW4Y55,KSW4Y55,KAW4Y55				-40	
KMW5Y55,KSW5Y55,KAW5Y55				-60	
KMW2Y62,KSW2Y62,KAW2Y62	700～890	620 min.		0	62
KMW3Y62,KSW3Y62,KAW3Y62				-20	
KMW4Y62,KSW4Y62,KAW4Y62				-40	
KMW5Y62,KSW5Y62,KAW5Y62				-60	
KMW2Y69,KSW2Y69,KAW2Y69	770～940	690 min.	17 min.	0	69
KMW3Y69,KSW3Y69,KAW3Y69				-20	
KMW4Y69,KSW4Y69,KAW4Y69				-40	
KMW5Y69,KSW5Y69,KAW5Y69				-60	
KMW2Y89,KSW2Y89,KAW2Y89	940～1100	890 min.	14 min.	0	69
KMW3Y89,KSW3Y89,KAW3Y89				-20	
KMW4Y89,KSW4Y89,KAW4Y89				-40	
KMW2Y96,KSW2Y96,KAW2Y96	980～1150	960 min.	13 min.	0	69
KMW3Y96,KSW3Y96,KAW3Y96				-20	
KMW4Y96,KSW4Y96,KAW4Y96				-40	

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 M6.61** 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 M6.62**. Outer surface of the specimens is to be free from any cracks exceeding 3 *mm* 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 M 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 these tests.

Table M6.61 Tensile Strength Requirements for Butt Weld

Grade of welding consumables	Tensile strength (N/mm^2)
*KMW*2*Y*42,*KSW*2*Y*42,*KAW*2*Y*42 *KMW*3*Y*42,*KSW*3*Y*42,*KAW*3*Y*42 *KMW*4*Y*42,*KSW*4*Y*42,*KAW*4*Y*42 *KMW*5*Y*42,*KSW*5*Y*42,*KAW*5*Y*42	520 min.
*KMW*2*Y*46,*KSW*2*Y*46,*KAW*2*Y*46 *KMW*3*Y*46,*KSW*3*Y*46,*KAW*3*Y*46 *KMW*4*Y*46,*KSW*4*Y*46,*KAW*4*Y*46 *KMW*5*Y*46,*KSW*5*Y*46,*KAW*5*Y*46	540 min.
*KMW*2*Y*50,*KSW*2*Y*50,*KAW*2*Y*50 *KMW*3*Y*50,*KSW*3*Y*50,*KAW*3*Y*50 *KMW*4*Y*50,*KSW*4*Y*50,*KAW*4*Y*50 *KMW*5*Y*50,*KSW*5*Y*50,*KAW*5*Y*50	590 min.
*KMW*2*Y*55,*KSW*2*Y*55,*KAW*2*Y*55 *KMW*3*Y*55,*KSW*3*Y*55*KAW*3*Y*55 *KMW*4*Y*55,*KSW*4*Y*55,*KAW*4*Y*55 *KMW*5*Y*55,*KSW*5*Y*5,*KAW*5*Y*55	640 min.
*KMW*2*Y*62,*KSW*2*Y*62,*KAW*2*Y*62 *KMW*3*Y*62,*KSW*3*Y*62,*KAW*3*Y*62 *KMW*4*Y*62,*KSW*4*Y*62,*KAW*4*Y*62 *KMW*5*Y*62,*KSW*5*Y*62,*KAW*5*Y*62	700 min.
*KMW*2*Y*69,*KSW*2*Y*69,*KAW*2*Y*69 *KMW*3*Y*69,*KSW*3*Y*69,*KAW*3*Y*69 *KMW*4*Y*69,*KSW*4*Y*69,*KAW*4*Y*69 *KMW*5*Y*69,*KSW*5*Y*69,*KAW*5*Y*69	770 min.
*KMW*2*Y*89,*KSW*2*Y*89,*KAW*2*Y*89 *KMW*3*Y*89,*KSW*3*Y*89,*KAW*3*Y*89 *KMW*4*Y*89,*KSW*4*Y*89,*KAW*4*Y*89	940 min.
*KMW*2*Y*96,*KSW*2*Y*96,*KAW*2*Y*96 *KMW*3*Y*96,*KSW*3*Y*96,*KAW*3*Y*96 *KMW*4*Y*96,*KSW*4*Y*96,*KAW*4*Y*96	980 min.

Table M6.62 Butt Weld Bend Test for the Bend Radius

Grade of welding consumable	Radius of plunger (*mm*)
*KMW*2*Y*42～50, *KSW*2*Y*42～50, *KAW*2*Y*42～50 *KMW*3*Y*42～50, *KSW*3*Y*42～50, *KAW*3*Y*42～50 *KMW*4*Y*42～50, *KSW*4*Y*42～50, *KAW*4*Y*42～50 *KMW*5*Y*42～50, *KSW*5*Y*42～50, *KAW*5*Y*42～50	2.0*t*
*KMW*2*Y*55～69, *KSW*2*Y*55～69, *KAW*2*Y*55～69 *KMW*3*Y*55～69, *KSW*3*Y*55～69, *KAW*3*Y*55～69 *KMW*4*Y*55～69, *KSW*4*Y*55～69, *KAW*4*Y*55～69 *KMW*5*Y*55～69, *KSW*5*Y*55～69, *KAW*5*Y*55～69	2.5*t*
*KMW*2*Y*89, *KSW*2*Y*89, *KAW*2*Y*89 *KMW*3*Y*89, *KSW*3*Y*89, *KAW*3*Y*89 *KMW*4*Y*89, *KSW*4*Y*89, *KAW*4*Y*89	3.0*t*
*KMW*2*Y*96, *KSW*2*Y*96, *KAW*2*Y*96 *KMW*3*Y*96, *KSW*3*Y*96, *KAW*3*Y*96 *KMW*4*Y*96, *KSW*4*Y*96, *KAW*4*Y*96	3.5*t*

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 M6.63** according to the test procedures specified in preceding **-1** or the type of suffixes to be added to the grade marks.

Table M6.63 Requirements for Hydrogen Contents

Grade of welding consumables	Suffixes	Requirements for Hydrogen Contents (cm^3/g)		
		Glycerine method	Mercury method	Gas chromatographic method
*KMW*2*Y*42～50 *KMW*3*Y*42～50 *KMW*4*Y*42～50 *KMW*5*Y*42～50	*H*10	0.05 max.	0.10 max.	0.10 max.
*KSW*2*Y*42～50 *KSW*3*Y*42～50 *KSW*4*Y*42～50 *KSW*5*Y*42～50				
*KAW*2*Y*42～50 *KAW*3*Y*42～50 *KAW*4*Y*42～50 *KAW*5*Y*42～50				
*KMW*2*Y*55～69 *KMW*3*Y*55～69 *KMW*4*Y*55～69 *KMW*5*Y*55～69				

*KSW*2*Y*55～69 *KSW*3*Y*55～69 *KSW*4*Y*55～69 *KSW*5*Y*55～69	*H*5	-	0.05 max.	0.05 max.
*KAW*2*Y*55～69 *KAW*3*Y*55～69 *KAW*4*Y*55～69 *KAW*5*Y*55～69				
*KMW*2*Y*89, 96 *KMW*3*Y*89, 96 *KMW*4*Y*89, 96	*H*5	-	0.05 max	0.05 max
*KSW*2*Y*89, 96 *KSW*3*Y*89, 96 *KSW*4*Y*89, 96				
*KAW*2*Y*89, 96 *KAW*3*Y*89, 96 *KAW*4*Y*89, 96				

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

1 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 are to comply with the requirements specified for multi-run technique.

2 A hydrogen test is to be carried out in addition to the test specified in **-1** above for the welding consumables whose grade symbols end in *Y*69, *Y*89 or *Y*96.

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.

Chapter 7 Non-Destructive Testing Service Suppliers

7.1 General

7.1.1 Application*

1 The Non-Destructive Testing (*NDT*) Service Suppliers which conduct *NDT* (including the Advanced Non-Destructive Testing (*ANDT*) specified in **Chapter 9**, unless otherwise specified) for registered ships and offshore structures during classification survey are to comply with this Chapter.

2 The requirements of this chapter apply to following *NDT* Service Suppliers.

(1) Independent *NDT* companies

(2) Internal departments of fabricators, e.g., shipyards, hull block/section fabricators performing *NDT*

The *NDT* service specified in this Chapter covers the service application to the following hull structure and associated items at the fabrication stage during new construction:

(a) The welding of components that are integrated into the ship or offshore structure.

(b) The fabrication of independent fuel or cargo tanks (including those intended for low flashpoint fuels, e.g. Type A, B and C independent tanks as described in **Part N of the Rules** and **Part GF of the Rules**).

(c) Items listed within the definition of hull structure as follows.

i) hull envelope including all internal and external structures;

ii) superstructures, deckhouses and casings;

iii) welded foundations, e.g. main engine seatings;

iv) hatch coamings, bulwarks;

v) all penetrations fitted and welded into bulkheads, decks and shells;

vi) the fittings of all connections to decks, bulkheads and shells, such as air pipes and ship side valves – all ILLC 1966, as amended, items;

vii) welded attachments to shell, decks and primary members, e.g. crane pedestals, bitts and bollards, but only in regards to their interaction on the hull structure.

(d) Rudders of welded construction.

3 The requirements of this chapter are intended to ensure that such *NDT* Service Suppliers are using appropriate procedures, have qualified and certified personnel and have implemented written procedures for the training, experience, education, examination, certification, performance, application, control, verification and reporting of *NDT*. In addition, *NDT* Service Suppliers are to furnish appropriate equipment and facilities commensurate with providing a professional *NDT* service.

4 In case where such a firm requests approval, the Society may approve it as a *NDT* Service Supplier.

5 The Society verifies the *NDT* Service Supplier in order to determine compliance with the requirements of this chapter. The method of verification is to be decided by the Society.

7.1.2 Definitions

The definitions of terms which appear in this chapter are specified in the following **Table M7.1**.

Table M7.1 The definitions of terms

NDT	Non-Destructive Testing The development and application of technical methods to examine materials or components in ways that do not impair their future usefulness and serviceability, in order to measure geometrical characteristics and to detect, locate, measure and evaluate flaws. *NDT* is also known as non-destructive examination (*NDE*), non-destructive inspection (*NDI*) and non-destructive evaluation (*NDE*). Comprising, but not limited to the following methods and techniques *MT*, *PT*, *RT*, *VT*, *UT* and *ET*.
ANDT	The above definition of *NDT* applies, however, *ANDT* includes advanced methods such

	as *RT-D*, *PAUT*, *TOFD* and *AUT*.
NDT Service Supplier	Independent *NDT* company or *NDT* department/section that forms a part of a company providing *NDT* services on new construction of ships and offshore structures, as applicable to the performing *NDT* on the items as listed in 7.1.1-2.
MT	Magnetic Particle Testing
PT	Penetrant Testing
RT	Radiographic Testing
RT-D	Digital Radiography Testing (A technique within the method *RT*, e.g. Computed Radiography or Direct Radiography).
UT	Ultrasonic Testing
PAUT	Phased Array Ultrasonic Testing, (A type of *UT* technique in which electronically controls the transmission time of a pulse wave transmitted from a plurality transducer as ultrasonic beam at an arbitrary refraction angle and focal length to detect flaws. A device that can display and record flaw detection results as a two-dimensional image).
TOFD	Time of Flight Diffraction (A type of *UT* technique in which plane flaw detection and dimension measurement are performed by a method using the correlation between interference waves at various probe positions or angles of incidence).
AUT	Automated Ultrasonic Testing. Technique by which an object is tested by ultrasound using probes operating under mechanical control and where ultrasonic data is collected automatically.
ET	Electromagnetic Testing, Eddy Current Testing and/or Alternating Current Field Measurements (*ACFM*), etc.
VT	Visual Testing
Industrial sector	Section of industry or technology where specialized *NDT* practices are used, requiring specific product-related knowledge, skill, equipment and/or training.
Product sector	A category of component that may be defined by type of manufacturing, fabrication, and/or shape, which may have unique, and/or general manufacturing/fabrication defect characteristics. Product sector examples include (but not limited to): castings, wrought products (forgings), rolled products, extruded products and welds.

7.1.3 References

1 The following referenced documents are to be used for the application of this chapter as appropriate. For updated references, the latest edition of the referenced document (including any amendments) applies.

(1) *ISO* 9712:2021: Non-destructive testing – Qualification and certification of *NDT* personnel

(2) *ISO/IEC* 17020:2012: Conformity assessment – Requirements for the operation of various types of bodies performing inspection

(3) *ISO/IEC* 17024:2012: Conformity assessment – General requirements for bodies operating certification of persons

(4) *ISO* 9001:2015: Quality Management Systems – Requirements

(5) *SNT-TC-1A*: 2020; Personnel Qualification and Certification in Nondestructive Testing

(6) *ANSI/ASNT CP*-189:2020; *ASNT* Standard for Qualification and Certification of Nondestructive Testing Personnel

2 Other national adoptions of the standards listed above **-1** are accepted as compliant and hence are accepted for use together with this document.

7.2 Requirements for the *NDT* Service Suppliers

7.2.1 General

The *NDT* Service Supplier is to document, as required in 7.3 to 7.6, that it has the competence and control needed to perform

the specified *NDT* services.

7.2.2 Requirements for Documents

The following documents are to be available for the Society upon request:

(1) An outline of *NDT* Service Supplier's organization and management structure, including any subsidiaries.

(2) Information on the structure of the *NDT* Service Supplier's quality management system.

(3) Quality manual and documented procedures covering the requirements given in 7.3

(4) For companies with in-house certification of personnel scheme; a written practice developed in accordance with a recognised standard or recommended practice (i.e. *ASNT's SNT-TC*-1*A*, 2020, *ANSI/ASNT CP*-189, 2020 or similar).

(5) Operational work procedures for each *NDT* method, including selection of the *NDT* technique.

(6) Training and follow-up programmes for *NDT* operators including practical training on various ship and offshore products.

(7) Written statement issued by the employer, based upon the scope of certification, authorising the operator to carry out specified tasks

(8) For suppliers who have personnel certification schemes, procedures for supervisor's authorisation of *NDT* operators.

(9) Experience of the *NDT* Service Supplier in the specific service area.

(10) For companies which obtain certification from an accredited certification body; a list of documented training and experience for *NDT* operators within the relevant *NDT* service area, including qualifications and third party certification per *ISO* 9712:2021 based certification schemes.

(11) Description of equipment used for the *NDT* services performed by the *NDT* Service Suppliers.

(12) A guide for *NDT* operators to use equipment mentioned in **(11)**.

(13) Record formats for recording results of the *NDT* service referred to 7.6.1.

(14) Information on other activities which may present a conflict of interest. (if applicable)

(15) Record of customer claims and corrective actions. (if applicable)

(16) Any legal proceedings against the company in the past/currently in the courts of law. (if applicable)

7.3 Quality Requirements

7.3.1 Quality Management System

1 *NDT* Service Suppliers are to have a documented quality management system, covering at least the following.

(1) Work procedures for all tasks and operations, including the various *NDT* methods and *NDT* techniques for which the *NDT* Service Supplier is involved.

(2) Preparation, issuance, maintenance and control of documents.

(3) Maintenance and calibration of the *NDT* equipment.

(4) Training programs for the *NDT* operators and the supervisors.

(5) Maintenance of records for *NDT* operators and supervisors training, qualification and certification.

(6) Certification of *NDT* operators (the latest version).

(7) Procedures for testing operator visual acuity.

(8) Supervision and verification of operation to ensure compliance with the *NDT* procedures.

(9) Quality management of subsidiaries.

(10) Job preparation.

(11) Order reference system where each engagement is traceable to when and where the test was carried out as well as who carried it out.

(12) Recording and reporting of information, including retention time of records.

(13) Code of conduct for the *NDT* Service Supplier's activities, especially *NDT* related activities.

(14) Periodic review of work process procedures.

(15) Corrective and preventive action.

(16) Feedback and continuous improvement.

(17) Internal audits.

(18) Provisions of accessibility to required codes, standards and procedures to assist *NDT* operators.

2 A documented quality system complying with the most recent version of *ISO*/*IEC* 17020:2012 and including the above information mentioned in **-1** would be considered acceptable. The *NDT* Service Supplier may satisfy the requirements of Type A or Type B or Type C inspection body, as described in *ISO*/*IEC* 17020:2012. In all cases, production staff is not allowed to inspect their own work in the case of Type C inspection body.

7.3.2 Qualification and Certification of *NDT* Personnel

1 The *NDT* Service Supplier is responsible for the qualification and preferably 3rd party certification of its supervisors and operators to a recognised certification scheme based on *ISO* 9712:2021 or *JIS Z* 2305.

2 The *NDT* Service Supplier is to be responsible for the above **-1**.

3 Personnel qualification by an employer based upon relevant and/or recommendation standards which are found acceptable by the Society (e.g. *SNT-TC*-1*A*, 2020 or *ANSI*/*ASNT CP*-189, 2020 etc.) may be accepted if the *NDT* Service Supplier's written practice is reviewed and found acceptable by the Society. In such cases, the *NDT* Service Supplier's written practice is at a minimum, except for the impartiality requirements of a certification body and/or authorised body, generally to comply with the requirements of *ISO* 9712:2020.

4 For *NDT* operators holding certificates issued via an employer based scheme, the employer's certification is deemed revoked when employment is terminated by either party.

5 Supervisor and operator certificates and competence are to comprise all industrial sectors and techniques being applied by the supplier.

6 Level 3 personnel are certified by one of the following means:

(1) obtain certification from an accredited certification body.

(2) obtain certification from an employer based scheme via the examination method, as detailed in the written practice. It is not permissible to directly appoint a level 3 without examination if the intended certification route is from an employer based scheme.

7.3.3 Supervisor

1 The *NDT* Service Supplier have a supervisor or supervisors, responsible for the following:

(1) validate *NDT* instructions and procedures established and reviewed by level 3 personnel;

(2) review of *NDT* reporting;

(3) supervise all tasks and *NDT* operations at all levels;

(4) inspection of *NDT* equipment, tools and calibration;

(5) re-evaluate the qualification of the operators annually on behalf of the *NDT* Service Supplier.

2 Normally, the *NDT* Service Supplier employs (on a full-time basis) a level 3 supervisor, certified to level 3 in the applicable method(s) as per the requirements of this chapter.

3 It is recognised that an *NDT* Service Supplier may not directly employ a Level 3 in all the stated methods practiced. In such cases, it is permissible to employ an external Level 3 who is certified by an accredited certification body in those methods not held by the full-time Level 3(s) of the *NDT* Service Supplier.

4 Alternatively, and by agreement with the Society, the *NDT* Service Supplier may appoint an internal (full-time employed) supervisor of *NDT* activities, who does not hold level 3 certification. In this case, the supervisor is certified to a minimum of level 2. For *NDT* Service Suppliers operating this alternative approach, the *NDT* Service Supplier comply with all other requirements of this chapter and employ (either part time or on a contract basis) Level 3 *NDT* services (to carry out functions such as procedure development, procedure approval, consultancy, review etc.) from outside the *NDT* Service Supplier organisation. The appointed external level 3 is certified by an accredited certification body in all the applicable methods appropriate to the scope of the *NDT* operations.

7.3.4 Operators

1 Operators are at a minimum to be qualified and certified to Level 2 in the *NDT* method(s) concerned and as described in **7.3.2**.

