

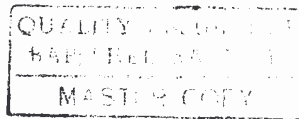
BHARAT HEAVY ELECTRICALS LIMITED
TIRUCHIRAPALLI 620 014

QUALITY ASSURANCE

SIP:NP:07

PAGE : 1 OF 23

WELDING QUALIFICATION FOR STRUCTURAL APPLICATIONS



REV.	DATE	PREPARED	REVIEWED		APPROVED
00	15/07/96	P.S.Narayanan	A.R.Reddy	V.Ravindran	V.Raghavendran

REVISION STATUS

REVISION NO:	CLAUSE NO	DETAIL OF REVISION
---------------------	------------------	---------------------------

1)PR:QE:172/00 renumbered
as SIP:NP:07.

2)Editorial corrections for
better clarity.

1.0 SCOPE**1.1 This procedure details out the requirements of**

- a) Welding procedure qualification for Manual and Submerged arc welding performed at sub contractors works for structural welding.
- b) Qualification tests for welders and welding operators in carbon steel and alloy steel welding.

1.2 REFERENCE DOCUMENTS**1.2.1 AWS D 1.1****1.2.2 ASME Sec 1X****2.0 MATERIALS****2.1 The following materials are used for welding procedure and welder qualification.**

- n) Carbon steel plates/sheets IS 8500, IS 2062
Gr A & B, ASTM A36
SA 515 Gr. 70
- h) Alloy steel Carbon SA588 Gr. A,
SA387 Gr12 & 22,
- c) Pipes/Tubes (carbon steel) SA 106 Gr.B,
SA 210 Gr.A1

2.1.1 The materials with equivalent chemical composition also may be used.**3.0 PROCEDURE QUALIFICATION****3.1 The procedure to be qualified shall be written clearly indicating the parameters in welding procedure specification as per Table I & II.****3.1.1 The fabricator should ensure that the data given in the WPS is exhaustive and takes care of all the relevant essential variables.****3.2 Preparation of test coupons:****3.2.1 Two plates of size 400 x 250 of required thickness shall be prepared by gas cutting or shearing.****3.2.2 The test plates shall be prepared as per rolling direction of plates as given in fig1.****3.2.3 The plates shall be beveled either by gas cutting and grinding or edge planning.**

- 3.2.4 The angle of bevel shall be as per WPS required to be qualified. (Single bevel edge preparation of included angle $60^{\circ} \pm 10^{\circ}$ with root gap of 0 to 3mm and land thickness of 0 to 3mm is suggested).
- 3.2.5 Matching consumables shall be used for welding test coupons as per written welding procedures.
- 3.2.6 Welders engaged in qualifying the procedure shall have adequate experience to produce a satisfactory weld and they shall not be exposed to inclement conditions during preparation of Test Coupons.
- 3.2.7 Test Coupons shall be welded in the presence of Inspecting Engineers.
- 3.2.8 Weld cleaning shall be done in the same position as the weld is being qualified.
- 3.2.9 Test Coupons shall have stamp of the Inspecting Engineers on all the test-pieces prior to cutting specimens from test coupons.
- 3.3 Visual Inspection of Plate shall be carried out as per SIP:NP:06.
- 3.4 All the test welds shall be radiographically tested before preparing mechanical test specimens. Ultrasonic testing may be done in the presence of Inspection Engineer in lieu of radiography.
- 3.5 Radiography shall be evaluated as per BHE:NDE:S:RT5.
- 3.6 Mechanical Tests:
 - 3.6.1 Reduced section tension test is carried to ensure the tensile strength.
 - 3.6.2 Root and face or side bend tests are carried out to confirm the soundness of welds.
 - 3.6.3 Macro etch tests for ensuring soundness and fusion of welds.
- 3.7 Test Specimens:
 - 3.7.1 The type and number of specimens that must be tested to qualify a welding procedure is given in Table III & IV and Fig. 1 & 2, the thickness range is based on the thickness of the test coupon welded.
- 3.8 Qualification - Types and Limitation:
 - 3.8.1 Procedure qualified in groove weld qualifies fillet also as per Table III & IV and figure 3,4,5 and 6.
 - 3.8.2 For range of thickness qualified (for plate and pipe) refer Table III & IV.

- 3.9 Requalification is required in the following cases.
- 3.9.1 Shield metal arc welding.
- 3.9.1.1 A change increasing filler metal strength level (e.g. a change from E 70 xx to E 80 xx and not vice versa).
- 3.9.1.2 A change from low Hydrogen type electrode to non-low hydrogen type of electrode and not vice versa.
- 3.9.1.3 A change of electrode amperage and voltages that is not within ranges recommended by the electrode manufacturer.
- 3.9.1.4 For a specified groove a change of more than + or -25% in the specified number of passes. If the area of the groove is changed the number of passes can be changed proportional to the area.
- 3.9.1.5 A change in position in which welding is done.
- 3.9.1.6 A change in type of groove (a change from V to U, for example).
- 3.9.1.7 An increase of diameter of electrode by more than 1mm over that used in the procedure qualification.
- 3.9.1.8 A change exceeding the tolerances in shape of any one type of groove involving:
- a. a decrease of included angle of the groove.
 - b. a decrease in root opening of the groove.
 - c. a increase in root face of the groove.
 - d. the omission but not inclusions, of backing material.
- 3.9.1.9 A decrease of more than 13°C in min. specified preheat and interpass temperature.
- 3.9.1.10 In vertical welding, a change in progression specified for any pass from upward to downward or vice versa.
- 3.9.1.11 The omission but not inclusion of back gouging.
- 3.9.1.12 The addition or deletion of post weld heat treatment.
- 3.9.2 Submerged arc welding
- 3.9.2.1 A change from one approved flux wire combination except for a change decreasing filler metal strength level.