2 Operators who are qualified and certified as Level 1 are to only undertake the gathering of data and the using of *NDT* methods. They are not, however, to undertake the performing data interpretation or data analysis.

3 Operators are to have adequate knowledge of materials, welds, structures or components as well as of *NDT* equipment and its limitations that is sufficient to apply the relevant *NDT* method for each application appropriately.

7.3.5 Sub-contractors

1 The *NDT* Service Suppliers are to provide information on agreements and arrangements if any part(s) of the *NDT* services

provided are subcontracted, included level 3 *NDT* services (as described in 7.3.3).

2 The *NDT* Service Suppliers, in the following-up of subcontracts, are to give consideration to the quality management system of the subcontractor.

3 Subcontractors are to meet the same requirements placed upon the *NDT* Service Suppliers for any *NDT* performed.

7.4 Equipment

7.4.1 Equipment

1 The *NDT* Service Suppliers are to maintain records of the *NDT* equipment used and detailed information related to maintenance, calibration and verification activities. Operators are to be familiar with the specific equipment type prior to using it.

2 Where the equipment is of unique nature, operators are to be trained by competent personnel in the operation and use of the equipment before carrying out *NDT* using such equipment.

3 Under all circumstances, the *NDT* Service Suppliers are to possess sufficient equipment to carry out the services being a part of the *NDT* scope required by the Society.

7.5 Work instructions and procedures etc.

7.5.1 Work instructions and procedures

1 The *NDT* Service Suppliers are to produce written procedures for the *NDT* being applied. These procedures are to be written, verified or approved by the *NDT* Service Supplier's Level 3 supervisor (either internal, or external, as described in 7.3.3).

2 Procedures are to be documented and include all relevant information relating to the inspection, including the defect evaluation acceptance criteria deemed appropriate by the Society.

3 All *NDT* procedures and instructions are to be properly documented in such a way that the performed testing can be easily traced and/or repeated at a later stage.

4 All *NDT* procedures stipulated in 7.5.1 are to be reviewed by the Society.

7.6 Reporting

7.6.1 Reporting to the Society

1 All *NDT* are to be properly documented in such a way that the performed testing and examination can be easily retraced and/or repeated as a later stage.

2 All reports are to identify the defects present in the tested area, and include a conclusive statement as to whether the material, weld, component or structure satisfies the acceptance criteria.

3 All reports are to include references to the applicable standards, *NDT* procedures and acceptance criteria applied with respect to the applicable *NDT* method/technique. In general, the acceptance criteria are to comply with relevant Society Rules.

4 All reports are to be signed by the personnel with the appropriate level of certification, and the appropriate signatory status as defined in the Quality Management System.

Chapter 8 NON-DESTRUCTIVE INSPECTION FOR THE WELDED JOINTS OF HULL CONSTRUCTIONS

8.1 General

8.1.1 General*

1 Non-destructive test is normally to be performed by the shipbuilder or its subcontractors in accordance with this chapter.

2 It is the shipbuilder's responsibility to assure that testing specifications and procedures are adhered to during the construction and that relevant reports are made available to the Society on the findings made by non-destructive test.

3 Members subject to inspections, the locations of inspections and the number of inspections are to be as deemed appropriate by the Society.

8.1.2 Application

1 This chapter applies to the non-destructive inspections for the welded joints of hull constructions during new building. The details of the base metals, welding procedures and welded joints to be subject to the requirements of this chapter are as follows.

(1) Base metals

This chapter applies to the following types of base metals: the rolled steels for hulls specified in **3.1**, **3.10** and **3.12**, **Part K of the Rules**; the rolled steels for low temperature service specified in **3.4**, **Part K of the Rules**; the rolled stainless steels specified in **3.5**, **Part K of the Rules**; the high strength rolled steels for offshore structures specified in **3.8**, **Part K of the Rules**; the steel castings specified in **5.1**, **Part K of the Rules**; and the steel forgings specified in **6.1**, **Part K of the Rules**.

(2) Welding procedures

This chapter applies to the following welding procedures: manual metal arc welding, metal arc welding (including flux cored wire arc welding), *TIG* welding, submerged arc welding, electro-slag welding and electro-gas welding.

(3) Welded joints

This chapter applies to the following types of welded joints: butt welded joints with full penetration, *T*-joints, corner and cruciform joints with or without full penetration, and fillet welds.

2 Base metals, welding procedures and welded joints other than those specified in the preceding **-1** are to be deemed appropriate by the Society.

3 Advanced non-destructive testing is to be in accordance with **Chapter 9**.

4 Non-destructive inspections for internal imperfections of the welded joints of hull constructions are, in principle, to be radiographic testing.

5 In cases where the following **(1)** and **(2)** are fulfilled, ultrasonic testing may be used in lieu of radiographic testing.

(1) Non-destructive inspection specifications comply with *ISO* 17640 or other standards deemed appropriate by the Society are approved by the Society.

(2) Non-destructive inspection specifications apply to ultrasonic testing for 1/10 of welds to be subject to radiographic testing of at least 3 ships and their consistent application is approved by the Society in advance.

8.1.3 Surveyor Presence at Non-destructive Test

1 For non-destructive test of surface imperfections, a Surveyor is, in principle, to be present during the test.

2 For non-destructive test of internal imperfections, a Surveyor is to be present at the following times.

(1) For radiographic testing, a Surveyor is to review the records of the test for judgement.

(2) For ultrasonic testing, a Surveyor is, in principle, to be present during the test. The Surveyor is also to review the records of the test for judgement.

8.1.4 Timing of Non-destructive Test

1 Non-destructive test shall be carried out after welds have cooled to ambient temperature and after post weld heat treatment where applicable.

2 For high strength steels for welded structures with specified minimum yield stresses in the range of 420 N/mm^2 to 690 N/mm^2, non-destructive test shall not be carried out before 48 hours have passed after the completion of welding. For steels with specified

minimum yield stresses greater than 690 N/mm^2, non-destructive test shall not be carried out before 72 hours have passed after the completion of welding. However, in cases where the following **(1)** and **(2)** are fulfilled, the 72-hour interval may be reduced to 48 hours for radiographic testing or ultrasonic testing.

(1) A complete visual for the entire welded joint and random magnetic particle or penetrant test for those locations indicated by the surveyor is carried out 72 hours after the welding work has been completed and the welds have cooled to the ambient temperature, and the results are to be a pass.

(2) The Surveyor determines that there is no indication of delayed cracking due to low temperatures occurring.

3 Notwithstanding the preceding **-2**, where post weld heat treatment is carried out, the requirement of the preceding **-2** may be mitigated when agreed to by the surveyor.

4 In cases where evidence of delayed cracking due to low temperatures has been observed, or in the case of high thickness welds, a longer interval or additional random inspection at a later period may be required when deemed necessary by the surveyor.

8.1.5 Application of Non-destructive Test Method

1 The methods mentioned in this chapter for the detection of surface imperfections are visual testing (*VT*), liquid penetrant testing (*PT*) and magnetic particle testing (*MT*). The methods mentioned for detection of internal imperfections are ultrasonic testing (*UT*) and radiographic testing (*RT*).

2 The locations to which non-destructive test methods may be applied are specified in **Table M8.1** according to joint type and base metal thickness.

Table M8.1 Applicable Non-destructive Test Methods for the Welded Joints

Welded joint	Thickness of base metal	Applicable test methods
Butt welded joints	< 8 *mm*(1)	*VT*, *PT*, *MT*, *RT*
	≥ 8 *mm*	*VT*, *PT*, *MT*, *UT*, *RT*
T-joints, corner joints and cruciform joints with full penetration	< 8 *mm*(1)	*VT*, *PT*, *MT*, *RT*(3)
	≥ 8 *mm*	*VT*, *PT*, *MT*, *UT*, *RT*(3)
T-joint, corner joints and cruciform joints with partial penetration, and fillet weld joints	all	*VT*, *PT*, *MT*, *UT*(2), *RT*(3)

Notes:

(1) In cases where thickness is below 8 *mm*, the Society may consider the application of an appropriate advanced ultrasonic testing method.

(2) In cases where it is deemed appropriate by the Society, ultrasonic testing may be used to check the extent of penetration for *T*-joints, and corner and cruciform joints.

(3) In cases where it is deemed appropriate by the Society, radiographic testing may be applied.

8.2 Qualification of Non-destructive Testing Personnel

8.2.1 Qualification and Certification of Non-destructive Testing Personnel

1 Supervisors and operators are to be recognised by a certification scheme based upon *ISO* 9712 or *JIS Z*2305. The aforementioned standards, in principle, refer to the most recent version published.

2 The shipbuilder or its subcontractor is to be responsible for the preceding **-1**.

3 Operator certificates issued by an employer based upon relevant and/or recommendation standards which are found acceptable by the Society (e.g. *SNT-TC*-1*A*, 2016 or *ANSI*/*ASNT CP*-189, 2016 etc.) may be accepted if the shipbuilder's or its subcontractor's written practice is reviewed and found acceptable by the Society. In such cases, the shipbuilder's or its subcontractor's written practice is at a minimum, except for the impartiality requirements of a certification body and/or authorised body, to comply with *ISO* 9712.

4 Supervisor and operator certificates and competence are to appropriate for the non-destructive inspection methods being employed by the shipbuilder or its subcontractor.

8.2.2 Supervisor

1 The shipbuilders or its subcontractors are to have a supervisor or supervisors who are responsible for the appropriate execution of non-destructive test operations and for the professional standard of the operators and their equipment, including the professional administration of the working procedures.

2 Supervisors are to be certified to Level 3 by a certification body deemed appropriate by the Society (e.g. The Japanese Society for Non-destructive Inspection) based upon **8.2.1**.

3 In relation to the preceding **-2**, shipbuilders or its subcontractors are to employ, on a full-time basis, at least one supervisor for all non-destructive testing methods which are carried out by the shipbuilder or its subcontractor, except in cases where it is recognised that it is difficult for the shipbuilder or its subcontractor to directly employ a Level 3 certified supervisor for all the stated non-destructive testing methods.

4 Supervisors are to be directly involved in the review and acceptance of non-destructive inspection specifications, the making of test records and survey records, and the calibration of non-destructive testing equipment and tools.

5 Supervisors are to evaluate the competence of operators annually.

8.2.3 Operator

1 Operators, in principle, are to be certified to Level 2 by a certification body deemed appropriate by the Society (e.g. The Japanese Society for Non-destructive Inspection), based upon **8.2.1**, except in cases where the requirement of **8.2.1-3** is to be applied.

2 Operators who are qualified and certified as Level 1 are to only undertake the gathering of data and the using of non-destructive testing methods. They are not, however, to undertake the performing data interpretation or data analysis.

3 Operators are to have adequate knowledge of materials, welds, structures, or components as well as of non-destructive testing equipment and its limitations that is sufficient to apply the relevant non-destructive testing method for each application appropriately.

8.3 Surface Condition

8.3.1 Surface Condition

1 Location of inspections are to be free from scale, slag, loose rust, weld spatter, oil, grease, dirt, or paint that might affect the sensitivity of the testing method.

2 Preparation and cleaning of welds for subsequent non-destructive test are to be in accordance with the accepted non-destructive inspection specifications.

3 The Society may not accept result of non-destructive test to be carried out on surface that prevent proper interpretation.

8.4 General Plan of Non-destructive Inspection

8.4.1 General

1 Members subject to inspections, location of inspections and the quality level specified in *ISO* 5817 are to be planned by the shipbuilder according to ship design, ship type and welding the processes used. The aforementioned standards, in principle, refer to the most recent version published.

2 Prior to welding works, the shipbuilder is to submit the non-destructive inspection plan containing the details of the non-destructive test to be applied, the members subject to inspections, the location of inspections, the number of inspections, test length and Quality Level to the Society for approval. The Society, however, may require changes in non-destructive test to be applied, the members subject to inspections, the locations of inspections, the number of inspections, test length and Quality Level where deemed necessary even after a non-destructive inspection plan has been approved.

3 Particular attention is to be paid to inspecting welds in highly stressed areas and welds in primary and special structures.

4 Non-destructive inspection plans are to only be released to the personnel in charge of the non-destructive test and its supervision.

8.4.2 Location of Inspections*

1 In selecting the locations of inspections, emphasis is to be given to the following locations:

(1) Welds in high stressed areas

(2) Fatigue sensitive areas

(3) Field erected welds

(4) Suspected problem areas

(5) Welds which are inaccessible or very difficult to inspect in service

(6) Other important structural elements

(7) Welds for which non-destructive inspections are deemed necessary by the Surveyor

2 Block construction welds performed in yards, or at subcontracted yards or facilities are to be considered when selecting locations of inspections.

3 The result of non-destructive inspections and the locations of inspection are to be in total correspondence.

4 For welded constructions (e.g. marine and offshore structures) other than hull constructions, the locations of inspections is to be as deemed appropriate by the Society.

5 If an unacceptable level of indications is found, the number of inspections is to be increased in accordance with **8.9.2**.

8.4.3 Non-destructive Test Application Procedure*

1 All welds over their full length are to be subject to visual test by personnel designated by the shipbuilder, and such personnel may be exempted from the qualification requirements specified in **8.2**.

2 When it is deemed necessary by the Surveyor, liquid penetrant testing or magnetic particle testing is to be used when investigating the outer surface of welds, checking the intermediate weld passes and back-gouged joints prior to subsequent passes deposition.

3 For non-destructive test of surface imperfections for important *T*-joints or corner joints, liquid penetrant testing or magnetic particle testing deemed appropriate by the Society is to be carried out.

4 Welded connections between large castings (e.g. rudder horn) or forged components and rolled steels for hull are to be tested over their full length using liquid penetrant testing or magnetic particle testing, and locations deemed appropriate by the Society are to be tested using ultrasonic testing or radiographic testing.

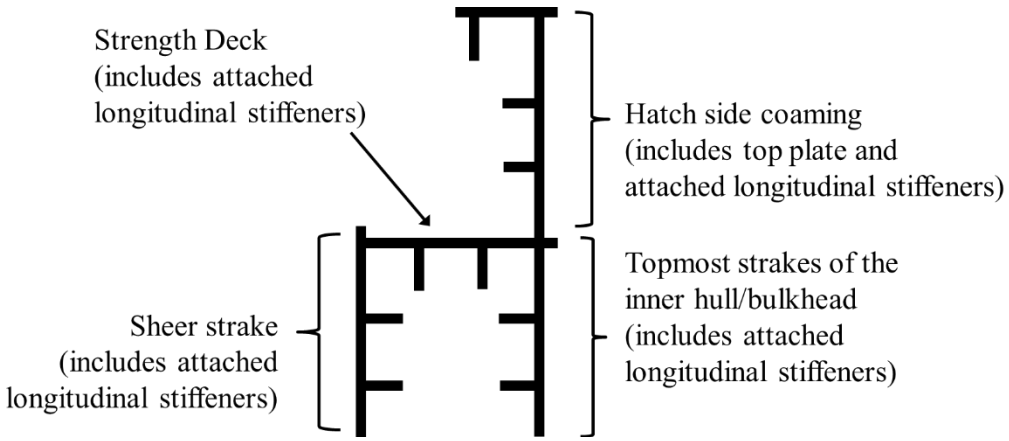
5 Non-destructive test to be applied are to be suited for the detection of particular types, orientations and dimensions of discontinuities. In addition, the non-destructive test method is to be agreed by the Society.

6 In general, start/stop points in welds made using automatic (mechanised) welding processes are to be examined using ultrasonic testing or radiographic testing, except for internal members where the omission of testing is to be agreed by the Surveyor.

7 Where the surveyor becomes aware that a location has been repaired without a record of the original defect, the shipyard is to carry out additional tests on locations adjacent to the repaired location according to the Surveyor's instructions.

8 Ultrasonic testing is to be carried out on all block-to-block butt joints of all upper flange longitudinal structural members in the cargo hold region of container carriers applying extremely thick steel plates which complies with **10.5, Part 2-1, Part C**. Upper flange longitudinal structural members include the topmost strakes of the inner hull/bulkhead, the sheer strake, strength deck, hatch side coaming plate, coaming top plate, and all attached longitudinal stiffeners. These members are shown in **Fig. M8.1**.

Fig. M8.1 Members in Container Carriers Subject to Additional Non-destructive Inspections



8.5 Non-destructive Testing Procedure

8.5.1 General

1 The testing method, equipment and conditions are to comply with recognized national or international standards, or other documents deemed appropriate by the Society.

2 The shipbuilder and its subcontractor is to obtain the confirmation of the Society for non-destructive inspection specifications containing sufficient details of the testing method to be applied. For non-destructive inspection specifications of ultrasonic testing, the shipbuilder or its subcontractor is to obtain approval of the Society in accordance with **8.1.2-5**.

3 Members subject to inspections, location of inspections and test length are to be in accordance with the decision of the Surveyor and the approved non-destructive inspection plans specified in **8.4**.

4 The testing volume is to be the zone which includes the weld and base metal for at least 10 *mm* on each side of the weld, or the width of the *HAZ*, whichever is greater. In all cases, the inspection is to cover the whole testing volume.

5 Where it is deemed necessary by the Surveyor, provision is to be made for the Surveyor to verify the testing method, the test records specified in **8.7**, and the inspection records specified in **8.8**.

6 Where the Surveyor decides that the proportion of non-conforming indications is abnormally high, the number of inspections is to be increased.

8.5.2 Visual Testing

The personnel in charge of visual testing is to confirm that the surface condition is acceptable prior to carrying out the inspection. Visual testing are to be carried out in accordance with standards agreed upon between the shipbuilder and the Society.

8.5.3 Liquid Penetrant Testing*

1 Liquid penetrant testing is to be carried out in accordance with *ISO* 3452-1, *ISO* 3452-2, *ISO* 3452-3, *ISO* 3452-4, *JIS Z* 2343-1, *JIS Z* 2343-2, *JIS Z* 2343-3, *JIS Z* 2343-4 or equivalent standards approved by the Society. The aforementioned standards, in principle, refer to the most recent version published.

2 The surfaces of the location of inspections are to be clean and free from any contaminants or paint that may impede the penetration of the inspection media.

3 The temperatures of the locations of inspections are to be typically between 5 °*C* and 50 °*C*. Where the temperature is outside of this temperature range, it is to be as deemed appropriate by the Society.

8.5.4 Magnetic Particle Testing*

1 Magnetic particle testing is to be carried out in accordance with *ISO* 17638, *JIS Z* 2320-1, *JIS Z* 2320-2, *JIS Z* 2320-3 or equivalent standards approved by the Society. The aforementioned standards, in principle, refer to the most recent version published.

2 The surfaces of the locations of inspections are to be clean, dry and free from any contaminants or paint that may impede the test and its accurate evaluation.

8.5.5 Radiographic Testing*

1 Radiographic testing is to be carried out in accordance with *ISO* 17636, *JIS Z* 3104 or equivalent standards approved by the Society. The aforementioned standards, in principle, refer to the most recent version published.

2 Test length of the location of inspections is to be not less than either 300 *mm* or the overall length of the welds inspected, whichever is smaller.

3 Consideration may be given for a reduction of inspection frequency for automated welds where quality assurance techniques indicate consistent satisfactory quality.

4 The surfaces of the locations of inspections are to be free from any irregularities that may impede the test and its accurate evaluation.

8.5.6 Ultrasonic Testing

1 Ultrasonic testing is to be carried out in accordance with *ISO* 17640, *ISO* 11666, *ISO* 23279 or equivalent standards approved by the Society. The aforementioned standards, in principle, refer to the most recent version published.