- 3.9.2.2 A change from one approved flux wire combination for which there is no AWS classification
- 3.9.2.3 A change in diameter of electrodes when using an alloy flux
- 3.9.2.4 A change in the number of electrode used.
- 3.9.2.5 A change in the type of current(AC or DC) or polarity when welding quenched and tempered steel or when using an alloy flux.
- 3.9.2.6 A change of more than 10% above or below specified mean amperage for each dia of electrodes used if the wire feed speed is measured and controlled rather than the amperage,a change of more than 10% in the specified wire feed speed.
- 3.9.2.7 A change of more than 7% above or below the specified the mean arc voltage for each dia electrode used.
- 3.9.2.8 A change of more than 15% above or below the specified mean travel speed.
- 3.9.2.9 A change of more than 10% or 3mm whichever is greater,in the longitudinal spacing of the area.
- 3.9.2.10 A change of more than 10% or 1.6mm whichever is greater in the lateral spacing of the area.
- 3.9.2.11 A change of more than $\pm 10^\circ$ in the angular position of any parallel electrode.
- 3.9.2.12 A change in the angle of electrodes in machine or automatic welding of more than:
 - a) $\pm 3^\circ$ in the direction of travel
 - b) $\pm 5^\circ$ normal to the direction of travel
- 3.9.2.13 For a specified groove, a change of more than $\pm 25\%$ in the specified number of passes. If the area of the groove is changed,it is permissible to change the number of passes in proportion to the area.
- 3.9.2.14 A change in position in which welding is done
- 3.9.2.15 For a change in groove type(a change from V-groove to U-groove for example)
- 3.9.2.16 A change in the shape of any one type of groove involving:
 - a) A decrease in the included angle of the groove
 - b) A decrease in the root opening of the groove
 - c) An increase in the root face of the groove
 - d) The omission, but not inclusion of backing
- 3.9.2.17 A decrease of more than 13°C in the min. specified pre heat or interpass temperature.

- 3.9.2.18 An increase in the dia of electrode used over that called for in the WPS.
- 3.9.2.19 The omission, but not the inclusion, of back gouging.
- 3.9.2.20 The addition of or deletion of postweld heat treatment.
- 3.9.3 Qualification of fillet weld:
 - 3.9.3.1 The type and number of specimens that must be tested to qualify a fillet welding procedure are shown in Table VI.
 - 3.9.3.2 A 'T' test fillet weld as shown in Fig. 7 shall be made for each procedure and position to be used in construction. One test weld shall be the max. size single pass fillet and one test weld shall be the minimum size multiple pass fillet weld use in construction. These two fillet weld tests may be combined in a single test weldment or assembly. The weldment shall be cut perpendicular to the direction of welding at three locations as shown in Fig. 7.
 - 3.9.3.3 Specimens representing one face of each of three cuts shall be macro etched after preparing the specimen with suitable finish for etching.
- 4.0. Personnel qualification: (Carbon steel and alloy steel welding)
 - 4.1 For carbon steel welding carbon steel material shall be used. For alloy steel welding alloy steel materials shall be used.
 - 4.1.1 A welder may also be qualified by welding a satisfactory procedure qualification test plate.
 - 4.2 For pipe or tube welding, welder/welding operator shall be qualified as per the welding procedure.
 - 4.3 Groove weld, plate qualification test:
 - 4.3.1 Qualification test for welders engaged in manual arc welding. Joint details of test plate are, thickness 25mm or above; single v-groove, 60° included angle; 3mm root opening (see fig.8). Minimum length of welding groove shall be 125mm. With this test, welder gets qualified for unlimited thickness.
 - 4.3.2 Qualification test for welding operators engaged in sub-merged arc welding. Joint detail of test plate for operators are thickness 25mm plate, single V-groove, 20° included groove angle, 15mm root opening with backing. Backing must be at least 10mm x 75mm if radiography is used for testing without removal of backing. It must be at least 10mm x 38mm for mechanical testing or if radiography is used for testing after the backing is removed. Minimum length of welding groove shall be 380mm (see fig 9). This test will qualify the welding operator for groove and fillet welding in materials of unlimited thickness.

4.3.3. Position of test weld.

4.3.3.1 Qualification in 1G(flat) position qualifies for 1G(flat) position groove welding.

4.3.3.2 If vertical welding is also anticipated, the welder shall be qualified in 3G (Vertical) position only; qualification in 3G (Vertical) position qualifies for 1G (Flat), 2G (Horizontal) and 3G (Vertical) position groove welding. If welder is qualified for 4G position, this qualifies for 1G (Flat) also but not in 3G (Vertical). Details are given below.