2 Test length of the locations of inspections are to be not less than either 300 *mm* or the overall length of the welds inspected, whichever is smaller.

8.6 Non-destructive Testing Criteria

8.6.1 General

1 As far as necessary, testing techniques are to be combined to facilitate the assessment of indications against the acceptance criteria.

2 Where equivalency is established and it is deemed appropriate by the Society, alternative acceptance criteria not specified in this chapter may be applied.

8.6.2 Quality Level

1 For hull constructions, Quality Level C is, in principle, to be applied. Where it is deemed necessary by the Society, Quality level B may be applied.

2 Testing Level and Acceptance Level of non-destructive testing to be applied are to be appropriate level which corresponds to Quality Level agreed by the Society in accordance with **Tables M8.2** to **M8.7**.

8.6.3 Testing Level

1 Testing Level specified in **Tables M8.2** to **M8.7** stipulates testing coverage and the probability of detection. Accuracy of test and the probability of detection increase from Testing Level A to Testing Level C.

2 Testing Level for non-destructive testing to be applied is to be agreed by the Society. Testing Level D is intended for special applications, and may only be used when defined by specification.

3 Testing Level to be applied is to be specified in the non-destructive testing specifications and the non-destructive inspection plan.

8.6.4 Acceptance Level

Acceptance Level is to be in accordance with each standard specified in **Tables M8.2** to **M8.7**, or as deemed appropriate by the Society. The aforementioned standards, in principle, refer to the most recent version published.

8.6.5 Visual Testing Criteria *

The Acceptance Levels and required Quality Levels for visual testing are to be in accordance with **Table M8.2** and deemed appropriate by the Society.

Table M8.2 Each Level of Visual Testing Corresponding to Quality Level

Quality Levels (*ISO* 5817)(1)	Testing Levels (*ISO* 17637)(1)	Acceptance Levels(2)
B	Level not specified	*B*
C		*C*
D		*D*

Notes:

(1) To be in accordance with this standard or an equivalent standard approved by the Society.

(2) The Acceptance Levels for visual testing are the same for the Quality Levels specified in *ISO* 5817.

8.6.6 Liquid Penetrant Testing Criteria

The Acceptance Levels, Testing Level and required Quality Levels for liquid penetrant testing are to be in accordance with **Table M8.3**.

Table M8.3 Each Level of Liquid Penetrant Testing Corresponding to Quality Level

Quality Levels (*ISO* 5817)[(1)]	Testing Levels (*ISO* 3452-1)[(1)]	Acceptance Levels (*ISO* 23277)
B	Level not specified	2*X*
C		2*X*
D		3*X*

Note:

(1) To be in accordance with this standard or an equivalent standard approved by the Society.

8.6.7 Magnetic Particle Testing Criteria

The Acceptance Levels, Testing Level and required Quality Levels for magnetic particle testing are to be in accordance with **Table M8.4**.

Table M8.4 Each Level of Magnetic Particle Testing Corresponding to Quality Level

Quality Levels (*ISO* 5817)[(1)]	Testing Levels (*ISO* 17638)[(1)]	Acceptance Levels (*ISO* 23278)
B	Level not specified	2*X*
C		2*X*
D		3*X*

Note:

(1) To be in accordance with this standard or an equivalent standard approved by the Society.

8.6.8 Radiographic Testing Criteria

1 The Acceptance Levels, Testing Level and required Quality Levels for radiographic testing are to be in accordance with **Table M8.5**.

2 Reference radiographs are to be submitted to the Society after they are evaluated in accordance with *ISO* 5817, *ISO* 10675-1 or a standard deemed appropriate by the Society. The aforementioned standards, in principle, refer to the most recent version published.

Table M8.5 Each Level of Radiographic Testing Level Corresponding to Quality Level

Quality Levels (*ISO* 5817)[(1)]	Testing Levels (*ISO* 17636-1)[(1)]	Acceptance Levels (*ISO* 10675-1)
B	Class *B*	1
C	Class *B*[(2)]	2
D	At least Class *A*	3

Notes:

(1) To be in accordance with this standard or an equivalent standard approved by the Society.

(2) For circumferential weld testing, the minimum number of exposures may correspond to the requirements of *ISO* 17636-1, Class *A*

8.6.9 Ultrasonic Testing Criteria

1 The Acceptance Level, Testing Level and required Quality Levels for ultrasonic testing are to be in accordance with **Tables M8.6** and **M8.7**.

2 Acceptance Level of ultrasonic testing applies to the non-destructive testing of butt welded joints, *T*-joints, corner joints and cruciform joints with full penetration of carbon steels with thicknesses from 8 *mm* to 100 *mm*.

3 Non-destructive inspection specifications for welded joints other than those specified in the preceding **-2** are to be approved by the Society apart from the non-destructive inspection specifications specified in **8.1.2-5**.

4 The nominal frequency of probes used is to be between 2 *MHz* and 5 *MHz*.

5 Acceptance Levels are to be in accordance with *ISO* 11666 or a recognized standard deemed appropriate by the Society. The aforementioned standard, in principle, refers to the most recent version published.

6 The sensitivity levels are to be set in accordance with *ISO* 17640. The aforementioned standard, in principle, refers to the most recent version published.

Table M8.6 Each level of Ultrasonic Testing Level Corresponding to Quality Level

Quality Levels (*ISO* 5817)[(1), (2)]	Testing Levels (*ISO* 17640)[(1), (2)]	Acceptance Levels (*ISO* 11666)[(1), (2)]
B	At least *B*	2
C	At least *A*	3
D	At least *A*	3[(3)]

Notes:

(1) To be in accordance with this standard or an equivalent standard approved by the Society.

(2) When characterization of indications is required, *ISO* 23279 is to be applied

(3) Ultrasonic testing is not recommended, but can be defined in a specification with same requirement as Quality Level *C*

Table M8.7 Recommended Testing and Quality Levels (*ISO* 17640)

Testing Levels (*ISO* 17640)[(1)]	Quality Levels (*ISO* 5817)
A	*C*, *D*
B	*B*
C	Quality Level deemed appropriate by the Society
D	Special Quality Level according to application target

Note:

(1) Testing Level D for special application is to be agreed to by the Society.

8.7 Test Records

8.7.1 Test Record Preparation

1 Test records are to be submitted to the Society for confirmation in each stage of the construction process deemed appropriate by the Surveyor.

2 In liquid penetrant testing, magnetic particle testing, radiographic testing and ultrasonic testing, the Surveyor is to decide whether the results are acceptable when the test records are submitted.

3 Test records are to be prepared by the shipbuilder or its subcontractor and are to include the following information:

(1) Date of testing

(2) Location of testing

(3) Position and dimension of the discontinuities

(4) Signature and qualification level of operators and supervisors

4 In the case of liquid penetrant testing, in addition to the preceding **-3**, the following information is to be included in the test records:

(1) Type of penetrant, cleaner and developer used

(2) Penetration time and development time

5 In the case of magnetic particle testing, in addition to the preceding **-3**, the following information is to be included in the test records:

(1) Type of magnetization

(2) Magnetic field strength

(3) Detection media

(4) Viewing conditions

(5) Demagnetization, if required

6 In the case of radiographic testing, in addition to the preceding **-3**, the following information is to be included in the test records:

(1) Radiographs

(2) Type of discontinuity

7 In the case of ultrasonic testing, in addition to the preceding **-3**, the following information is to be included in the test records:

(1) Information and calibration result of ultrasonic equipment used

(2) Echo height of detected discontinuity

8.8 Inspection Records

8.8.1 Inspection Record Preparation

1 Inspection records are to be submitted to the Society for confirmation for each stage of the construction process deemed appropriate by the Surveyor.

2 Inspection records are to be prepared by the shipbuilder or its subcontractor and are to include the following information.

(1) Date of inspection

(2) Hull number, location of inspections and test length

(3) Signature and qualification level of operators

(4) Identification of the component inspected

(5) Identification of the welded joints inspected

(6) Steel grade, welded joint type, base metal thickness and welding procedure

(7) Acceptance criteria

(8) Testing standards used

(9) Testing equipment and arrangement used

(10) Any test limitations, viewing conditions and temperature

(11) Results with references given to acceptance criteria, locations and dimensions of reportable indications

(12) Acceptance criteria for discontinuities, date of evaluation, and signatures of operators

(13) Records of all repaired welds.

(14) Number of repairs if a specific location is repaired more than twice

3 In the case of liquid penetrant testing, in addition to the preceding **-2**, the following information is to be included in the inspection records:

(1) Type of penetrant, cleaner and developer used

(2) Penetration time and development time

4 In the case of magnetic particle testing, in addition to the preceding **-2**, the following information is to be included in the inspection records:

(1) Type of magnetization

(2) Magnetic field strength

(3) Detection media

(4) Viewing conditions

(5) Demagnetization, if required

5 In the case of radiographic testing, in addition to the preceding **-2**, the following information is to be included in the inspection records. This information (including that of the preceding **-2**), in addition to documents, is to be recorded in a medium deemed appropriate by the Society. In addition, where it is to be deemed necessary by the Society, the unprocessed original images and digitally processes images is to be submitted to the Society.

(1) Type and size of radiation source (width of radiation source), X-ray voltage

(2) Type of film/designation and number of film in each film holder/cassette

(3) Number of radiographs (exposures)

(4) Type of intensifying screens

(5) Exposure technique, time of exposure and source-to-film distance

(6) Distance from radiation source to weld

(7) Distance from source side of the weld to radiographic film

(8) Angle of radiation beam through the weld (from normal)

(9) Sensitivity, type and position of *IQI* (source side or film side)

(10) Density

(11) Geometric un-sharpness

(12) Other information deemed necessary by the Society

6 In the case of ultrasonic testing, in addition to the preceding **-2**, the following information is to be included in the inspection records. The method for review and evaluation of ultrasonic testing results are to be confirmed by the Surveyor at a frequency deemed appropriate by the Surveyor.

(1) Type and identification of ultrasonic equipment used (instrument maker, model, series number), probes (instrument maker, serial number), transducer type (angle, serial number and frequency) and type of couplant (brand).

(2) Sensitivity levels calibrated and applied for each probe

(3) Transfer loss correction applied type of reference blocks

(4) Signal response used for defect detection

(5) Reflections interpreted as failing to meet acceptance criteria

8.8.2 Keeping of Inspection Records

The shipbuilder is to keep the inspection records specified in **8.8.1** at least for 5 years.

8.9 Repair of Faulty Welds, etc.

8.9.1 General

Unacceptable indications are to be eliminated and repaired where necessary. The repair welds are to be inspected on their full length using appropriate non-destructive testing method at the discretion of the Surveyor.

8.9.2 Repair and Treatment after the Repair*

1 When unacceptable indications are found, additional areas of the same weld length are to be inspected unless it is agreed to without any doubt by the surveyor and fabricator that the indication is isolated. In the case of automatically welded joints, additional non-destructive testing are to be extended to all areas of the same weld length.

2 All radiographs exhibiting non-conforming indications are to be brought to the attention of the Surveyor. Such welds are to be repaired and inspected as required by the Surveyor. When non-conforming indications are observed at the end of a radiograph, additional radiographic testing is generally required to determine their extent. As an alternative, the extent of non-conforming welds may be ascertained by excavation when approved by the surveyor.

8.9.3 Quality Improvements

1 Additional non-destructive testing can be required at the discretion of Surveyor when repeated non- acceptable discontinuities are found.

2 Where the faulty welds are more than 10 % of the number of inspection, the results of an investigation into the substantial causes of the faults as well as the measures taken to improve quality are to be submitted to the Surveyor.

3 The shipbuilder is to take appropriate action to monitor and improve the quality of welds to the required level. The repair rate is to be recorded by the shipyard and any necessary corrective actions are to be identified in the shipbuilder's QA system.

Chapter 9 Advanced Non-Destructive Testing

9.1 General

9.1.1 General

1 The requirements in this chapter are applied when Advanced Non-Destructive Testing (hereinafter referred to as "*ANDT*") is used in lieu of radiographic tests or ultrasonic tests for materials and welded joints during construction of ships, etc. specified in the Rules. For the welded joints of liquefied gas cargo tanks specified in **Part N** and liquefied gas fuel tanks specified in **Part GF**, the radiographic tests are not to be completely replaced by Phase Array Ultrasonic Testing (hereinafter referred to as "*PAUT*") or Time of Flight Diffraction (hereinafter referred to as "*TOFD*")

2 *ANDT* is to be performed by the shipbuilder, manufacturer or its subcontractors (hereinafter referred to as the "supplier") in accordance with these requirements. The Surveyor is, in principle, to be present during the test.

3 Suppliers are to adhere to *ANDT* specifications and procedures. Reports on *ANDT* findings are to be made available to the Society.

4 *ANDT* methods, structural members to be subjected to testing, locations to be tested and the number of tests are to be agreed on between the supplier and the Society. *ANDT*, however, need not be performed in addition to that required for the structural members and locations to be tested as well as the number of tests specified in the Rules.

5 Notwithstanding the requirements specified in **8.1.2-5**, *ANDT* for the welded joints of hull structures specified in **Chapter 8** of this Part is to be in accordance with **9.5**. Approved *ANDT* in accordance with **9.5** may be applied to all locations to be tested specified in the non-destructive inspection plan.

9.1.2 Definitions

The terms used in this chapter are defined as follows in **Table M9.1**.

Table M9.1 Definitions

ANDT	Advanced Non-Destructive Testing
RT-D	Digital Radiography Testing
RT-S	Radioscopic Testing with Digital Image Acquisition, (Dynamic ≥12 bit)
RT-CR	Testing with Computed Radiography using storage phosphor imaging plates
PAUT	Phased Array Ultrasonic Testing
TOFD	Time of Flight Diffraction
AUT	Automated Ultrasonic Examinations. A technique of ultrasonic examination performed with equipment and search units that are mechanically mounted and guided, remotely operated, and motor-controlled (driven) without adjustments by the technician. The equipment used to perform the examinations is capable of recording the ultrasonic response data, including the scanning positions, by means of integral encoding devices such that imaging of the acquired data can be performed.
SAUT	Semi-Automated Ultrasonic Examinations. A technique of ultrasonic examination performed with equipment and search units that are mechanically mounted and guided, manually assisted (driven), and which may be manually adjusted by the technician. The equipment used to perform the examinations is capable of recording the ultrasonic response data, including the scanning positions, by means of integral encoding devices such that imaging of the acquired data can be performed.

9.2 Application

9.2.1 Material

The requirements in this chapter are applied to the materials specified in **Part K of the Rules**.

9.2.2 Welding Procedure

The requirements in this chapter are applied to the welding procedures specified in **Table M9.2**. *ANDT* for other welding procedures may be in accordance with the requirements in this chapter, upon approval by the Society.

Table M9.2 Welding procedures

Welding procedure		Reference number *ISO* 4063
Manual welding	Shield Metal Arc Welding (*SMAW*)	111
Resistance welding	Flash Welding (*FW*)	24
Semi-automatic welding	(1) Metal Inert Gas Welding (*MIG*) (2) Metal Active Gas Welding (*MAG*) (3) Flux Cored Arc Welding (*FCAW*)	131 135, 138 136
TIG welding	Gas Tungsten Arc Welding (*GTAW*)	141
Automatic welding	(1) Submerged Arc Welding (*SAW*) (2) Electro-gas Welding (*EGW*) (3) Electro-slag Welding (*ESW*)	12 73 72

9.2.3 Welded Joints

The requirements in this chapter, in principle, are applied to welded joints with full penetration. Other welded joints (e.g. T, corner and cruciform joints) may be tested using *PAUT*. Welded joints to which *ANDT* is applied are to be confirmed by the Society before application.

9.2.4 Timing

1 *ANDT* is to be performed after welds have cooled to an appropriate temperature and after post weld heat treatment (where applicable) has been performed.

2 The timing of *ANDT* is to be in accordance with **8.1.4** when it is applied to the welds of hull structures using high tensile steels for which the minimum yield stress is more than 420 N/mm^2.

9.3 Testing Method

9.3.1 General

The *ANDT* specified in this chapter, in principle, includes *PAUT* (only automated or semi-automated), *TOFD* and *RT-D*. Other *ANDT* may be applied in accordance with the requirements of this chapter provided that it is deemed appropriate by the Society.

9.3.2 Testing Methods for Welded Joint Types

The testing methods for the *ANDT* subject to the requirements of this chapter are specified according to material and welded joint type as shown in **Table M9.3**.

Table M9.3 Testing Method According to Material and Welded Joint

Material and Welded Joint	Base Metal Thickness (t)	Testing Method
Carbon steel butt welded joints	$t < 6$ *mm*	*RT-D*
	$6\ mm \le t \le 40\ mm$	*PAUT*, *TOFD*, *RT-D*
	$t > 40$ *mm*	*PAUT*, *TOFD*, *RT-D*(2)
Carbon steel *T*-joints and corner joins with full penetration	$t \ge 6$ *mm*	*PAUT*, *RT-D*(2)
Carbon steel cruciform joints with full penetration	$t \ge 6$ *mm*	*PAUT*(2)
Austenitic stainless steel(1) butt welded joints	$t < 6$ *mm*	*RT-D*
	$6\ mm \le t \le 40\ mm$	*RT-D*, *PAUT*(2)
	$t > 40$ *mm*	*PAUT*(2), *RT-D*(2)
Austenitic stainless steel(1) *T*-joints and corner joins with full penetration	$t \ge 6$ *mm*	*PAUT*(2), *RT-D*(2)
Aluminium alloy butt welded joints	$t < 6$ *mm*	*RT-D*
	$6\ mm \le t \le 40\ mm$	*RT-D*, *TOFD*, *PAUT*
	$t > 40$ *mm*	*TOFD*, *PAUT*, *RT-D*(2)
Aluminium alloy *T*-joints and corner joins with full penetration	$t \ge 6$ *mm*	*PAUT*(2), *RT-D*(2)
Aluminium alloy cruciform joints with full penetration	$t \ge 6$ *mm*	*PAUT*(2)
Copper alloy castings	—	*PAUT*, *RT-D*(2)
Steel forgings	—	*PAUT*, *RT-D*(2)
Steel castings	—	*PAUT*, *RT-D*(2)
Rolled steels and aluminium alloy forgings	$t < 6$ *mm*	*RT-D*
	$6\ mm \le t \le 40\ mm$	*PAUT*, *TOFD*, *RT-D*
	$t > 40$ *mm*	*PAUT*, *TOFD*, *RT-D*(2)

Notes:

(1) Where deemed necessary by the Society, either special specifications, supplementary devices (using angle compression waves, creep wave probes or a combination of both for detecting defects close to the surface) or a combination of both may be required when *PAUT* or *TOFD* are applied to anisotropic materials.

(2) Where the supplier has special qualifications for each type of *ANDT* and is agreed to by the Society, said *ANDT* may be applied.

9.4 *ANDT* Personnel Qualifications

9.4.1 *ANDT* Personnel Qualifications and Certification

1 Supplier supervisors and operators are to be recognised by a certification scheme based on *ISO* 9712:2012 or *JIS Z* 2305. The aforementioned standards, in principle, refer to the most recent version published.

2 The supplier is to be responsible for the preceding **-1**.

3 Personnel qualification by an employer based on standards deemed acceptable or recommended by the Society (e.g. *SNT-TC-1A*, 2016 or *ANSI/ASNT CP*-189, 2016) may be accepted if the supplier's written practice is reviewed and found acceptable by the Society. In such cases, the supplier's written practice, except for the impartiality requirements of a certification body or authorised body, is to at a minimum comply with *ISO* 9712:2012.