Qualification	Type of weld & Plate positions	position of welding qualified	
		Groove	Fillet
Weld plate groove	1G	F	F, H
	2G	F, H	F, H
	3G	F, H, V	F, H, V
	4G	F, OH	F, H, OH
	3G+4G	All	All

Note: F = Flat, H = Horizontal, V = Vertical, OH = Overhead.

4.3.3.3 When there is a change in direction of welding in 3G position, this needs requalification.

4.3.3.4 For fillet welding, welders need not be qualified separately. Qualification in groove welding will qualify for fillet welding also.

4.3.4 Limitations and variables:

4.3.4.1 Change in base metal within carbon steel or alloy steel material need not necessitate re-qualification.

4.3.4.2 A welder/operator shall be qualified for each of the process used.

4.3.4.3 A welder qualified for shielded metal arc welding with an electrode identified in the following table shall be considered qualified to weld or tack weld with any other electrode listed in a numerically lower group designation. In other words, a welder qualified with basic coated electrode is eligible to weld with any other electrode.

GROUP DESIGNATION	AWS ELECTRODE CLASSIFICATION		
F4	E XX 15,	E XX 16,	E XX 18
F3	E XX 10,	E XX 11,	
F2	E XX 12	E XX 13	E XX 14
F1	E XX 20,	E XX 24,	E XX 27, E XX 28

4.3.4.4 An operator qualified with an approved wire and flux combination shall be considered qualified to weld any other approved wire and flux combination for the process used in qualification test.

4.3.4.5 Weld cleaning shall be done with the test weld in the same position being qualified.

4.3.5 Visual inspection shall be carried out as per SIP:NP:06.

4.3.6 Radiographic examination of a welder's or welding operator's qualification test plate may be done in lieu of the guided bend tests as prescribed below:

4.3.7 Bend tests will be conducted on each test plate. Number and type of specimens and range of thickness qualified are as given below.

Type of weld	Thickness of test plate as welded	Plate thickness qualified	Bend tests No. of specimens		
			All positions		
			Face	Root	Side
Groove	25mm & over	Unlimited	-	-	2

4.3.8 Method of cutting bend test specimens:

4.3.8.1 Side bend specimen shall be cut and prepared from the test plate as shown in fig.10

4.3.9 Method of testing the specimen (Bend test):

- 4.3.9.1 Each side bend specimen shall be bent in a suitable jig using a mandrel of diameter 4 times the thickness of the test specimen. For test specimen of 10mm thick, for example, mandrel diameter shall be 40mm. The specimens shall be bent through 180° ('U' shape).
- 4.3.10 Test results required:
- 4.3.10.1 For bend test, the convex surface of the side bend specimen shall be examined for the appearance of cracks or other open defects. Any specimen in which a crack or other open defect is present after the bending, exceeding 3mm measured in any direction shall be considered as having failed. Cracks occurring in the corners of the specimen during testing shall not be considered.
- 4.3.10.2 For Radiographic test, the acceptance requirements are as per BIII:NDP:S:RT5.
- 4.3.10.3 In case a welder fails to meet the requirements of one or more test welds, a retest may be allowed under the following conditions.
- 4.3.10.3.1 An immediate retest may be made consisting of two test welds, of each type and position which he failed, all the test specimens of which shall meet all the requirements for such welds.
- 4.3.10.3.2A Retest may be made provided there is evidence that the welder has had further training or practice. In this case a complete retest (Single, test welds of each type) shall be made.
- 4.3.11 The welders/welding operators qualification shall be considered as remaining in effect indefinitely unless
- a) The welding operator is not engaged in the given process of welding for which welding operator is qualified for a period exceeding six months or unless
- b) There is some specific reason to question the welding operators ability.
- 4.3.12 The manufacturer shall maintain the records of the qualification test results of the welders and the records shall be available to the Inspection Engineers for verification. A proforma for this purpose is given in Table VII.

Identification # _____
 Revision _____ Date _____ By _____
 Authorized by _____ Date _____
 Type - Manual () Semi-Automatic ()
 Machine () Automatic ()

JOINT DESIGN USED Type _____ Single () Double Weld () Backing Yes () No () Backing Material _____ Root Opening _____ Root Face Dimension _____ Groove Angle _____ Radius (J-U) _____ Back Gouging: Yes () No () Method _____		POSITION Position of Groove _____ Fillet _____ Vertical Progression: Up () Down ()	
BASE METALS Material Spec. _____ Type or Grade _____ Thickness Groove _____ Fillet _____ Diameter (Pipe), _____		ELECTRICAL CHARACTERISTICS Transfer Mode (OMAW) Short-Circuiting () Globular () Spray () Current: AC () DCEP () DCEN (), Pulsed () Other _____	
FILLER METALS AWS Specification _____ AWS Classification _____		TECHNIQUE Stringer or Weave Bead _____ Multi-pass or Single Pass (per side) _____ Number of electrodes _____ Electrode Spacing Longitudinal _____ Lateral _____ Angle _____	
SHIELDING Flux _____ Gas _____ Composition _____ Electrode-Flux (Class) _____ Flow Rate _____ Gas Cup Size _____		Contact Tube to Work Distance _____ Peening _____ Interpass Cleaning: _____	
PREHEAT Preheat Temp., Min. _____ Interpass Temp., Min. _____ Max. _____		POSTWELD HEAT TREATMENT Temp. _____ Time _____	

[illegible]