4 Supervisor and operator certificates and competence are to comprise all industrial sectors and techniques being applied by the supplier.

9.4.2 Supervisors

1 Suppliers are to have a supervisor or supervisors who are responsible for the appropriate execution of *ANDT* operations and for

the professional standard of the operators and their equipment, including the professional administration of the working procedures.

2 Supervisors are to be independently certified to Level 3 by a third party based on **9.4.1** and deemed acceptable by the Society.

3 In relation to the preceding **-2**, suppliers are to employ, on a full-time basis, at least one supervisor for all *ANDT* methods which are carried out by the supplier, except in cases where it is recognised that it is difficult for the supplier to directly employ a Level 3 certified supervisor for all the stated *ANDT* methods.

4 Supervisors are to be directly involved in the review and acceptance of *ANDT* specifications and procedures, test records, inspection records and the calibration of *ANDT* equipment and tools.

5 Supervisors are to evaluate operator skills and qualifications at least every 12 months.

9.4.3 Operators

1 Operators are, in principle, to be at least qualified and certified to Level 2 for the *NDT* method(s) concerned and as described in **9.4.1**, except in cases where **9.4.1-3** is applied.

2 Operators who are qualified and certified as Level 1 are to only undertake the gathering of data and the using of *ANDT* methods. They are not, however, to perform data interpretation or data analysis.

3 Operators are to have adequate knowledge of materials, welds, structures or components as well as of *ANDT* equipment and its limitations that is sufficient to apply the relevant *ANDT* method for each application appropriately.

9.5 *ANDT* Specification Verification

9.5.1 General

Suppliers are to submit the documents listed in the following **(1)** through **(3)**:

(1) *ANDT* technical documents;

(2) The *ANDT* specifications specified in **9.8**; and

(3) The results of the software simulations specified in **9.5.2**, when applicable.

9.5.2 Software Simulations

1 Software simulation may be required by the Society, when *PAUT* or *TOFD* are applied.

2 Software simulation may include initial test set-up, scan plan, volume coverage and result image of artificial flaws, etc.

3 Where deemed necessary by the Society, artificial defect modeling/simulation may be required.

9.5.3 *ANDT* Specification Verification Tests*

1 Verification tests for *ANDT* specifications are to include the following **(1)** through **(4)**:

(1) Review of available performance data for the inspection system (detection abilities and defect sizing accuracy);

(2) Identification and evaluation of significant parameters and their variability;

(3) Planning and execution of verification tests using qualification blocks and onsite testing for the purpose of confirmation for a repeatability and reliability for inspection systems; and

(4) Making out of test reports for the verification tests specified in the preceding **(3).**

2 The data with respect to the repeatability and reliability obtained by the verification tests specified in the preceding **-1(3)** is to be analyzed by comparing test reports for qualification blocks with those for onsite testing. Qualification blocks are to be manufactured in accordance with a recognized standard deemed appropriate by the Society. Onsite verification test plans are to be confirmed by the Society.

9.5.4 *ANDT* Specification Approval

Test reports for the verification tests specified in **9.5.3** are to be submitted to the Society for the purpose of *ANDT* specification approval.

9.5.5 Onsite Verification Tests

1 After *ANDT* specifications are approved in accordance with the requirements specified in **9.5.4**, a supplemental *NDT* is to be performed at locations to be tested agreed to by the Society among those for which *ANDT* is performed for the purpose of verifying the validity of *ANDT* results.

2 Notwithstanding the preceding **-1**, the aforementioned supplemental *NDT* may be reduced or omitted at the discretion of the Society provided that *ANDT* results can be appropriately compared with technical documents submitted by the supplier and the validity of *ANDT* results can be verified.

3 Documents with respect to probability of detection (*POD*) and sizing accuracy are to be created where deemed necessary by the Society.

4 When the surveyor in attendance judges that the *ANDT* is not being carried out in accordance with its approved specifications, the *ANDT* is to be suspended immediately. In such cases, the supplier is to conduct an additional investigation and is to re-verify the validity of the *ANDT* specifications in order to determine the cause of the failure.

5 When a significant nonconformity is found, the Society has the right to reject the *ANDT* results.

9.6 Surface Condition

9.6.1 Surface Condition

1 Locations to be tested are to be free from scales, loose rust, weld spatter, oil, grease, dirt or paint that may affect *ANDT* detection sensitivity.

2 Where *PAUT* or *TOFD* are to be performed on painted surfaces, the suitability and sensitivity of the test are to be confirmed in accordance with an appropriate transfer correction method defined in the specifications. In all cases, the reasons for transfer losses exceeding 12 *dB* are to be examined, and further preparation of the scanning surfaces is to be conducted so that transfer losses do not exceed 12 *dB*.

3 Where *ANDT* is to be performed on painted surfaces, the relevant procedures are to be qualified on a painted surface in accordance with **9.5.3**.

4 Requirements for acceptable test surface finishes are to ensure accurate and reliable detection of defects. For the testing of welded joints, the weld is to be ground or machined in cases where the test surface is irregular or has other features likely to interfere with the interpretation of *ANDT* results.

9.7 *ANDT* Selection

9.7.1 *ANDT* Selection

1 The locations to be tested and the number of *ANDT* tests are to be planned by the supplier according to ship design, ship or equipment type and welding processes used.

2 Particular attention is to be paid to highly stressed areas.

3 The locations to be tested by *ANDT* are to be ones deemed appropriate by the Society according to material of the welded joints to which *ANDT* is applied.

9.8 *ANDT* Requirements

9.8.1 General

1 Suppliers are to ensure that personnel performing *ANDT* or interpreting *ANDT* results are qualified to the appropriate level specified in **9.4**.

2 All *ANDT* is to be performed in accordance with *ANDT* specifications.

3 *ANDT* specifications are to be in accordance with the requirements provided below and those specified in **9.8.2**, **9.8.3** or **9.8.4**.

(1) *ANDT* specifications are to identify the members to be subjected to inspections, the *ANDT* method, the equipment to be used and the full extent of the examinations including any test restrictions.

(2) *ANDT* specifications are to specify requirements for the clear identification of those locations to be tested as well as for a data system or marking system to be applied to ensure repeatability of testing.

(3) *ANDT* specifications are to include the method and requirements for equipment calibration and functional checks, together with specific technique sheets or scan plans, for the component under tests.

(4) *ANDT* specifications are to be approved by personnel qualified to Level III in the appropriate technique in accordance with **9.4**.

(5) *ANDT* specifications are to be approved by the Society.

9.8.2 Phased Array Ultrasonic Testing (*PAUT*)

1 *PAUT* is to be performed according to procedures based on *ISO* 13588 and *ISO* 19285 or recognized equivalent standards

deemed acceptable by the Society. The aforementioned standards, in principle, refer to the most recent version published.

2 *PAUT* for base metals of metallic materials and non-metallic materials is to be as deemed appropriate by the Society.

3 The equipment used for *PAUT* is to conform to *ISO* 18563-1, *ISO* 18563-2, *ISO* 18563-3 or recognized equivalent standards deemed acceptable by the Society. The aforementioned standards, in principle, refer to the most recent version published.

4 Depending on the complexity of the location to be tested and the access to surfaces, there may be a requirement for additional scans or a supplementary *NDT* to ensure that full coverage of locations to be tested is achieved.

5 Where a special scan plan is applied, it is to be included in *PAUT* specifications for welds together with other representative scans.

6 *PAUT* specifications are, at a minimum, to include the following information shown in **Table M9.4**. When an essential variable given in **Table M9.4** is to be changed from its specified value or range of values, the verification of the validity for the *PAUT* specifications specified in **9.5.3** is to be performed according to the details of the change and then be approved by the Society.

7 When a nonessential variable given in **Table M9.4** is to be changed from its specified value or range of values, the verification of validity of the *PAUT* specifications specified in **9.5.3** may be omitted. In such cases, the *PAUT* specifications are to be rewritten and then approved by the Society.

8 All changes of essential or nonessential variables are to be written in the most recent approved *PAUT* specifications specified in the preceding **-6** and **-7**.

9 The testing levels specified in the *PAUT* specifications are to be in accordance with *ISO* 13588 or equivalent recognized standards accepted by the Society. The aforementioned standards, in principle, refer to the most recent version published.

10 The purpose of the testing is to be specified in the *PAUT* specifications. Based on this, the volume coverage is to be determined.

11 Scan plans (including volume coverage, base metal thickness and weld geometry) are to be submitted to the Society. Where *PAUT* is applied as the *NDT* specified in **Chapter 8**, such plans may be included in the non-destructive inspection plan.

12 Where indication evaluations are only based on amplitude, *E* scans (or linear scans) are to be utilized to scan the fusion faces of welds so that the sound beam is perpendicular to the fusion face ±5°. This, however, does not apply to cases where the Society finds the existence and size of discontinuities at fusion faces are able to be appropriately detected by *S* (sectorial) scans using the *PAUT* specifications. Where the *POD* of an *S* scan is verified, reference blocks containing suitable reflectors in fusion zone locations are to be used.

13 The reference blocks used are to be appropriate for the testing level. The design and manufacture of reference blocks are to be in accordance with *ISO* 13588 or recognized equivalent standards deemed by the Society. The aforementioned standards, in principle, refer to the most recent version published.

14 Indications detected are to be evaluated either by length and height or by length and maximum amplitude. Indication assessment is to be in accordance with *ISO* 19285 or recognized equivalent standards deemed acceptable by the Society. The 6 *dB* drop method is only to be used as sizing technique for measuring indications that are larger than the beam width. The aforementioned standards, in principle, refer to the most recent version published.

Table M9.4 *PAUT* Specification Requirements

	Item	Essential Variables
1	Material type or weld configuration to be inspected, including thickness dimensions and material product form (castings, forgings, pipes, plates, etc.)	*X*
2	Scanning surfaces of locations to be tested (one surface, one side; one surface, both sides)	*X*
3	Technique(s) (straight beam, angle beam, contact, or immersion)	*X*
4	Scan plan (probe position according to base metal thickness, and groove shape and dimensions)	*X*
5	Angle(s) and mode(s) of wave propagation in the material (compressional wave or shear wave)	*X*
6	Search unit and wedge type, frequency, element size and number, element pitch and gap dimensions, and element shape	*X*
7	Focal range (identify plane, depth, or sound path)	*X*
8	Virtual aperture size (number of elements, effective height(1) and element width)	*X*
9	Focal laws for *E*-scans and *S*-scans (range of element numbers used, angular range used, element or angle increment change)	*X*
10	Special search units, wedges, shoes, or saddles (when used)	*X*
11	*PAUT* instrument(s)	*X*
12	Calibration (calibration block(s) and technique(s))	*X*
13	Directions and extent of scanning	*X*
14	Scanning method (manual, semi-automatic or automatic scanning)	*X*
15	Methods for sizing indications and for distinguishing geometric indications from flaw indications	*X*
16	Methods for checking the effects of grating lobes and for treatment after checking said effects	*X*
17	Computer enhanced data acquisition (when used)	*X*
18	Scan overlap	*X*(2)
19	Supervisor and operator performance requirements (skill and qualifications)	*X*
20	Testing levels, acceptance levels and/ or recording levels	*X*
21	Supervisor and operator qualification level requirements	—
22	Surface condition (surface of location to be tested, reference block for calibration)	—
23	Couplant (brand name or type)	—
24	Post-inspection cleaning technique	—
25	Automatic alarm or recording equipment (when used)	—
26	Records, including minimum calibration data to be recorded (instrument settings)	—
27	Environmental and safety issues	—
28	Scan increment for recording *PAUT* data	—
29	Method for associating the locations to be tested, tests result and *PAUT* data	—

Notes:

(1) Effective height is the distance from the outside edge of the first to last element used in the focal law.

(2) To be treated as an essential variable only in cases where the range of scan overlap decreases.

9.8.3 Time of Flight Diffraction (*TOFD*)

1 *TOFD* is to be performed according to procedures based on *ISO* 10863 and *ISO* 15626 or recognized equivalent standards deemed acceptable by the Society. The aforementioned standards, in principle, refer to the most recent version published.

2 Depending on the complexity of the location to be tested and the access to surfaces, there may be a requirement for additional scans or a supplementary *NDT* to ensure that full coverage of the locations to be tested is achieved.

3 *TOFD* specifications are, at a minimum, to include the following information shown in **Table M9.5**. When an essential variable given in **Table M9.5** is to be changed from its specified value or range of values, the verification of validity for the *TOFD* specifications specified in **9.5.3** is to be performed according to the details of the change and then is to be approved by the Society.

4 When a nonessential variable given in **Table M9.5** is to be changed from its specified value or range of values, the verification of validity for the *TOFD* specifications specified in **9.5.3** may be omitted. In such cases, the *TOFD* specifications are to be rewritten and then approved by the Society.

5 All changes of essential or nonessential variables are to be written in the most recent approved *TOFD* specifications specified in the preceding **-3** and **-4**.

6 The testing levels specified in *TOFD* specifications are to be in accordance with *ISO* 10863 or recognized standards accepted by the Society. The aforementioned standards, in principle, refer to the most recent version published.

7 The purpose of the testing is to be specified in the *TOFD* specifications. Based on this, the volume coverage is to be determined.

8 Scan plans (including probe position, volume coverage, base metal thickness and weld geometry) are to be submitted to the Society. Where *TOFD* is applied to the *NDT* specified in **Chapter 8**, such plans may be included in the non-destructive inspection plan.

9 Where *TOFD* is not appropriately performed in dead zones, additional scans or supplementary *NDT* is to be performed to ensure that full coverage of the locations to be tested is achieved (Generally, either surfaces, back walls, or both may be dead zones).

Table M9.5 *TOFD* Specifications Requirements

	Item	Essential Variables
1	Material type or weld configuration to be inspected, including thickness dimensions and material product form (castings, forgings, pipes, plates, etc.)	*X*
2	Scanning surfaces of locations to be tested (one surface, one side; one surface, both sides)	*X*
3	Angle(s) of wave propagation in the material (compressional wave or shear wave)	*X*
4	Search unit and wedge type, frequency, element size and shape	*X*
5	Special search units, wedges, shoes, or saddles (when used)	*X*
6	*TOFD* instrument(s) and software(s)	*X*
7	Calibration (calibration block(s) and technique(s))	*X*
8	Directions and extent of scanning	*X*
9	Scanning method (manual, semi-automatic or automatic scanning)	*X*
10	Scan increment for recording *TOFD* data	*X*(1)
11	Methods for sizing indications and distinguishing geometric indications from flaw indications	*X*
12	Computer enhanced data acquisition (when used)	*X*
13	Scan overlap	*X*(2)
14	Supervisor and operator performance requirements (skill and qualifications)	*X*
15	Testing levels, acceptance levels or recording levels	*X*
16	Supervisor and operator qualification level requirements	—
17	Surface condition (surface of location to be tested, reference block for calibration)	—
18	Couplant (brand name or type)	—
19	Post-inspection cleaning technique	—
20	Automatic alarm and/or recording equipment (when used)	—
21	Records, including minimum calibration data to be recorded (instrument settings)	—
22	Environmental and safety issues	—

Notes:

(1) To be treated as an essential variable only in cases where the range of scan increment for recording *TOFD* data increases.

(2) To be treated as an essential variable only in cases where the range of scan overlap decreases.

9.8.4 Digital Radiography (*RT-D*)

1 *RT-D* is to be performed according to procedures based on *ISO* 17636-2 and *JIS Z* 3110 or recognized equivalent standards deemed acceptable by the Society. The aforementioned standards, in principle, refer to the most recent version published. In cases where other standards, however, are to be applied (e.g. those related to *IQI* placement), the Society approval is required in advance.

2 When an *RT-D* technique other than *RT-S* and *RT-CR* is applied, it is to be in accordance with the requirements of this chapter. In such cases, the *RT-D* specifications are to be demonstrated as equivalent to the requirements of this chapter and approved by the Society.

3 *RT-D* specifications are, at a minimum, to include the following information shown in **Table M9.6**. When the content of approved *RT-D* specifications are changed, the verification of validity for the *RT-D* specifications specified in **9.5.3** is to be performed according to the details of the change, and then is to be approved by the Society.

4 All content changes are to be written in the most recent approved *RT-D* specifications specified in the preceding **-3**.

5 For all *RT-D* techniques, detector (*IP* or digital detector array (*DDA*)) output quality control methods are to be specified in the *RT-D* specifications in addition to the other required information.

6 *RT-D* specifications are to specify the level of magnification, post-processing tools, image/data security and storage for final evaluation and reporting.

7 The testing levels specified in *RT-D* specifications are to be in accordance with *ISO* 13588 and *ISO* 19285 or recognized equivalent standards deemed acceptable by the Society. The aforementioned standards, in principle, refer to the most recent version published.

Table M9.6 *RT-D* Specification Requirements

	Item
1	Material type or weld configuration to be inspected, including thickness dimensions and material product form (castings, forgings, pipes, plates, etc.)
2	Digitizing System Description: (1) Manufacturer and model no. of digitizing system (2) Physical size of the usable area of the image monitor (3) Film size capacity of the scanning device (4) Spot size(s) of the film scanning system (when applying *RT-CR*) (5) Image display pixel size as defined by the vertical/horizontal resolution limit of the monitor (6) Illuminance of the video display (7) Data storage medium
3	Digitizing Technique: (1) Digitizer spot size (in microns) to be used (when applying *RT-S*) (2) Loss-less data compression technique, if used (3) Method of image capture verification (4) Image processing operations (5) Time period for system verification
4	Spatial resolution used: (1) Contrast sensitivity (density range obtained) (2) Dynamic range used (3) Spatial linearity of the system (4) Material type and thickness range (5) Source type or maximum *X*-ray voltage used (6) Detector type (7) Detector calibration (when applying *DDA*) (8) Minimum source-to-object distance (9) Distance between the test object and the detector (10) Source size (11) Test object scan plan (when applied) (12) Image Quality Measurement Tools (13) Image Quality Indicator (*IQI*) (14) Wire Image Quality Indicator (15) Duplex Image Quality Indicator (16) Image Identification Indicator (17) Testing levels, acceptance levels and/or recording levels (18) Personnel qualification requirements (19) Surface condition (20) Records, including minimum calibration data to be recorded (21) Environmental and Safety issues

9.9 Acceptance Level

9.9.1 General

1 This section specifies the acceptance criteria for the assessment of *PAUT*, *TOFD* and *RT-D* results.

2 It may be necessary to combine testing methods to facilitate accurate assessments. In such cases, the acceptance criteria for each test method used are to be applied.

9.9.2 Phased Array Ultrasonic Testing (*PAUT*)

1 Quality levels, testing level and acceptance level are to be in accordance with **Table M9.7**.

2 Quality levels and acceptance levels for welded joints are to be in accordance with *ISO* 19285 or recognized equivalent standards deemed acceptable by the Society. The aforementioned standards, in principle, refer to the most recent version published.

3 Acceptance level for the base metals of metallic materials and non-metallic materials are to be in accordance with the Rules or as deemed appropriate by the Society.