Procedure Qualification Record (PQR) # _____
Test Results

TENSILE TEST

Specimen no.	Width	Thickness	Area	Ultimate tensile load, lb	Ultimate unit stress, psi	Character of failure and location

GUIDED BEND TEST

Specimen No.	Type of bend	Result	Remarks

VISUAL INSPECTION

Appearance _____
 Undercut _____
 Piping porosity _____
 Convexity _____
 Test date _____
 Witnessed by _____

Radiographic-ultrasonic examination

RT report no: _____ Result _____
 UT report no: _____ Result _____

FILLET WELD TEST RESULTS

Minimum size multiple pass	Maximum size single pass
Macroetch	Macroetch
1. _____ 3. _____	1. _____ 3. _____
2. _____	2. _____

All-weld-metal tension test

Tensile strength, psi _____
 Yield point/strength, psi _____
 Elongation in 2 in., % _____
 Laboratory test no. _____

Welder's name _____ Clock no. _____ Stamp no. _____
 Tests conducted by _____ Laboratory _____

Test number _____
 Per _____

We, the undersigned, certify that the statements in this record are correct and that the test welds were prepared, welded, and tested in accordance with the requirements of section 5, Part B of ANSI/AWS D1.1. (_____) Structural Welding Code-Steel.

Signed _____
 Manufacturer or Contractor

By _____
 Title _____
 Date _____

TABLE -III

Number and type of Test Specimens and range of thickness qualified :

Procedure qualification complete prior penetration groove welds : Dimensions in mm

PLATE THICKNESS mm	NO. OF SAMPLE WELDS PER POSITION	NDT*	TEST SPECIMENS REQUIRED				PL. THICKNES QUALIFIED
			REDUCED SECTION TENSION	ROOT BEND	FACE BEND	SIDE BEND	
Upto 10	1	Yes	2	2	2	-	2T
Above 10 & less than 25	1	Yes	2	-	-	4	Unlimited
25 and above	1	YES	2	-	-	4	Unlimited

NOTE: All welded test plates shall be visually inspected.
 *4 minimum of 150mm of effective length shall be tested by radiographic or Ultrasonic testing prior to mechanical testing.

TABLE -IV Pipes / Tubes

Number and type of Test Specimens and range of thickness qualified :

Procedure qualification complete prior penetration groove welds : Dimensions in mm

Nominal Diameter (D)	Wall Thick ness (T)	NO. OF SAMPLE WELDS PER POSITION	NDT*	TEST SPECIMENS REQUIRED				QUALIFICATION RANGE	
				REDUCED SECTION TENSION	ROOT BEND	FACE BEND	SIDE BEND	DIA	THICK NESS
D < 610	3 < T ≤ 10	1	Yes	2	2	2	-	D & above	3mm t
	10 < T < 19	1	Yes	2	-	-	4	-do-	T/2 to
	T ≥ 19	1	Yes	2	-	-	4	-do-	Above
D ≥ 610	3 < T ≤ 10	1	Yes	2	2	2	-	Above 10	3mm t
	10 < T < 19	1	Yes	2	-	-	4	Above 610	T/2 to
	T ≥ 19	1	Yes	2	-	-	4	Above 610	Above

NOTE: All welded test pipes or tubes shall be visually inspected.
 The full circumference of weld seam shall be tested by radiographic or Ultrasonic testing prior to mechanical testing.

TABLE-V
PROCEDURE QUALIFICATION - TYPE AND POSITION LIMITATION

QUALIFICATION TEST		TYPE OF WELD AND POSITION OF WELDING QUALIFIED			
WELD	PLATE POSITION	PLATE		PIPE	
		GROOVE	FILLET	GROOVE	FILLET
Plate - groove (Complete joint penetration)	1G	Flat	Flat	Flat	Flat
	2G	Horizontal	Horizontal & Flat	Flat & Horizontal	Flat & Horizontal
Plate fillet	1F	---	Flat	Flat	Flat
	2F	---	Flat & Horizontal	Flat & Horizontal	Flat & Horizontal
	3F	---	Horizontal	Horizontal	Horizontal
	4F	---	Vertical Over head		Over head
Pipe-groove	1G Rotated	F	F	F	F
	2G	F,H	F,H	F,H	F,H
Complete joint } penetration }	5G	F,V,OH	F,V,OH	F,V,OH	F,V,OH
	6G	F,H,V,OH (Note 1)	F,H,V,OH	F,H,V,OH (Note 1)	F,H,V,OH (Note 1)
Pipe fillet	1F Rotated--		F	--	F
	2F --		F,H	--	F,H
	2F Rotated--		F,H	--	F,H (Note 2)
	4F --		F,H,OH	--	F,H,OH
	5F --		All	--	All

Note 1 Qualifies for fillet and groove welds in all positions except for complete joint Penetration groove welding of T-, Y-, and K-joints.
 2. Qualifies for horizontal fillet welds on rotated pipes only.

TABLE - VI
NUMBER AND TYPE OF TEST SPECIMENS AND RANGE OF THICKNESS QUALIFIED

Test specimen	Fillet size	No. of welds per procedure	Test specimen reqd. Macro etch.	sizes qualified	
				Plate thick	Fillet size
'T' Test Fig.2	Single pass max. 1 in each size to be used in construction	1 in each position to be used	3 Faces	Unlimited	Max. tested single pass & smaller
	Multi pass - min. 1 in each size to be used in construction	1 in each position to be used	3 Faces	Unlimited	Min. tested multiple pass & larger.

TABLE- VII**WELDER AND WELDING OPERATOR QUALIFICATION TEST RECORD**

Welder or welding operator's name _____ Identification No. _____
 Welding process _____ Manual _____ Semi-automatic _____ Machine _____
 Position _____
 Flat, horizontal, overhead or vertical. If vertical state whether upward or downward) _____
 In accordance with Procedure specification No. _____
 Material specification _____
 Diameter and wall thickness (if pipe) otherwise joint thickness _____
 Thickness range: This qualifies _____
FILLER METAL
 Specification No. _____ Classification _____ F.No. _____
 Describe filler metal (if not covered by AWS Specification) _____
 Is backing strip used? _____
 Filler metal diameter and trade name _____ Flux for submerged arc or gas
 for gas metal arc or flux cored arc welding _____

GUIDE BEND TEST RESULTS

Type	Result	Type	Result

Test conducted by _____ Laboratory Test No. _____ Per. _____

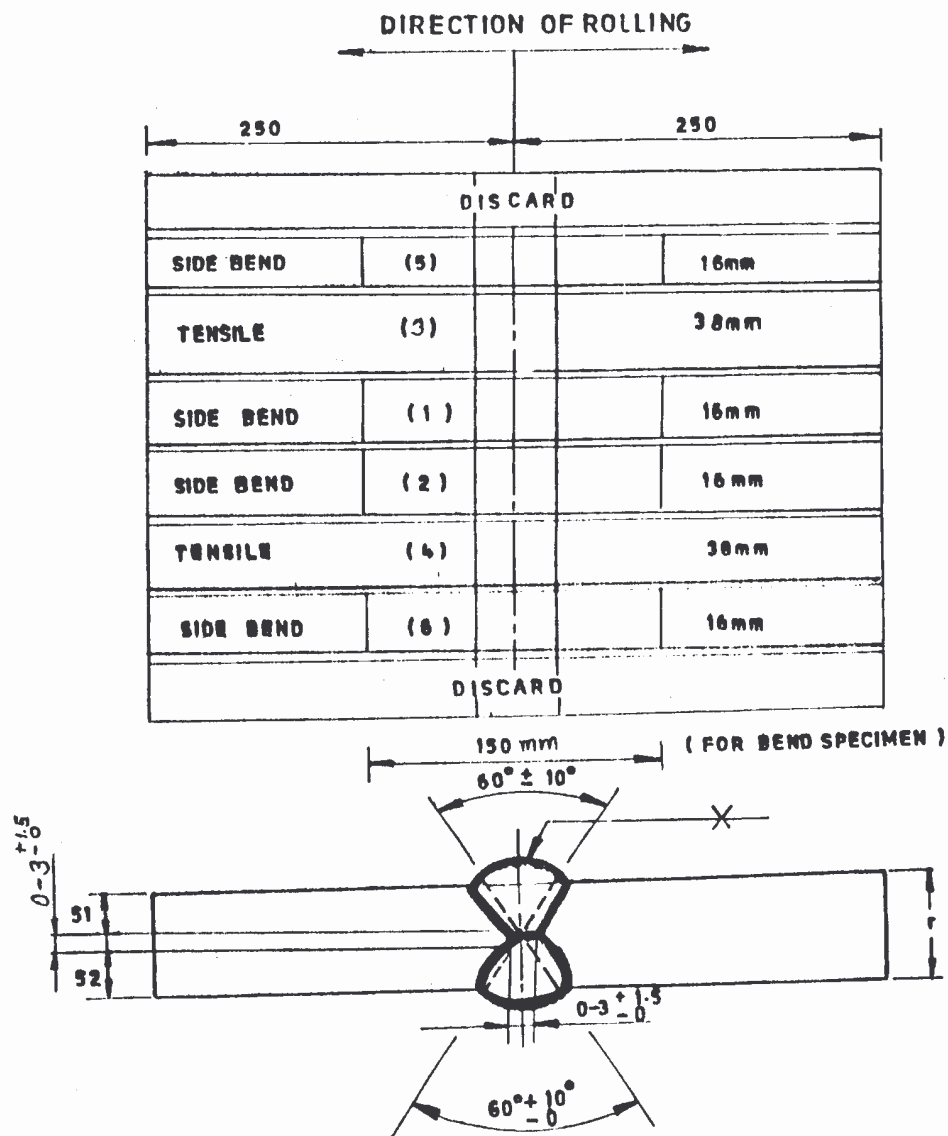
RADIOGRAPHIC TEST RESULTS

Film Identification	Results	Remarks	Film Identification	Results	Remarks

Test witnessed by _____ Test No. _____

We the undersigned, certify that the statements in this record are correct and that
 the welds were prepared and tested in accordance with the requirements of 5C or D of AWS D1.1
 Structural Welding Code.

Manufacturer or Contractor _____



DOUBLE GROOVE WELDS MAY HAVE GROOVES OF THE EQUAL DEPTH, BUT THE DEPTH OF THE SHALLOWER GROOVES SHALL BE NOT LESS THAN ONE FOURTH OF THE THICKNESS OF THE THINNER PART JOINED.