Table M9.7 *PAUT* acceptance level

Quality level *ISO* 5817	Testing level *ISO* 13588	Acceptance level *ISO* 19285
C, *D*	*A*	3
B	*B*	2
By agreement	*C*	1
Special application	*D*	By agreement

9.9.3 Time of Flight Diffraction (*TOFD*)

1 Quality levels, testing level and acceptance level are to be in accordance with **Table M9.8**.

2 Quality levels and acceptance levels for welded joints are to be in accordance with *ISO* 15626 or recognized equivalent standards deemed acceptable by the Society. The aforementioned standards, in principle, refer to the most recent version published.

Table M9.8 *TOFD* acceptance level

Quality level *ISO* 5817	Testing level *ISO* 10863	Acceptance level *ISO* 15626
B	*C*	1
C	At least *B*	2
D	At least *A*	3

9.9.4 Digital Radiography (*RT-D*)

1 Quality levels, testing level and acceptance level are to be in accordance with **Table M9.9**.

2 Quality levels and acceptance levels for welded joints are to be in accordance with *ISO* 10675-1, *ISO* 10675-2 or recognized equivalent standards deemed acceptable by the Society. The aforementioned standards, in principle, refer to the most recent version published.

Table M9.9 *RT-D* acceptance level

Quality level *ISO* 5817 or *ISO* 10042	Testing level *ISO* 17636-2	Acceptance level *ISO* 10675-1 or *ISO* 10675-2
B	*B*	1
C	*B*(1)	2
D	*A*	3

Note:

(1) For circumferential weld testing, the minimum number of exposures may correspond to the requirements of *ISO* 17636-2 class *A*.

9.10 Test Records

9.10.1 General

In addition to the reference standards for the test, test records are to include at least the information specified in this section.

9.10.2 Test Object Information

Test records are to include the following test object information

(1) Test object identification

(2) Dimensions (including wall thickness)

(3) Material type and product form

(4) Geometrical configuration,

(5) Locations tested

(6) Welding process and heat treatment method

(7) Surface condition and temperature

(8) Manufacturing stage

(9) NK Rules referenced

9.10.3 Equipment Information

Test records are to include the equipment information specified in **Table M9.10**.

Table M9.10 Equipment information

Method	Information
All	Manufacturer and type of instrument, including identification numbers
PAUT	(1) Manufacturer, type, frequency of phased array probes including number and size of elements, material and angle(s) of wedges with identification numbers (2) Details of reference block(s) with identification numbers (3) Type of couplant used
TOFD	(1) Manufacturer, type, frequency, element size and beam angle(s) of probes with identification numbers (2) Details of reference block(s) with identification numbers (3) Type of couplant used
RT-D	(1) System of marking used (2) Radiation source, type and size of focal spot and identification of equipment used (3) Detector, screens and filters and detector basic spatial resolution

9.10.4 Test Method Information

Test records are to include the test method information specified in **Table M9.11**.

Table M9.11 Test method information

Method	Information
All	(1) Testing level and reference to written *ANDT* specifications (2) Test length (3) Reference points and coordinate system details (4) Method and values used for range and sensitivity settings (5) Signal processing details and scan increment settings (6) Access limitations and deviations from standards (if any)
PAUT	(1) Increment (*E*-scans) or angular increment (*S*-scans) (2) Element pitch and gap dimensions (3) Focus (calibration should be the same as scanning) (4) Virtual aperture size (number of elements and element width) (5) Element numbers used for focal laws (6) Documentation on permitted wedge angular range from manufacturer (7) Calibration documentation, *TCG* and *ACG* (angle gain compensation) (8) Scan plan
TOFD	(1) *TOFD* setup details (2) Offset scan details (if required)
RT-D	(1) Detector position plan (2) Tube voltage used and current, or source type and activity (3) Time of exposure and source-to-detector distance (4) Type and position of image quality indicators (5) Achieved and required SNR_N for *RT-S* (6) Achieved and required grey values or SNR_N for *RT-CR* (7) For *RT-S*, type and parameters such as gain, frame time, frame number, pixel (size, calibration procedure) (8) For *RT-CR*, scanner type and parameters such as pixel size, scan speed, (gain, laser intensity, laser spot size) (9) Image-processing parameters used (e.g. digital filters)

9.10.5 Test Result Information

Test records are to include the test result information specified in **Table M9.12**.

Table M9.12 Test result information

Method	Information
All	(1) Acceptance criteria applied (2) Tabulated survey records (including location and size of relevant indications and assessment results) (3) Test results (including data on software used) (4) Test date (5) References to the raw data used (6) Date(s) of scan or exposure and test report (7) Operator names, signatures and certification levels
PAUT	(1) Phased array images of at least those locations where relevant indications have been detected on hard copy, all images or data available in soft format (2) Reference points and coordinate system details
TOFD	*TOFD* images of at least those locations where relevant *TOFD* indications have been detected

9.10.6 Other

1 *ANDT* results are to be recorded and evaluated by the supplier on a continual basis. Where deemed necessary by the surveyor, these records are to be submitted to the surveyor.

2 The supplier is responsible for the review, interpretation, evaluation and acceptance of the *ANDT* results. Test records are to include information related to test results in accordance with the acceptance criteria specified in the *ANDT* specifications.

3 Where a special *ANDT* is applied, the particular requirements and details are to be included in the test records in accordance with the recognized standards for each *ANDT*.

4 The supplier is to keep the inspection records specified in **9.10** for a period of time deemed appropriate by the Society.

9.11 Unacceptable Indications and Repairs

9.11.1 General

All indications (discontinuities) exceeding the applied acceptance criteria are to be classed as defects, and are to be eliminated and repaired according to surveyor instructions. *NDT* for repaired parts is to be performed in accordance with the Rules or surveyor instructions.

Contents

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part M WELDING

M1 GENERAL

M1.1 General

M1.1.1 Application

With respect to the provisions of **1.1.1-3, Part M of the Rules**, in the case of partial weldings such as repairing, a welding method according to the standards different from **Part M of the Rules** (e.g. underwater welding according to *AWS D*3.6) may be applied when deemed to be appropriate by the Society after considering the degree and scope of application. In such cases, the welding procedure and related specifications related to the intended welding are to be submitted to the Society for confirmation in advance.

M1.2 Tests before Welding Works

M1.2.1 Execution of Tests

The wording "survey methods which it considers to be appropriate" in **1.2.1-1, Part M of the Rules** means survey methods which the Society considers to be able to obtain information equivalent to that obtained through traditional ordinary surveys where the Surveyor is in attendance, notwithstanding any of the requirements in this Part.

M1.4 Inspection and Quality for Weld

M1.4.1 Implementation of Inspection

"Where the quality and the control system of weld are deemed appropriate by the Society" specified in **1.4.1-2**, **Part M of the Rules**, means that the quality and the control system of manufacturer are approved by the Society according to **"Rules for Approval of Manufacturers and Service Suppliers"** or deemed equivalent thereto.

M1.4.2 Quality and Repair

1 In the inspection during welding works specified in **1.4.2-1(1)**, **Part M of the Rules**, the wording "Inspection items during welding works which are designated by the Surveyor" means the following examples.

(1) Confirmation of edge preparation (intersection of weld line, fillet welding joints where the grooves are required from designing point, on-site cutting portion, etc.)

(2) Confirmation of the fitting accuracy after tack welding (gaps, misalignments, deformations, etc.)

(3) Prevention of the structural mismatching between important members (connecting parts between bulkhead and inner bottom plate, etc.)

(4) Confirmation of the preheating

(5) Confirmation of the condition after back chipping

(6) Other matters deemed necessary by the Surveyor

2 In visual inspection of welded joints specified in **1.4.2-1(2)**, **Part M of the Rules**, the Surveyor may require magnetic particle examination or liquid penetrant examination where deemed necessary.

3 In non-destructive inspection of welded joints specified in **1.4.2-1(3)**, **Part M of the Rules**, "non-destructive inspection which is separately specified by the Society" means the followings in addition to **Chapter 8**, **Part M of the Rules**.

(1) For the welded joints of machinery, piping and tanks of liquefied gas carrier, non-destructive inspection is to be in accordance

with the relevant requirements in the Rules.

(2) For the welded joints of hull construction of aluminium alloy, welded joints of equipment or welded joints of connection between hull structure and equipment, non-destructive inspection is to be deemed appropriate by the Surveyor.

M2 WELDING WORKS

M2.1 General

M2.1.1 Application

1 In **2.1.1-3, Part M of the Rules**, application of welding consumables used for rolled stainless steel etc. is to comply with the requirements specified in **-2** to **-5** as follows.

2 Rolled Stainless Steel

(1) The welding consumables corresponding to the kind of the steel materials are, in principle, to be selected in accordance with **Table M2.1.1-1**. Other considerations for selecting welding consumables may be acceptable in cases where technical documents clarifying the suitability of the selection are submitted and deemed to be appropriate by the Society.

(2) For welded joints of steels of which the minimum proof stress is specified to greater value in accordance with **3.5.5-1, Part K of the Rules**, the welding consumables of which the specified minimum proof stress is equivalent to or greater than the steels are to be used.

3 Aluminium Alloys

(1) The selection of welding consumables for the welding joints of the aluminium alloys is to be as specified in **Table M2.1.1-2**. However, for the welding joints of 6000 series alloys, *RA/WA*, *RB/WB* or *RC/WC* may be used.

(2) The selection of welding consumables for welding joints to different aluminium alloys is to comply with the followings.

(a) For the welding joints of 5000 series alloys, any welding consumables corresponding to the kind of alloys specified in **Table M2.1.1-2** may be used.

(b) For welding joints of 6000 series alloys, *RA/WA*, *RB/WB* or *RC/WC* in lieu of *RD/WD* may be used.

(c) For welding joints of 5000 series alloys and 6000 series alloys, the welding consumables corresponding to 5000 series alloys specified in **Table M2.1.1-2** may be used.

4 Stainless steel pipes, steel tubes for boilers and heat exchangers, steel pipes for pressure piping, headers and steel pipes for low temperature service

The welding consumables corresponding to the kind of steel pipes (of tubes) or headers are, in principle, to be selected in accordance with **Table M2.1.1-1** or **Table M2.1.1-3**. Other considerations for selecting welding consumables may be acceptable in cases where technical documents clarifying the suitability of the selection are submitted and deemed to be appropriate by the Society.

5 Rolled steels for boilers and pressure vessels

The welding consumables corresponding to the kind of steel are, in principle, to be selected in accordance with **Table M2.1.1-4**. Other considerations for selecting welding consumables may be acceptable in cases where technical documents clarifying the suitability of the selection are submitted and deemed to be appropriate by the Society.

Table M2.1.1-1 Application of Welding Consumables
(Rolled Stainless Steel and Stainless Steel Pipes)

Kind and grade of base plates		Grade of applicable welding consumables			
Rolled Stainless Steel	Stainless Steel Pipe				
*KSUS*304	*K*304*TP*	*KD*308	*KY*308	*KW*308	*KU*308
		*KD*308*L*(1)	*KY*308*L*(1)	*KW*308*L*(1)	*KU*308*L*(1)
*KSUS*304*L*	*K*304*LTP*	*KD*308*L*	*KY*308*L*	*KW*308*L*	*KU*308*L*
*KSUS*304*N1*	-	*KD*308*N*2	*KY*308*N*2	*KW*308*N*2	-
*KSUS*304*N2*	-	*KD*308*N*2	*KY*308*N*2	*KW*308*N*2	-
*KSUS*304*LN*	-	*KD*308*L*(1)	*KY*308*L*(1)	*KW*308*L*(1)	*KU*308*L*(1)
*KSUS*309*S*	*K*309*STP*	*KD*309	*KY*309	*KW*309	*KU*309
		*KD*309*L*(1)	*KY*309*L*(1)	*KW*309*L*(1)	*KU*309*L*(1)
*KSUS*310*S*	*K*310*STP*	*KD*310	*KY*310	*KW*310	*KU*310
		-	*KY*310*S*	-	-
*KSUS*316	*K*316*TP*	*KD*316	*KY*316	*KW*316	*KU*316
		*KD*316*L*(1)	*KY*316*L*(1)	*KW*316*L*(1)	*KU*316*L*(1)
*KSUS*316*L*	*K*316*LTP*	*KD*316*L*	*KY*316*L*	*KW*316*L*	*KU*316*L*
*KSUS*316*N*	-	*KD*316	*KY*316	*KW*316	*KU*316
*KSUS*316*LN*	-	*KD*316*L*(1)	*KY*316*L*(1)	*KW*316*L*(1)	*KU*316*L*(1)
*KSUS*317	*K*317*TP*	*KD*317	*KY*317	*KW*317	*KU*317
		*KD*317*L*(1)	*KY*317*L*(1)	*KW*317*L*(1)	*KU*317*L*(1)
*KSUS*317*L*	*K*317*LTP*	*KD*317*L*	*KY*317*L*	*KW*317*L*	*KU*317*L*
*KSUS*317*LN*	-	*KD*317*L*(1)	*KY*317*L*(1)	*KW*317*L*(1)	*KU*317*L*(1)
*KSUS*321	*K*321*TP*	-	*KY*321	-	-
		*KD*347	*KY*347	*KW*347	*KU*347
*KSUS*323*L*	-	*KD*2209	*KY*2209	*KW*2209	-
*KSUS*329*J*1	*K*329*J*1*TP*	*KD*329*J*1	-	-	-
*KSUS*329*J*3*L*	*K*329*J*3*LTP*	*KD*2209	*KY*2209	*KW*2209	-
*KSUS*329*J*4*L*	*K*329*J*4*LTP*	*KD*329*J*4*L*	*KY*329*J*4*L*	*KW*329*J*4*L*	-
*KSUS*347	*K*347 *TP*	*KD*347	*KY*347	*KW*347	*KU*347
*KSUS*821*L*1	-	*KD*2209	*KY*2209	*KW*2209	-

Note:

(1) The specified minimum proof stress and tensile strength of the applicable welding consumables are equivalent to or greater than those of the base plate steels are to be used.

Table M2.1.1-2 Application of Welding Consumables (Aluminium Alloys)

Kind and grade of aluminium alloy to be welded		Grade of applicable welding consumables (1)
5000 series	5754*P*	*RA/WA*, *RB/WB*, *RC/WC*
	5086*P*, 5086*S*	*RB/WB*, *RC/WC*
	5083*P*, 5083*S*	*RC/WC*
	5383*P*, 5383*S*	*RC/WC*
	5059*P*, 5059*S*	*RC/WC*
	5456*P*	*RC/WC*
6000 series	6005*AS*	*RD/WD*
	6061*P*, 6061*S*	*RD/WD*
	6082*S*	*RD/WD*

Note:

(1) The symbols used for the welding consumables in this Table are the last two characters used for the same materials shown in **Table M6.51, Part M of the Rules**.

Table M2.1.1-3 Application of Welding Consumables
(Steel tubes for boiler and heat exchangers, steel pipes for pressure piping, headers and steel pipes for low temperature service)

Kind of base pipe (or tube)	Grade of base pipe (or tube)	Grade of applicable welding consumables (1)
Steel tubes for boilers and heat exchangers, steel pipes for pressure piping, headers	*KSTB*33, *KSTB*35, *KSTPG*38, *KSTS*38, *KSTPT*38	1, 2, 3, 51, 52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, *L*1, *L*2, *L*3
	*KSTB*42, *KSTPG*42, *KSTS*42, *KSTPT*42, *KBH*-1	51, 52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, *L*2, *L*3, 2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42
	*KSTS*49, *KSTPT*49, *KBH*-2	51, 52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, *L*3, 2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42
Steel pipes for low temperature service	*KLPA*	*L*1, *L*2, *L*3, 54, 54*Y*40, 55*Y*40
	KLPB, *KLPC*	*L*2, *L*3
	*KLP*9	*L*91, *L*92

Note:

(1) The symbols for the welding consumables listed above indicate materials which are specified in **Table M6.1**, **Table M6.12**, **Table M6.21**, **Table M6.29** or **Table M6.58, Part M of the Rules** that have the same mark at the end. (For example, "3" indicates *KMW*3, *KAW*3, *KSW*3 and *KEW*3; "*L*3" indicates *KMWL3*, *KAWL*3 and *KSWL3*; and "3*Y42*" indicates *KMW*3*Y*42, *KAW*3*Y*42 and *KSW*3*Y*42.)

Table M2.1.1-4 Application of Welding Consumables
(Rolled steels for boilers and pressure vessels)

Kind of base plate	Grade of base plate	Grade of applicable welding consumables (1)
Rolled steel for boilers	*KP*42	51, 52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, *L*2, *L*3, 2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42
	*KP*46, *KPA*46, *KP*49, *KPA*49	51, 52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, *L*3, 2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42
Rolled steel for pressure vessels	*KPV*24(2)	2, 3, 52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, 2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42
	*KPV*32(3)	52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40, 2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42
	*KPV*36	63*Y*47, 2*Y*42, 3*Y*42, 4*Y*42, 5*Y*42, 2*Y*46, 3*Y*46, 4*Y*46, 5*Y*46, 3*Y*50, 4*Y*50, 5*Y*50
	*KPV*42, *KPV*46	63*Y*47, 3*Y*50, 4*Y*50, 5*Y*50, 3*Y*55, 4*Y*55, 5*Y*55
	*KPV*50	3*Y*55, 4*Y*55, 5*Y*55, 3*Y*62, 4*Y*62, 5*Y*62

Notes:

(1) The symbols for the welding consumables listed above indicate materials which are specified in **Table M6.1**, **Table M6.12**, **Table M6.21**, **Table M6.29** or **Table M6.58, Part M of the Rules** that have the same mark at the end. (For example, "3" indicates *KMW*3, *KAW*3, *KSW*3 and *KEW*3; "*L*3" indicates *KMWL3*, *KAWL*3 and *KSWL3*; and "3*Y42*" indicates *KMW*3*Y*42, *KAW*3*Y*42 and *KSW*3*Y*42.)

(2) The symbols for the welding consumables listed above as "2, 3, 52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40" are applicable only for *KMW* and *KSW*.

(3) The symbols for the welding consumables listed above as "52, 53, 54, 52*Y*40, 53*Y*40, 54*Y*40, 55*Y*40" are applicable only for *KMW* and *KSW*.

M2.2 Work Scheme

M2.2.1 Welding Application Plan

1 In **2.2.1(2)**, **Part M of the Rules**, for steels considered to have the brittle crack arrest properties specified in **3.12**, **Part K of the Rules**, the welding procedures and related specifications approved for the steels excluding "*BCA*6000" or "*BCA*8000" given in **Table K3.40** or **Table K3.41, Part K of the Rules,** may be applied except for the large heat input welding specified in Note (6) of **Table M4.2, Part M of the Rules**.

2 With regard to corrosion resistant steel for cargo oil tanks, the wording "other items considered necessary by the Society" stipulated in **2.2.1(3), Part M of the Rules** means brands of welding consumables and brands of corrosion resistant steel listed in "Particulars of Approval Conditions" of corrosion resistant steel.

M2.2.2 Welding Procedure and Related Specification

1 For **2.2.2-2(2)**, **Part M of the Rules**, suffixes added to the grades specified in **Table K3.40** or **Table K3.41, Part K of the Rules** (e.g. "-*BCA*6000") need not be included except for the large heat input welding specified in Note (6) of **Table M4.2, Part M of the Rules**.

2 For **2.2.2-2(2), Part M of the Rules**, suffixes added to the grades specified in **Table K3.42, Part K of the Rules** (e.g. "-*RCU*") need not be included.

M2.4 Welding Process

M2.4.1 Selection of Welding Consumables

1 With respect to the provisions of **2.4.1**, **Part M of the Rules**, semi-automatic welding consumables may be used in automatic welding work.