EDGE PREPARATION DETAILS FOR TEST PLATE

FIG-1

LOCATION OF TEST SPECIMENS ON WELDED TEST PIPE

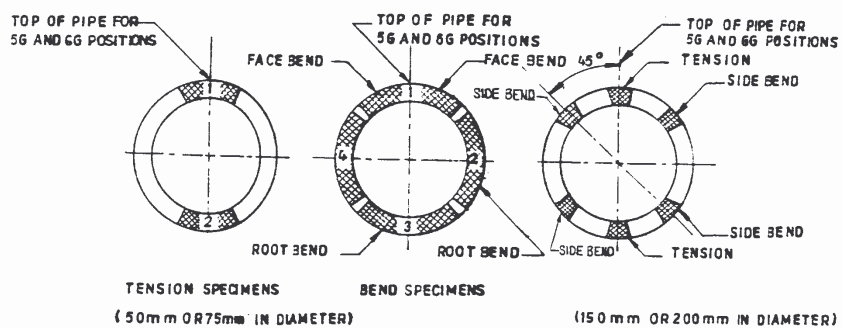


FIG-2

TEST POSITION OF TEST PLATES FOR GROOVE WELDS

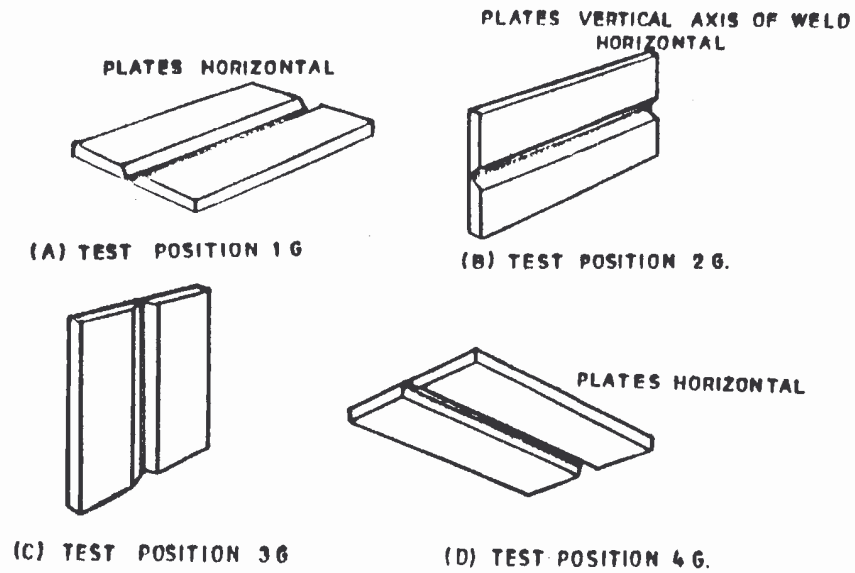


FIG.3