2 "It is deemed to be appropriate by the Society" specified in **2.4.1(2)(c)**, **Part M of the Rules** is, in principle, to be as provided below:

(1) The steel materials are to be in accordance with the followings:

(a) The steel materials are to be *KA*32, *KD*32, *KA*36 or *KD*36 of *TMCP* not exceeding 25 *mm* in thickness.

(b) The carbon equivalent (C_{eq}) of steel materials is to be calculated in accordance with **Note (3)** of **Table M2.4.3-1** and to be not more than 0.36%.

(2) The welding method is to be one pass horizontal fillet welding either by manual welding or gravity welding, and to have been approved by the Society in accordance with the requirements in **M4.3.1**.

(3) Approval is to have been obtained form the Society for electrodes as being the non-low hydrogen electrodes for high tensile steel in accordance with the requirements in **M6.2.1**.

(4) Notwithstanding the requirement in preceding **(3)**, low hydrogen electrodes are to be used for repair welding.

3 "Welding consumables different from those given in **Table M2.1** may be selected" specified in **2.4.1-1(3)**, **Part M of the Rules**, means cases where the standard value for the strength of the welding metal is lower than the standard value for the strength of base metal.

4 Backing flux used for submerged arc one side automatic welding is not included in the backing specified in **2.4.1-2**, **Part M of the Rules**

5 The wording "measures deemed appropriate by the Society" stipulated in **Note (4)** of **Table M2.1, Part M of the Rules** means applying corrosion protection in accordance with **3.3.5.4-1(1), Part 1, Part C of the Rules** or **22.4.3(1), Part CS of the Rules** to welded parts.

M2.4.3 Preheating, etc.

The control standards for short bead, preheating and line heating in the processing and welding of rolled steels for hulls and rolled steels for low temperature service are to be in accordance with **Table M2.4.3-1**.

Table M2.4.3-1 Control Standards for the Processing and Welding of Rolled Steels for Hulls and Rolled Steels for Low Temperature Service

Items for control standard		Mild steel		High tensile steels[1]							Rolled steels for low temperature service[13]		
				Conventional type[2]			*TMCP* type						
		Grade	Control standard	Grade	Control standard		Grade	Carbon equivalent for steel C_{eq}[3][4][5]	Control standard		Carbon equivalent for steel C_{eq}[3][4][5]	Control standard	
Length of short bead[6]	Tack and repair weld of scar	*KE*	30 *mm* or over	*KA*32 *KD*32 *KE*32	50 *mm* or over[12]		*KA*32 *KD*32 *KE*32	0.36% or below[7]	10 *mm* or over[8]		More than 0.36%	50 *mm* or over	
											0.36% or below	10 *mm* or over	
	Repairing of welded bead			*KA*36 *KD*36 *KE*36			*KA*36 *KD*36 *KE*36		30 *mm* or over		More than 0.36%	50 *mm* or over	
											0.36% or below	30 *mm* or over	
Preheating in working	Temperature need preheating[9]	*KA* *KB* *KD* *KE*	-5° C or below	*KA*32 *KD*32 *KE*32 *KA*36	5° C or below[10][12]		*KA*32 *KD*32 *KE*32 *KA*36	0.36% or below[7]	0° C or below[10]		More than 0.36%	5° C or below	
											0.36% or below	0° C or below	
	Preheating temperature		20 ° C or over	*KD*36 *KE*36	50° C or over		*KD*36 *KE*36		20° C or over		More than 0.36%	50° C or over	
											0.36% or below	20° C or over	
Line heating (Thermal fairing)	Maximum heating temperature of steel Surface	*KA* *KB* *KD* *KE*	[11]	*KA*32 *KD*32 *KE*32 *KA*36	Water cooling just after heating	650° C or below	*KA*32 *KD*32 *KA*36 *KD*36	0.38% or below	Water cooling just after heating	1000° C or below	—	Air cooling after heating	900° C or below
				*KD*36 *KE*36	Air cooling after heating	900° C or below			Air cooling after heating				
					Air cooling and subsequent water cooling after heating	900° C or below (Starting temperature of water cooling is to be 500° C or below)	*KE*32 *KE*36	0.38% or below	Water cooling just after heating	900° C or below	More than 0.36%	Air cooling and subsequent water cooling after heating	900° C or below (Starting temperature of water cooling is to be 500° C or below)
									Air cooling after heating		0.36% or below		900° C or below (Starting temperature of water cooling is to be 550° C or below)

Notes:

(1) In *KA*40, *KD*40, *KE*40 and *KE*47, the control standards for the conventional high tensile steels are applied except for the case specially approved by the Society. *KF*32, *KF*36 and *KF*40 are to be as deemed to appropriate by the Society.

(2) The conventional type is the high tensile steel of which grades of heat treatment specified in **Notes (3)** of **Table K3.3, Part K of the Rules**, as other than the *TMCP* type.

(3) C_{eq} is to be calculated by the following formula and is to be rounded to two decimal places.

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \ (\%)$$

(4) The control standards when the value of C_{eq} exceeds the value in this Table, in principle, are to be applied as conventional type.

(5) When there are differences in C_{eq} of the steel materials, the control standard corresponding to the higher value of C_{eq} is to be applied.

(6) The length of bead is to be measured from the starting point of weld to the centre of the crater at the termination of the weld.

(7) Where cold cracking susceptibility P_{cm} is substituted for C_{eq}, the control standards are to be as deemed to appropriate by the Society. P_{cm} is to be calculated by the following formula and is to be rounded to two decimal places.

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B \quad (\%)$$

(8) It is recommended that for *KE*32 and *KE*36 to be not less than 30 *mm*.

(9) Even in cases where the temperature exceeds the value given in this Table, preheating may be required depending on the thickness of steel materials, degree of restrain and welding heat input.

(10) Electrodes are to be of the low hydrogen electrodes. However, in horizontal butt welding, overhead fillet welding, etc., extremely low hydrogen electrodes (the quantity of hydrogen measured by the glycerine replacement method is not more than 0.03 cm^3/g) is to be used, or in cases the temperature exceeds the value in this Table. Preheating is to be carried out.

(11) It is recommended that the conventional control standards for the conventional high tensile steels are applied to *KE*.

(12) For *KE*47, in the cases where P_{cm} is less than or equal to 0.19, 25 *mm* of short bead length and air temperature of 0°C or below may be adopted where approved by the Society.

(13) These control standards apply to *KL*24*A*, *KL*24*B*, *KL*27, *KL*33 and *KL*37. The standards for other grades are to be as deemed appropriate by the Society.

(14) For steels considered to have brittle crack arrest properties specified in **3.12, Part K of the Rules,** the control standards for the steels excluding "*BCA*6000" or "*BCA*8000" given in **Table K3.40** or **Table K3.41, Part K of the Rules**, are to be applied.

M4 WELDING PROCEDURE AND RELATED SPECIFICATIONS

M4.1 General

M4.1.1 Application

The wording "welding procedure" specified in **4.1.1-3, Part M of the Rules** is the following welding procedure qualification test such as for stud welding.

(1) Test assemblies

The four studs of maximum diameter used in the actual work are to be welded to the test assembly in suitable dimensions as specified in **Fig. M4.1.1-1** at proper intervals. The test assembly is to be welded under the same or similar condition employed in the actual work.

(2) Bend test

Three pieces of four studs are to be bent from the root to an angle of ninety degrees with the hammer or lever as specified in **Fig. M4.1.1-2**. In this case, the stud is not allowed to be broken or to be cracked.

(3) Macroscopic test

The macroscopic specimen is to be produced from the centre line section of the rest one stud, and it is to be inspected the deposited condition and the existence of defect.

(4) Hardness test

Vickers hardness is to be measured at the positions shown in **Fig. M4.1.1-3** of the specimen used by macroscopic test in preceding **(3)**. However, hardness values are for reference only.

Fig. M4.1.1-1 Test Assembly

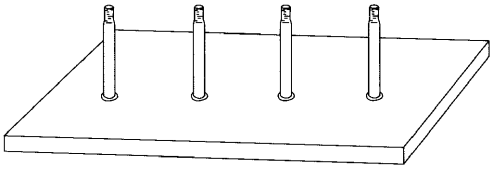


Fig. M4.1.1-2 Test Procedure

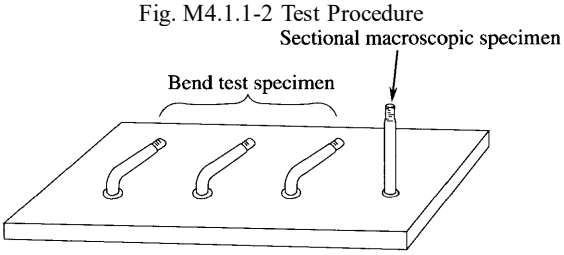
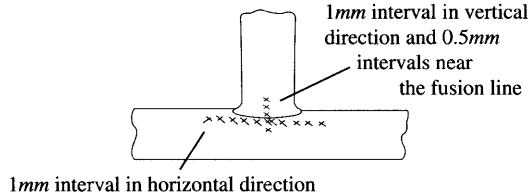


Fig. M4.1.1-3 Guidance of Hardness Tests



M4.1.3 Execution of Tests

The wording "deemed appropriate by the Society" specified in **4.1.3-2, Part M of the Rules** means the following **(1)** to **(3)**.

(1) Where the technical documents concerning the welding procedure which deemed appropriate by the Surveyor.

(2) Where the alteration of procedure are considered by the Surveyor to be not impairing the property of the joint.

(3) Where the welding conditions of semi-automatic fillet welding, which has already been approved by the Society, are applied to

automatic fillet welding (including robotic welding). In this case, the automatic operation is to be confirmed as appropriate by the Surveyor.

M4.1.4 Range of Approval

1 Application of provisory requirement specified in **4.1.4-1, Part M** of the Rules is to be applied to **4.1.4-1(4)(c), Part M of the Rules** and to be in accordance with **Table M4.1.4-1**. In this case, test records which the Surveyor deems appropriate are to be submitted to the Surveyor.

Table M4.1.4-1 Range of Approval for Rolled Steel for the Large Heat Input Welding

Grade of test assembly(1)	Approval range of grade
KA	*KA*
KB	*KA*, *KB*
KD	*KA*, *KB*, *KD*
*KA*32	*KA*, *KA*32
*KD*32	*KA*, *KB*, *KD*, *KA*32, *KD*32
*KA*36	*KA*, *KA*32, *KA*36
*KD*36	*KA*, *KB*, *KD*, *KA*32, *KD*32, *KA*36, *KD*36
*KA*40	*KA*32, *KA*,36, *KA*40
*KD*40	*KA*32, *KD*32, *KA*36, *KD*36, *KA*40, *KD*40

Note:

(1) For thickness above 50 *mm*, this Table is not applicable.

2 With respect to the provisions of **4.1.4-1(1)** and **-2(1), Part M of the Rules**, fillet weld joints, T-joints with full penetration and T-joints with partial penetration welding positions included in the approval of butt welding are to be in accordance with the following.

(1) For plates, **Table M4.1.4-2 of this guidance** and **Table M5.10, Part M of the Rules**

(2) For pipes, **Table M4.1.4-3 of this guidance** and **Table M5.11, Part M of the Rules**

Table M4.1.4-2 Correspondence of Fillet weld joints, T-joints with Full Penetration and T-joints with Partial Penetration Welding Positions to Butt Welding Positions for Plates

Butt welding position (welding position during tests)	Fillet weld joints, T-joints with full penetration and T-joints with partial penetration welding positions deemed to be included in butt welding positions
Flat (*PA*)	Flat (*PA*)
	Horizontal-vertical (*PB*)
Horizontal (*PC*)	Horizontal (*PC*)
	Horizontal-vertical (*PB*)
Vertical upward (*PF*)	Vertical upward (*PF*)
Vertical downward (*PG*)	Vertical downward (*PG*)
Overhead (*PE*)	Horizontal overhead (*PD*)
	Overhead (*PE*)

Table M4.1.4-3 Correspondence of Fillet weld joints and T-joints with Full Penetration Welding Positions to Butt Welding Positions for Pipes

Butt welding position (welding position during tests)	Fillet weld joints and T-joints with full penetration welding positions deemed to be included in butt welding positions
Flat (*PA*)	Flat (*PA*)
	Horizontal vertical (*PB*)
Horizontal (*PC*)	Horizontal vertical (*PB*)
Tube position for welding upwards (*PH*)	Tube position for welding upwards (*PH*)
Tube position for welding downwards (*PJ*)	Tube position for welding downwards (*PJ*)

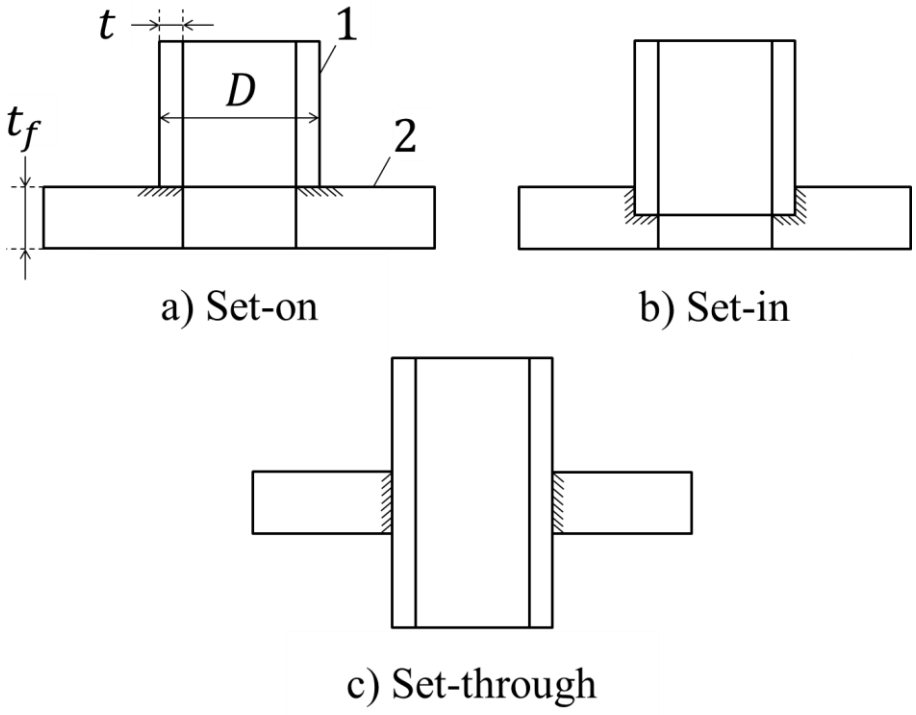
3 The wording "Set-on, Set-in and Set-through" specified in **4.1.4-2(1), Part M of the Rules** means the following **(1)** to **(3)**.

(1) Set-on means a shape in which the end of the pipe is abutted against the surface of the flange (or main pipe)(**Fig. M4.1.4-1 a)**).

(2) Set-in means a shape in which a pipe is inserted into a socket within the flange (or main pipe) (**Fig. M4.1.4-1 b)**).

(3) Set-through means a shape in which a pipe penetrates a hole in the flange (or main pipe) (**Fig. M4.1.4-1 c)**).

Fig. M4.1.4-1 Kinds of pipe assemblies



Notes:

(1) *1* is the pipe (or tube), *2* is the flange (or the main pipe (or tube))

(2) *D* is outside diameter of the pipe (or tube)

(3) *t* is thickness of the pipe (or tube)

(4) t_f is thickness of the flange(or the main pipe (or tube))

4 The wording "deemed appropriate by the Society" specified in **4.1.4-3, Part M of the Rules** means the following **(1)** to **(3)**.

(1) Heat input

Heat input of welding for actual works is to be complied with the requirements specified in the following **(a)** and **(b)**.

(a) The upper limit of heat input approved is 1.25 times the heat input used in welding the test piece, but not over 55 *kJ/cm*. However, for high heat input processes specified in Note (6) of **Table M4.2, Part M of the Rules**, the upper limit is 1.1 time the heat input used in welding the test piece.

(b) The lower limit of heat input approved is 0.75 times the heat input used in welding the test piece.

(2) Preheating and interpass temperature

Preheating and interpass temperature for actual work are to be complied with the requirements specified in the following **(a)** and **(b)**.

(a) The minimum preheating temperature is that used in the qualification test.

(b) The maximum interpass temperature is that used in the qualification test.

(3) Post-weld heat treatment

The heat treatment used in the qualification test is to be maintained during actual work. Holding time may be adjusted as a function of thickness.

Table M4.1.4-4 Type of Welded 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	A, C, D
Fillet welding			E	E

Table M4.1.4-5 Thickness

Thickness of test assembly t (mm)(1)	Range of approval
$t \leqq 3$	0.5 mm to $2t$(2)
$3 < t \leqq 20$	3 mm to $2t$(2)
$t > 20$	0.8t and above

Notes:

(1) In case of joints between dissimilar thickness, thickness t is to be in accordance with the followings.
Butt joints: t is the thickness of the thinner plate
Fillet joints: t is the thickness of the thicker plate

(2) For combination welding procedure, maximum thickness is to be t (See **M4.1.4-4(2)(h)**).

Table M4.1.4-6 Throat Thickness of Fillet Welds

Throat thickness of test assembly ℓ (mm)	Range of approval
$\ell < 10$	0.75ℓ to 1.5ℓ
$10 \leqq \ell$	7.5 mm and above

Table M4.1.4-7 Kind of Aluminium Alloys

Grade of test assembly			Material classification	Range of approval[2), 3)]
Aluminium alloys[1)]	5000 series	5754*P*	A	(A+A)
		5086*P*, 5086*S*, 5083*P*, 5083*S*, 5383*P*, 5383*S*, 5059*P*, 5059*S*, 5456*P*	B	(A+A), (B+B), (A+B)
	6000 series	6005*AS* 6061*P*, 6061*S* 6082*S*	C	(C+C)

Notes:

(1) All temper conditions indicated with grades are to be included (See **Table K8.3(a)**, **Table K8.3(b), Part K of the Rules**).

(2) Combination of the same material's classification includes welded joints of different grade of aluminium alloys within the same material's classification. Combination of the different material's classification includes welded joints of different grade of aluminium alloys within each material's classification.

(3) The qualification of one alloy also qualifies the procedures for other alloys of the same material classification which have an equal or lower specified tensile strength after welding.

Table M4.1.4-8 Range of approval for Rolled Steels for Low Temperature Service

Grade of test assembly	Approval range of grade[1)]
KL24A	*KL24A*
KL24B	*KL24A*, *KL24B*
KL27	*KL24A*, *KL24B*, *KL27*
KL33	*KL24A*, *KL24B*, *KL27*, *KL33*
KL37	*KL37*
KL2N30	*KL2N30*
KL3N32	*KL3N32*
KL5N43	*KL5N43*
KL9N53	*KL9N53*
KL9N60	*KL9N60*

Note:

(1) Only when the same kind of heat treatment is used.

5 For the wording "deemed appropriate by the Society" specified in **4.1.4-5, Part M of the Rules**, the approval of welding procedure and related specifications of rolled stainless steel, aluminium alloys and rolled steels for low temperature service are to comply with the requirements specified in the following **(1)** to **(3)**, provided that the applied welding condition is the same.