TEST POSITIONS OF PLATES FOR FILLET WELDS

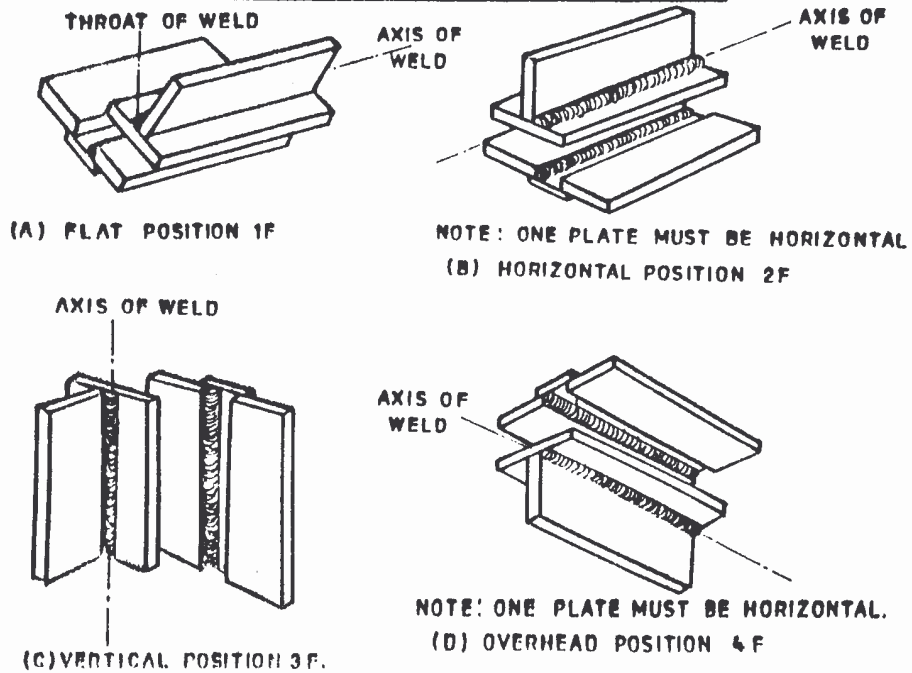


FIG - 4

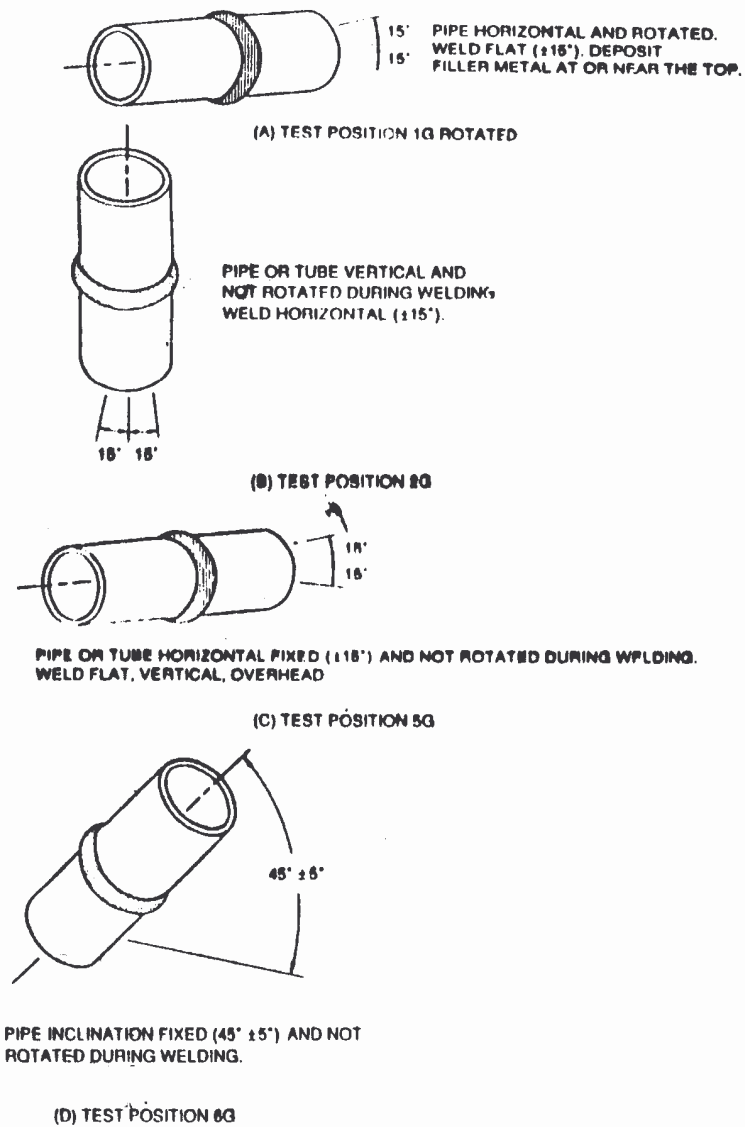


Figure 5. — Positions of Test Pipe or Tubing for Groove Welds

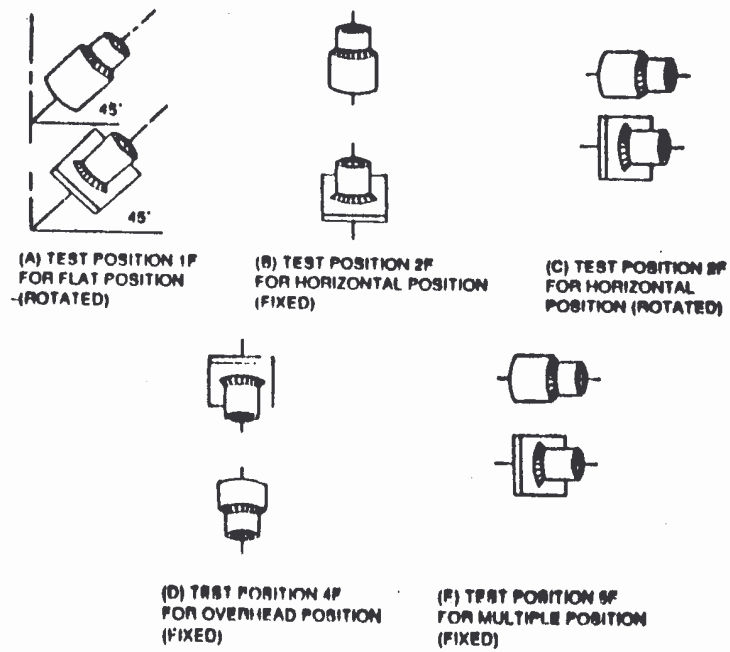
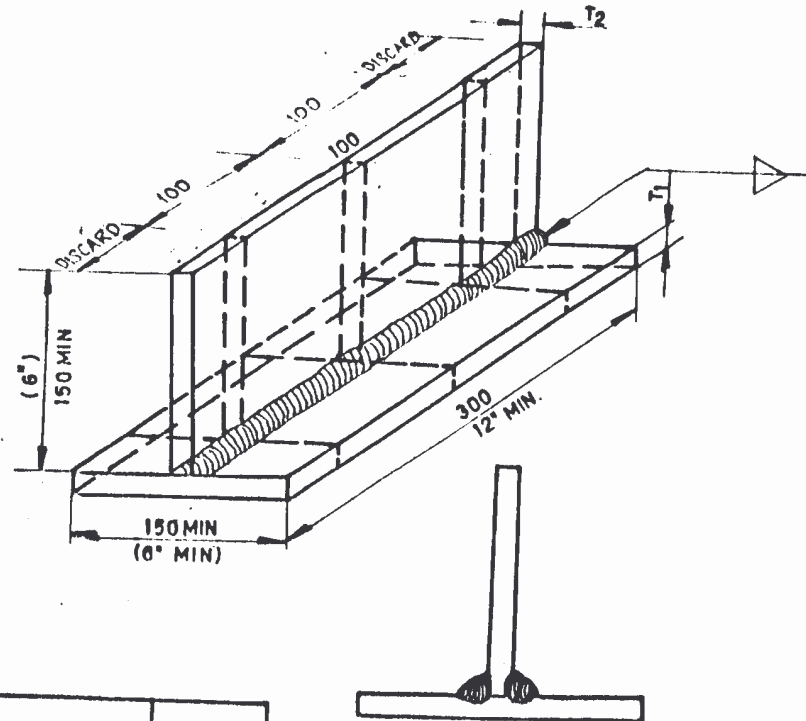


Figure .6 — Positions of Test Pipes for Fillet Welds



MACRO ETCH TEST SPECIMEN.

WRLD SIZE, MM	T ₁ MIN. MM	T ₂ MIN. MM
5	13	5
6	19	6
8	25	8
10	25	10
12	25	12
16	25	16
19	25	19
19	25	25

FILLET WELD SOUNDNESS TEST FOR PROCEDURE
QUALIFICATION.

FIG-7

**TEST PLATE FOR UNLIMITED THICKNESS
WELDER QUALIFICATION.**

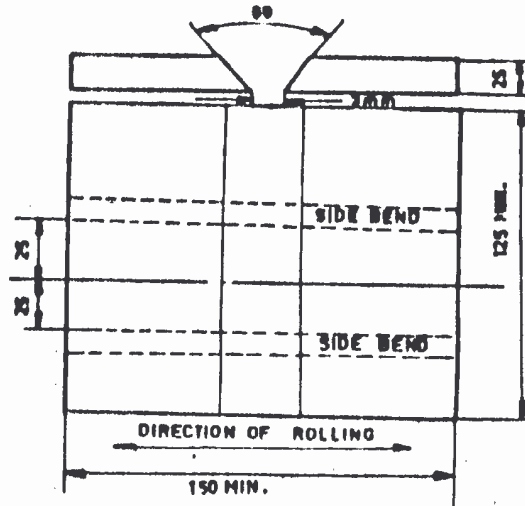


FIGURE-8

**TEST PLATE FOR UNLIMITED THICKNESS WELDING
OPERATOR QUALIFICATIONS.**

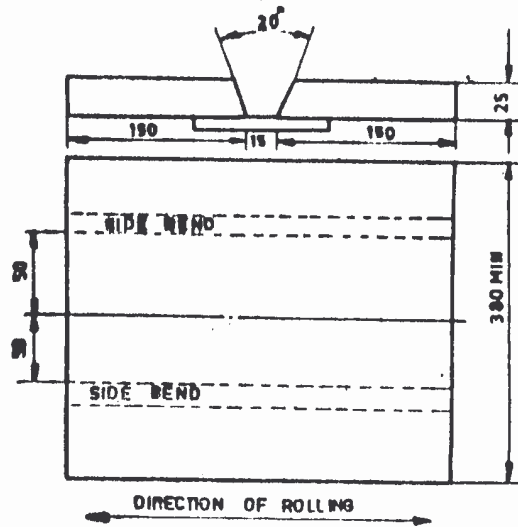
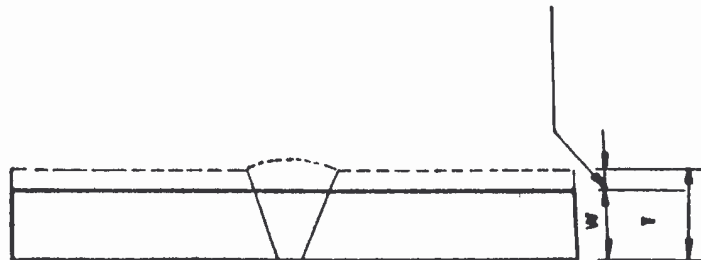


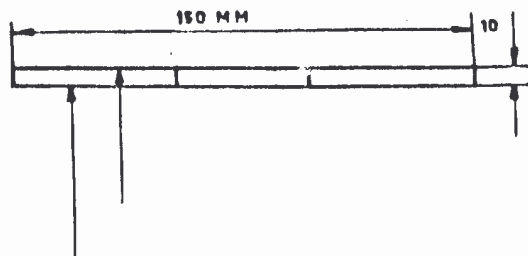
FIGURE-9

SIDE BEND SPECIMENS

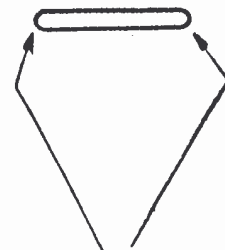
MATERIAL TO BE REMOVED
WHEN PLATE THICKNESS
EXCEEDS 38MM.



FOR PLATES UP TO 38MM WIDTH 'W' EQUALS
PLATE THICKNESS 'T' FOR PLATES OVER 38MM
THICK CUT SPECIMENS INTO MINIMUM NUMBER
OF APPROXIMATELY EQUAL STRIPS NOT
EXCEEDING 38 MM WIDTH.



IF OXYGEN CUT NOT LESS THAN
3MM SHALL BE MACHINED FROM
EDGES.



RADIUS ALL CORNERS
10MM MAX.

FIGURE-10