(1) Rolled Stainless Steel

For rolled stainless steel, **4.1.4-1** and **-3**, **Part M of the Rules** (excluding the requirements of large heat input welding) is to be applied. However, the kind of base metal is to be the same as test assembly. Where the provisory requirement specified in **3.5.5-1**, **Part K of the Rules** is applied, the steel with the specified minimum proof stress less than that of the tested steels may be included. In addition, the heat input, interpass temperature and post-weld heat treatment for *KSUS*329*J*1, *KSUS*329*J3L*, *KSUS*329*J4L*, *KSUS*323*L*, *KSUS*821*L*1, *K*329*J*1*TP*, *K*329*J3LTP* and *K*329*J4LTP* are to be in accordance with the following **(a)** to **(c)**.

(a) Heat input

Heat input of welding for actual work is to comply with the following requirements:

i) The upper limit of heat input approved is to be 1.25 times the heat input when welding the test assembly, but is not to exceed 35 *kJ/cm*.

ii) The lower limit of heat input approved is to be 0.75 times the heat input when welding the test assembly, but is not to exceed 5 *kJ/cm*.

(b) Interpass temperature

The maximum interpass temperature is to be the one used when welding the test assembly, but is not to exceed 150°C.

(c) Post-weld heat treatment

Post-weld heat treatment is to be avoided.

(2) Aluminium Alloys

The requirements specified in the following **(a)** thorough **(h)** are to be applied.

(a) Type of welded joints

Type of welded joints is to be as specified in **Table M4.1.4-4**. Where the welding procedures of butt welded joints are approved, the fillet welded joints corresponding to the welding position are to be included.

(b) Thickness

Range of thickness is to be as specified in **Table M4.1.4-5**.

(c) Throat thickness of fillet welds

Throat thickness of fillet welds is to be as specified in **Table M4.1.4-6**.

(d) Kind of aluminium alloys

Kind of aluminium alloys is to be as specified in **Table M4.1.4-7**.

(e) Kind of welding consumables

Range of approval for welding consumables is to be as specified in the followings.

(i) Welding consumables having the same grade as used for the procedure qualification tests.

(ii) Welding consumables having the higher specified strength than the welding consumable used for the procedure qualification tests.

(f) Preheat and interpass temperature

Preceding **-4(2)** is to be applied.

(g) Post-weld heat treatment or ageing

The heat treatment or ageing used in the qualification test is to be maintained during actual work. However, prolonged natural ageing may be used as the artificial ageing for 6000 series alloys.

(h) Joints for combination welding procedure

In the joint welded by dissimilar processes (combination welding), the subsequent process may be excluded, provided the weldings are applied within the approved thickness range and no alteration of the welding sequence from approved condition is made.

(3) Rolled Steels for Low Temperature Service

- 4.1.4-1 and **-3**, **Part M of the Rules** are to be applied. However, thickness and the kind of base metal are to be in accordance with the following **(a)** and **(b)**:

(a) Thickness

The range of thickness is to be as specified in **Table M4.2**, **Part M of the Rules**. Moreover, the upper limit of the range of thickness is, in principle, to be a maximum of 40 *mm*. An upper limit of more than 40 *mm*, however, may be used when deemed appropriate by the Society.

(b) Kind of base metal

The kind of base metal is, in principle, to be as specified in **Table M4.1.4-8**.

M4.2 Tests for Butt Welded Joints

M4.2.2 Kinds of Test

As for the welding of aluminium alloys, imperfections detected by visual or non-destructive testing are to be assessed in accordance with *ISO* 10042:2018, Level *B*, except for excess weld metal or convexity, excess throat thickness and excess of penetration for which Level *C* applies.

M4.2.3 Test Assemblies

In cases where it is difficult to collect a specified number of test specimens from a single test assembly due to tube diameter, the test specimens may be collected from the minimum number of required test assemblies.

M4.2.5 Tensile Tests

In tensile test specified in **4.2.5, Part M of the Rules**, procedure of approval for tensile test is to be complied with as follows:

(1) Documents for shape of test specimens and test procedure

(2) Documents for strength of weld connections (including microscopic photograph of welding parts)

(3) Tensile tests for deposited metal and heat affected zone of welding

M4.2.7 Impact Tests

1 With respect to **Notes (1)** of **Table M4.9, Part M of the Rules**, the wording "impact test requirements deemed appropriate by the Society" refers to the following.

(1) Where the thickness of test assemblies is more than 50 *mm* and not exceeding 70 *mm*, values in **Table M4.2.7-1**.

(2) Where the thickness of test assemblies is exceeding 70 *mm*, values deemed appropriate by the Society.

2 The wording "where deemed appropriate by the Society" in **4.2.7-7, Part M of the Rules** means the member to be welded by the welding procedure in question is considered to have a low risk of brittle fracture, such as engine seats, stern frames and crane posts, etc.

Table M4.2.7-1 Impact Test Requirements for Butt Welded Joint

(Rolled Steels for Hull whose thickness of test assemblies is more than 50 *mm* and not exceeding 70 *mm*)

<table>
<tr><th rowspan="3">Grade of steel</th><th rowspan="3">Testing temperature
(℃)</th><th colspan="3">Value of minimum mean absorbed energy (J)</th></tr>
<tr><th colspan="2">For manually or semi-automatically welded joints</th><th rowspan="2">For automatically welded joints</th></tr>
<tr><th>Downhand, Horizontal Overhead</th><th>Vertical upward, Vertical downward</th></tr>
<tr><td>KA(1)</td><td>20</td><td rowspan="10">47</td><td rowspan="6">41</td><td rowspan="6">41</td></tr>
<tr><td>KB(1), KD</td><td>0</td></tr>
<tr><td>KE</td><td>-20</td></tr>
<tr><td>KA32, KA36</td><td>20</td></tr>
<tr><td>KD32, KD36</td><td>0</td></tr>
<tr><td>KE32, KE36</td><td>-20</td></tr>
<tr><td>KF32, KF36</td><td>-40</td><td rowspan="5">46</td><td rowspan="5">46</td></tr>
<tr><td>KA40</td><td>20</td></tr>
<tr><td>KD40</td><td>0</td></tr>
<tr><td>KE40</td><td>-20</td></tr>
<tr><td>KF40</td><td>-40</td></tr>
<tr><td>KE47</td><td>-20</td><td colspan="3">64</td></tr>
</table>

Note:

(1) For a bond and heat affected zone, value of minimum mean absorbed energy is to be 34*J*.

M4.3 Tests for Fillet Weld Joints

M4.3.1 Application

The fillet welding procedure qualification test using non-low hydrogen electrodes for high tensile steels is to be in accordance with the following requirements in addition to **4.3, in Part M of the Rules**.

(1) Welding process

The welding process is to be the one pass horizontal fillet welding either by gravity welding or manual welding.

(2) Test assemblies

(a) The test assemblies are to be *KA*32, *KD*32, *KA*36 or *KD*36 of *TMCP* steels defined in **Note (1)** of **Table M2.4.3-1**.

(b) The carbon equivalent C_{eq} of the test assemblies is to be calculated by the method shown in **Note (3)** of **Table M2.4.3-1**, which is, in principle, to be not larger than 0.36%.

(c) The thickness of test assemblies is to be the maximum thickness of plates used in actual work.

(3) Electrodes

The electrodes are to have been approved by the Society as the non-low hydrogen electrodes for high tensile steels in accordance with **M6.2.1**.

(4) Kinds of test

For welding procedure qualification tests, the restrained fillet crack test shown in **(5)** below is to be added to those specified in **4.3.2, in Part M of the Rules**.

(5) Restrained fillet crack test

(a) The dimensions and shape of the test assemblies are to be as shown in **Fig. M4.3.1-1**.

(b) The welding procedure is to be in accordance with **Table M4.3.1-1**.

(c) The acceptance criteria are to be shown in accordance with **Table M4.3.1-2**.

M4.3.2 Kinds of Test

As for welding of aluminium alloys, imperfections detected by visual or non-destructive testing are to be assessed in accordance with *ISO* 10042:2018, Level *B*, except for excess weld metal or convexity, excess throat thickness and excess of penetration for which Level *C* applies.

M4.3.3 Test Assemblies and Welding

1 For **4.3.3-1, Part M of the Rules**, shop primer of test assemblies is equivalent to coatings of actual work.

Fig M4.3.1-1 Shapes of Test Assembly (Unit: *mm*)

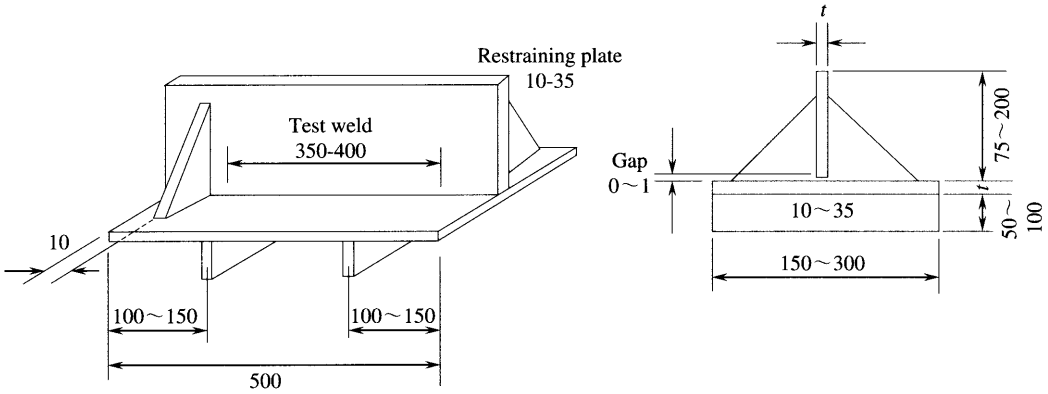


Table M4.3.1-1 Welding Procedure

Testing temperature	Room temperature
Welding sequence	After running one pass on one side, welding on the opposite side is to be carried out after chilling the test assembly to the testing temperature.

Table M4.3.1-2 Acceptance Criteria

Surface cracks	Liquid penetrant tests or magnetic particle tests are to be carried out for the whole length of the bead in 48 *hours* after completion of welding, where by it is to be verified that there are no surface cracks. However, cracks are not to be regarded as surface cracks.
Sectional cracks	For the three sectional faces of welds excluding craters, root cracks and toe cracks are to be inspected with a magnifying glass (magnifying ratio of 5 to 10 *times*), and it to be verified that there are no sectional cracks. However, those with a length of less than 0.5 *mm* may be ignored.
Hardness test	Hardness distribution at positions specified in **Fig. M4.7, Part M of the Rules** in addition to those specified in **6.2.13, Part M of the Rules** is to be measured. However, the measured hardness values are to be for reference only.

M5 WELDERS AND THEIR QUALIFICATION TESTS

M5.1 General

M5.1.2 Qualification Test Applications

The name of the automatic welding procedure to be used in automatic welding qualification tests is to be included on the welders qualification test application form.

M5.1.3 Welder Qualification Certificates

The symbols used on qualification certificates are to be in accordance with the essential variables applied in the welding of test assemblies during qualification tests (Initial). The symbols to represent qualifications consist of a combination of the symbols according to the variables specified in **5.2.1, Part M of the Rules**.

(1) The symbols used for qualifications for plates are to be indicated in the following order: welding process, product, type of welded joint, base metal, base metal thickness, welding position and detail of welded joint.
(Example: *MW-P-B-CS-t*10-*PA-ss nb*)

(2) The symbols used for qualifications for tubes are to be indicated in the following order: welding process, product, type of welded joint, base metal, base metal thickness, outside diameter, welding position and detail of welded joint.
(Example: *TW-T-B-CS-t*3-*D*20-*PC-ss gb*)

(3) The symbols used for qualifications for welders responsible for the setting up and/or adjusting of automatic welding process are to be indicated in the following order: welding process, base metal.
(Example: *SAW-CS*)

(4) The symbols used for qualifications for tack welding only are to be indicated in the following order: welding process, product, type of welded joint, base metal and welding position(s). In such cases, " t " is to be added before symbols indicating welding processes.
(Example: *tMW-P-B-CS-PA*)

M5.1.4 Period of Validity for Qualification Certificates

In cases where two or more qualifications are acquired, the dates of validity specified for all qualifications can be changed to the earliest date of validity at the request of the applicant.

M5.1.5 Verification of the validity of Qualification Certificates

The wording "in cases where deemed appropriately by the Society" in **5.1.5-2, Part M of the Rules** refers to only those cases where verification by a Society surveyor is required because the kind of base metal listed on the certificate is stainless steel, aluminium alloy or nickel steel, and the interval between welding work undertaken by the applicant has exceeded six months.

M5.1.6 Renewal of Qualification Certificates

1 In cases where the renewal method in **5.1.6-1(2), Part M of the Rules** is applied, documents which specify the welding condition (including all essential variables except for base metal thickness) applied as well as the extent of testing are specified is to be submitted.

2 A Surveyor is, in principle, to be present during ultrasonic testing.

3 With respect to the provisions of **5.1.6-1(2), Part M of the Rules**, the welded joints specified in the following **(1)** through **(3)** are to be used in qualification tests. In addition, the dimension of a single part to be evaluated is to be not less than the dimensions specified in **5.3.3, Part M of the Rules**.

(1) Welded joints welded in accordance with the requirements specified in **5.3.3, Part M of the Rules**.

(2) Welded joints of test assemblies which are attached in line with the butts or seams of the finished product, etc. and which are welded at the same time.

(3) Welded joints included in the butts and seams of finished products, etc.

4 With respect to the provisions of **5.1.6-1(3), Part M of the Rules**, it is preferable that the person who evaluates welds on behalf of a shipyard or manufacturer is themselves qualified in accordance with national or international qualification standards.

M5.2 Qualifications

M5.2.1 Kind of Qualification

The wording "in cases where deemed appropriately by the Society" in **5.2.1-2, Part M of the Rules** refers to the following **(1)** and **(2)**:

(1) The qualifications of welders engaged in *TIG* welding for the initial pass is to be *ss nb* or *ss gb* corresponding to the essential variables for product, type of welded joint, base metal, outside diameter (tube only) and welding position.

(2) The qualifications of welders engaged in welding after *TIG* welding for the initial pass may be *ss mb*, *bs mb* or *bs nb* corresponding to the essential variables for product, type of welded joint, base metal, base metal thickness, outside diameter (tube only) and welding position.

M5.2.2 Range of Qualification

1 Welders who possess qualifications related to welding processes using welding consumables may carry out welding work without welding consumables.

2 The wording "in cases where deemed appropriately by the Society" in **5.2.2-6, Part M of the Rules** refers to in the following **(1)** and **(2)**, in addition to **Table M5.2.2-1**:

(1) Welders who are qualified for welding positions of *PA*, *PE* and *PF*/*PG* for the butt welding of plates may perform the butt welding of tubes whose fixed outside diameters exceed 300 *mm* as *PH*/*PJ* in case where the essential variables relating to welding process, type of welded joint, base metal, and detail of welded joint are the same or are included in the acquired qualifications for the overlapping range of qualification for base metal thickness involved in each qualification.

(2) Welders who are qualified for welding positions of *PB*, *PD* and *PF*/*PG* for the fillet welding of plates may perform out the fillet welding for tubes fixed as *PH*/*PJ* in cases where the essential variables relating to welding process, type of welded joint, base metal, and detail of welded joint are the same or are included in the acquired qualifications, for the overlapping range of qualification for base metal thickness involved in each qualification.

Table M5.2.2-1 Applicable Welding Positions

Welding position used for test assembly			Position applicable to actual welding work	
			Tube	
			Butt welding	Fillet welding
Plate	Butt welding	*PA*	*PA*	*PA*, *PB*
		PC	*PA*, *PC*	*PA*, *PB*
		PE	*PA*, *PC*	*PA*, *PB*, *PD*
		PF	*PA*	*PA*, *PB*
		PG	-	-
	Fillet welding	*PA*	-	*PA*
		PB	-	*PA*, *PB*
		PC	-	*PA*, *PB*
		PD	-	*PA*, *PB*, *PD*
		PE	-	*PA*, *PB*, *PD*
		PF	-	*PA*, *PB*
		PG	-	-
			Plate	
			Butt welding	Fillet welding
Tube[1]	Butt welding	*PA*	*PA*	*PA*, *PB*
		PC	*PA*, *PC*	*PA*, *PB*, *PC*
		PH	*PA*, *PE*, *PF*	*PA*, *PB*, *PC*, *PD*, *PE*, *PF*
		PJ	*PA*, *PE*, *PG*	*PA*, *PB*, *PD*, *PE*, *PG*
	Fillet welding	*PA*	-	*PA*
		PB	-	*PA*, *PB*
		PD	-	*PA*, *PB*, *PC*, *PD*, *PE*
		PH	-	*PA*, *PB*, *PC*, *PD*, *PE*, *PF*
		PJ	-	*PA*, *PB*, *PD*, *PE*, *PG*

Note:

(1) This table may be applied when the outside diameter of a tube test assembly exceeds 25 *mm*

M5.3 Qualification tests

M5.3.1 Kinds and Procedures of Qualification Tests

The wording "in cases where deemed appropriately by the Society" in **5.3.1-3, Part M of the Rules** refers to the following **(1)** through **(3)**:

(1) With respect to the qualification tests for automatic welding procedures, the welded joints specified in the following **(a)** through **(c)** are to be used in qualification tests. In addition, the extent of the test carried out is to be not less than the dimensions specified in **5.3.3, Part M of the Rules**:

(a) Welded joints welded in accordance with the requirements specified in **5.3.3, Part M of the Rules**.

(b) Welded joints of test assemblies which are attached in line with the butts or seams of the finished product, etc., and are welded at the same time.

(c) Welded joints included in the butts and seams of finished products, etc.

(2) In cases where the welded joints specified in **(1)(c)** above are used, applicant is to designate the extent of the evaluation before welding.

(3) The setting up and/or adjusting of welding machines used in qualification tests and welding test assemblies is to be carried out in the presence of a surveyor.

M5.3.2 Testing Materials and Welding Consumables

The wording "equivalent quality approved by the Society" specified in **5.3.2, Part M of the Rules** refers to the following requirements or equivalent standards approved by the Society:

(1) Carbon steels

(a) For plate test assemblies

JIS G 3101 Rolled steel for general structure (*SS*400)

JIS G 3103 Carbon steel and molybdenum alloy steel plates for boilers and pressure vessels (*SB*410, *SB*450)

JIS G 3106 Rolled steel for welded structure (*SM*400*A* to *SM*400*C*)

(b) For tube test assemblies

JIS G 3456 Carbon steel pipes for high temperature service (*STPT*410)

JIS G 3461 Carbon steel boiler and heat exchanger tubes (*STB*410)

JIS G 3454 Carbon steel tubes for pressure service (*STPG*410)

Tube manufactured of rolled steel specified in **(a)** above

(c) For welding consumables

JIS Z 3211 (Covered electrodes for mild steel, high tensile strength steel and low temperature service steel)

JIS Z 3312 (Solid wires for MAG and MIG welding of mild steel, high strength steel and low temperature service steel)

(2) Stainless steels

(a) For plate test assemblies

JIS G 4304 Hot-rolled stainless steel plate, sheet and strip

JIS G 4305 Cold-rolled stainless steel plate, sheet and strip

(b) For tube test assemblies

JIS G 3448 Light gauge stainless steel tubes for ordinary piping

JIS G 3459 Stainless steel pipes

Tube manufactured of rolled steel specified in **(a)** above

(c) For welding consumables

JIS Z 3221 Stainless steel covered electrodes

JIS Z 3321 Stainless steel rods, wires and strip electrodes for welding

(3) Aluminium alloys

(a) For plate test assemblies

JIS H 4000 Aluminium and aluminium alloy sheets, strips and plates (*A*5083*P-O*)

(b) For tube test assemblies

JIS H 4080 Aluminium and aluminium alloys extruded tubes and cold-down tubes (*A*5083)

JIS H 4090 Aluminium and aluminium alloy welded pipes and tubes (*A*5083)

Tube manufactured of material specified in **(a)** above

(c) For welding consumables

JIS Z 3232 Aluminium and aluminium alloy welding rods and wires

M6 WELDING CONSUMABLES

M6.1 General

M6.1.3 Approval

1 The wording "brand" in **6.1.3-1, Part M of the Rules** includes the combination consisting of electrode numbers, flux, filler and backing etc. in addition to welding consumables (filler rod, filler wire) in general.

2 The treatment of **6.1.3-8, Part M of the Rules** is to be in accordance with **Table M6.1.3-1 of this guidance** and **Table M5.10, Part M of the Rules**.

Table M6.1.3-1 Correspondence of the Fillet Welding Positions with the Butt Welding Positions

Position of butt welding	Fillet welding position deemed to be included in butt welding position
Flat (*PA*)	Flat in fillet welding (*PA*)
	Horizontal-vertical in fillet welding (*PB*)
Horizontal (*PC*)	Horizontal in fillet welding (*PC*)
	Horizontal-vertical in fillet welding (*PB*)
Vertical upward (*PF*)	Vertical upward in fillet welding (*PF*)
Vertical downward (*PG*)	Vertical downward in fillet welding (*PG*)
Overhead (*PE*)	Horizontal overhead (*PD*)
	Overhead in fillet welding (*PE*)

M6.2 Electrodes for Manual Arc Welding for Mild and High Tensile Steels and Steels for Low Temperature Service

M6.2.1 Application

The approval test and annual inspections of non-low hydrogen electrodes for high tensile steels referred to in **2.4.1(2)(c), Part M of the Rules** are to be in accordance with the following requirements:

(1) Non-low hydrogen electrodes are to be used exclusively for fillet welding specified in **6.2.1(1)** and **(2), Part M of the Rules**.

(2) The quantity of the hydrogen in electrodes is, in principle, to be not greater than 0.25 cm^3/g (by the glycerin replacement method).

(3) The test assemblies used for approval tests and annual inspections are to be in accordance with the requirements in **M4.3.1(2)(a)** and **(b)**.

(4) The approval test is to be carried out by adding the following tests shown in **(5)** and **(6)** below to the tests specified in **6.2.3, Part M of the Rules**.

(5) Hydrogen test

(6) Surface crack test

Liquid penetrant tests or magnetic particle tests are to be carried out for the whole length of the bead in 48 *hours* after completion of welding, whereby it is to be verified that there are no surface cracks. However, crater cracks are not to be regarded as surface cracks.

(7) Annual inspections are to be in accordance with the requirements in **6.2.15, Part M of the Rules**.

M6.2.4 General Provisions for Tests

Hot cracking test specified in **6.2.4-1, Part M of the Rules** is to be done as follows:

(1) Test assemblies and welding method.

(a) Test assemblies are to be as shown in **Fig. M6.2.4-1** and the tack welds in preparation for the fillet welds is to make at the both ends of the plate.

(b) One test assembly is to be prepared for each diameter of electrode specified in **Table M6.2.4-1**.

(c) The fillet welding is to be carried out in the downhand position in one pass on each side and the welding current used is to

be the maximum of the range recommended by the manufacturer for the size of electrode used.

(d) The second fillet weld is to be started immediately after the completion of the first fillet weld from the end of the test specimen at which the first fillet weld was finished. Both fillet welds are to be executed at a constant speed and without weaving.

(e) Length of fused electrode in hot cracking test is to be as shown **Table M6.2.4-1** according to the diameter of electrodes.

(2) Surface inspections

After welding, the slag is to be removed from the fillet welds and after complete cooling, they are to be examined for cracks by a magnifying glass or by using penetrant fluids.

(3) Fracture test

(a) The first fillet weld is then to be cut out by machining or gouging and the second weld broken by closing the two plates together, subjecting the root of the weld to tension (*See* **Fig. M6.2.4-2**). The weld is then to be examined for evidence of hot cracking.

(b) There is to be no cracking in the fillet welds (except crater crack) either superficial or internal.

Fig. M6.2.4-1 Hot Cracking Test (Unit: *mm*)

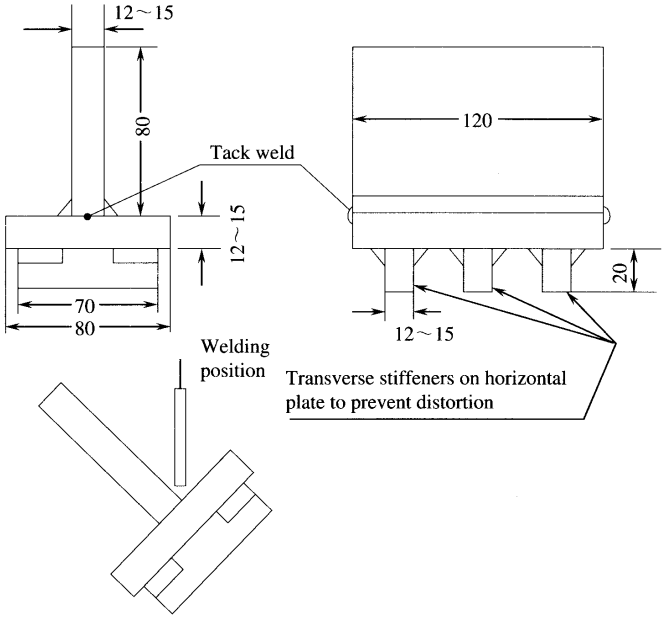


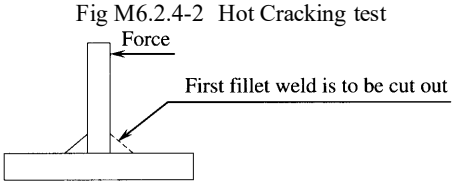
Table M6.2.4-1 Diameter and Fused Length of Electrode in Hot Cracking Test

Diameter of electrode(1)	Length of fused electrode	
	1st fillet	2nd fillet
4 *mm*	Approx. 200 *mm*	Approx. 150 *mm*
5 *mm*	Approx. 150 *mm*	Approx. 100 *mm*
6 *mm*	Approx. 100 *mm*	Approx. 75 *mm*

Note:

(1) If the electrode whose diameter is specified in the table is not producted, the electrode whose diameter is near to it may be used.

Fig M6.2.4-2 Hot Cracking test



M6.2.5 Welding Procedure of Test Assemblies

1 The positions of back welding described in **6.2.5-2(3), Part M of the Rules** are to be in accordance with **Table M6.2.5-1**.

2 The hydrogen test specimen specified in **6.2.5-3, Part M of the Rules** is to be in accordance with **M6.2.11-1**.

3 The radiographic tests specified in **6.2.5-6, Part M of the Rules** are to be carried out to verify the soundness of the test assembly by detecting defects originating from welding process, etc. (*i.e.* defects not directly originating from the welding consumables). However, the number of retests based on the results of radiographic tests is to be limited to twice (three times if the initial test assembly is included).

Table M6.2.5-1 Position of Back Welding

Position of face welding	Corresponding position of back welding
Flat	Overhead(1)
Horizontal	Horizontal
Vertical upward	Vertical upward
Vertical downward	Vertical downward
Overhead	Flat

Note:

(1) Using the electrodes for flat position only, the back welding is to be in flat position.

M6.2.11 Hydrogen Test

1 The glycerin method or the mercury method or the gas chromatography method specified in **6.2.11-1, Part M of the Rules** is to be in accordance with the following.

(1) Glycerin method

As a rule, mild and high tensile steels are to be used for the test assembly. Four test specimens with a dimension of 12 *mm* thick, 25 *mm* wide and 125 *mm* long are to be prepared. Before welding, the test specimens are to be weighted to the nearest 0.1 *g*. On the 25 *mm* surface of each test specimen, a single bead of welding is to be deposited 100 *mm* in length by 4 *mm* electrode, using 150 *mm* electrode. The welding is to be carried out using electrodes dried up by a suitable method recommended by the manufacture, with an arc of shortest possible length and with a current of 150*A*, is to be quenched in water at a temperature of approximately 20℃ for 30 *sec*, after removing the slag within a period of 30 *sec*. Subsequently, the test specimens are to be cleaned and be sealed into a hydrogen collector by means of the glycerin replacement method. The glycerin is to be kept at a temperature of approximately 45℃ during the test. The test time required for all the four test specimens from welding to the enclosure in the hydrogen collector is to be within 30 *min*. After immersing into glycerin for 48 *hours*, the test specimens are to be cleaned with water and alcohol and weighed with an accuracy of 0.1 *g* after being dried to measure the weight of the deposited metal. The volume of hydrogen gas collected is to be measured with an accuracy of 0.05 cm^3 and converted into that under the conditions 20℃ and 1 atmospheric (760 *mmHg*.).

(2) Mercury method

Mercury method is to be in accordance with the requirements in *ISO* 3690:2018.

(3) Gas chromatography method

Gas chromatography method is to be in accordance with the requirement in *ISO* 3690:2018 or *JIS Z* 3118 (Method of Measurement for Hydrogen Evolved from Steel Welds based on *ISO* 3690:2018).

2 Where the mean value of hydrogen by mercury method or gas chromatography method specified in **6.2.11-2**, **Table M6.9 Note**

(1), Part M of the Rules, is less than 0.05 cm^3/g the mark "*H5*" may be added after the grades mark by manufacturer recommends. (Example: *KMW*53*H5*)

M6.7 Welding Consumables for Stainless Steel

M6.7.2 Grades and Marks of Welding Consumables

Application of provisory requirement specified in **6.7.2-4, Part M of the Rules** is to be limited to the case where minimum proof stress of welding consumables of which the specified minimum proof stress is 315 N/mm^2 or less is specified at a greater value. In this case, the specified minimum proof stress is to be accordance with **Table M6.7.2-1** as a standard.

Table M6.7.2-1 Specified Minimum Proof Stress

Grade	Proof stress(N/mm^2)
-235M	235 min.
-275M	275 min.
-315M	315 min.

M6.7.9 Bend Test of Butt Welds

In **6.7.9-3, Part M of the Rules**, "longitudinal bend test deemed appropriate by the Society" means to comply with the requirements of the following **(1)** to **(3)**. After the test, there are to be neither cracks nor any other defects greater than 3 *mm* in length in any direction on the surface of bent specimen.

(1) The test specimens are to be the longitudinal face bend or root bend specimen specified in *JIS Z* 3122 "Methods of Bend Test for Butt Welded Joint".

(2) Inside bend radius is to be twice the thickness.

(3) Degree of bending is to be 180 degrees.

M7 Non-Destructive Testing Service Suppliers

M7.1 General

M7.1.1 Application

With respect to **7.1.1, Part M of the Rules**, for requirements specified in this chapter which are covered by the certificate issued to suppliers by the Japan Welding Engineering Society (JWES) in accordance with *WES* 8701 "Standard for certification of nondestructive inspection corporation for welded structures", the Society may regard such suppliers as satisfying the corresponding requirements in this chapter when confirming compliance with this chapter.

M8 NON-DESTRUCTIVE INSPECTION FOR THE WELDED JOINTS OF HULL CONSTRUCTIONS

M8.1 General

M8.1.1 General

For the wording "deemed appropriate by the Society" specified in **8.1.1-3, Part M of the Rules**, in ships of 30 *m* or over in length, the inspections are to be carried out for the block joints of structural members welded in the dry dock, on the slipway or at any other assembly space as shown in **Table M8.1.1-1**. For ships of less than 30 *m* in length, the range of the inspection, the members to be inspected and the number of photographs are to be determined by the Surveyor based on consultation with the manufacturer.

Table M8.1.1-1 Members Subject to Inspections and Number of Inspections

Members subject to inspections		Number of inspections for each members subject to inspection[*1, *2]		
		Hull within 0.6L amidship		Hull without 0.6L amidship
		Butt joints	Seam joints	Butt joints or Seam joints
Strength deck Side shell plating Bottom shell plating Hatch side coaming (including the top plate) [*3]	Plates	$\frac{6}{10}L$ One-third of the above mentioned number is to be the intersections of weld lines	$\frac{2}{10}L$	$\frac{2}{10}L$
Other member[*4]	Plates	$\frac{3}{40}L$ One-third of the above mentioned number is to be the intersections of weld lines	$\frac{1}{40}L$	$\frac{1}{40}L$
	Girders	$\frac{2}{40}L$		
	Frames	$\frac{3}{40}L$		

Notes:

＊1 Number of inspections is to round up decimal places per joints of each members subject to inspections.

＊2 Distribution of number of inspections may change in consideration of the type of ship, structural arrangement, welding process, arrangement of joints, etc.

＊3 Butt joints of the hatch side coaming exceeding 0.15L in length.

＊4 For automatic welded joints, the number of inspection may reduce up to the half of the number, upon the approval of Surveyor.

M8.4 General Plan of Non-destructive Inspection

M8.4.2 Location of Inspections

1 The locations of inspections are not to adjoin each other.

2 Where ultrasonic tests are accepted instead of radiographic tests according to the requirements of **8.1.2-5, Part M of the Rules**, the location of inspection of ultrasonic testing are to comply with the following requirements;

(1) For strength deck, side shell plating, bottom shell plating and hatch side coaming (including the top plate), although the number

of inspections are to be not more than the half number of inspections specified in **Table M8.1.1-1**, the locations of inspection are to be approved by the Surveyor. However, the intersections of butt welds are to be excluded.

(2) For structural members except for strength deck, side shell plating and bottom shell plating, the locations of inspection may be all the locations specified in **Table M8.1.1-1**. However, the intersections of the weld lines of plate members are to be excluded.

3 In addition to the preceding **-1** and **-2**, for the wording "Welds for which non-destructive inspections are deemed necessary by the Surveyor" in **8.4.2-1(7), Part M of the Rules**, non-destructive testing is to be carried out for parts of welded joints of hatch corner and welded joints of insert plate for working holes, as decided and instructed by the Surveyor.

4 If deemed necessary in consideration of the following items, the Surveyor may require, additional non-destructive inspections for welds other than those subject to non-destructive inspection, or the alteration of the non-destructive inspection procedure.

(1) The results of visual inspection for welds of the members

(2) The welding condition for the members (welding process, thickness, welding heat input)

M8.4.3 Non-destructive Test Application Procedure

1 Regarding the application of the requirements specified in **8.4.3-8, Part M of the Rules**, where welding base metals with different plate thicknesses, the thickness of the thinner plate may be used as the plate thickness of the welded joint.

2 Where the non-destructive testing specified in **8.4.3-8, Part M of the Rules** is carried out, the *TOFD* technique or phased array ultrasonic testing (*PAUT*) may be carried out. In such cases, the shipbuilder or its subcontractor is to obtain the approval of the Society.

M8.5 Non-destructive Testing Procedure

M8.5.3 Liquid Penetrant Testing

For the wording "it is to be deemed appropriate by the Society" in **8.5.3-3, Part M of the Rules**, special low/high temperature penetrants and reference comparator blocks are to be used. The penetration time is not to be less than 10 minutes and to be in accordance with manufacturer specifications. It is preferable that the development time be between 10-30 minutes.

M8.5.4 Magnetic Particle Testing

In magnetic particle testing, when using current flow equipment with prods, care is to be taken to avoid local damage to the material. Copper prod tips are not to be used. Prod tips are to be either lead, steel, aluminium or aluminium-copper braid. To ensure detection of discontinuities of any orientation, welds are to be magnetized in two directions approximately perpendicular to each other with a maximum deviation of 30°. Adequate overlapping is to ensure testing of the whole zone. As far as practicable, the continuous wet particle method is to be used.

M8.5.5 Radiographic Testing

In radiographic testing, marks indicating at least the location of inspections and the symbol that can identify the ship (e.g. ship number), date and time when photographed and something indicating the test condition (i.e. penetrometer and contrast indicator) are to be in the radiograph.

M8.6 Non-destructive Testing Criteria

M8.6.2 Quality Level

The wording "Where it is deemed necessary by the Society" in **8.6.2-1, Part M of the Rules** means the cases in which electro-gas welding is applied to container carrier hatch side coamings that are constructed of extremely thick steel plates which comply with **10.5, Part 2-1, Part C of the Rules**.

M8.6.5 Visual Testing Criteria

The wording "deemed appropriate by the Society" in **8.6.5, Part M of the Rules** means *IACS* Recommendation No.47 "Shipbuilding and Repair Quality Standard" or equivalent standard approved by the Society.

M8.9 Repair of Faulty Welds, etc.

M8.9.2 Repair and Treatment after the Repair

1 If the part is judged unacceptable (hereinafter referred to as "faulty welds"), the following measures are to be undertaken. The

faulty welds are to be repaired properly.

(1) In the plate members given in **Table M8.1.1-1**, additional non-destructive test is to be carried out for other two parts within the weld lines where the faulty welds are found.

(2) In the girder or frame members given in **Table M8.1.1-1**, additional non-destructive test is to be carried out for two welding joints for each member, which the same welding procedure with the faulty welds is applied to the same block joints.

(3) In preceding **(1)** and **(2)**, additional non-destructive test for automatic welding parts is to be extended to all length or all number of the welded joints.

2 Where faulty welds are found by the non-destructive test specified in preceding **-1**, the following measures are to be carried out for the welded joints.

(1) For the requirements specified in preceding **-1(1)**, non-destructive test is to be extended to all length of the welded joints.

(2) For the requirements specified in preceding **-1(2)**, non-destructive test is to be extended to all number of joints of the members.

(3) For the requirements specified in preceding **-1(3)**, the faulty welds are to be repaired.

(4) Notwithstanding the requirements specified in preceding **(1)** to **(3)**, all length or all number of welded joints may be repaired.

3 The faulty welds, which are detected as a result of non-destructive test specified in preceding **-2(1)** and **(2)**, are to be repaired.

4 Notwithstanding preceding **-1** to **-3,** repair process and additional non-destructive test in other welded joints are to be carried out according to the Surveyor's direction taking account of the condition of faulty welds (kind, size and distribution of defects, etc.).

5 For the requirements specified in preceding **-1** through **-4**, the faulty welds are to be repaired properly in accordance with the repair procedures specified in **2.2.2-3**, **Part M of the Rules**. Subsequent measures of the repaired parts are to be in accordance with the Surveyor's direction.

M9 Advanced Non-Destructive Testing

M9.5 *ANDT* Specification Verification

M9.5.3 *ANDT* Specification Verification Tests

"Qualifications block are to be manufactured in accordance with a recognized standard deemed appropriate by the Society" specified in **9.5.3-2, Part M of the Rules**, means the "Intermediate Level" qualification blocks specified in *ASME V Article 14 MANDATORY APPENDIX II UT PERFORMANCE DEMONSTRATION CRITERIA* or qualification blocks deemed equivalent by the Society. Where sizing error distributions and an accurate *POD* are evaluated, the "High Level" qualification blocks specified in *ASME V Article 14 MANDATORY APPENDIX II UT PERFORMANCE DEMONSTRATION CRITERIA* or qualification blocks deemed equivalent by the Society are to be used.