**BHARAT HEAVY ELECTRICALS LIMITED**
**TIRUCHIRAPPALLI 620 014 INDIA**

# QUALITY CONTROL PROCEDURE FOR MANUFACTURE OF NON PRESSURE PARTS

**QCP:002 / 02** 

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| Prepared by<br>Quality Assurance | G S N Murthy | |

| Reviewed by | Signature | |
|---|---|---|
| Engineering | Structures | Fuel Firing |
| O P & C | | |
| Manufacturing | Shops | Ancillary Development |
| Quality Assurance | | |
| Quality Control | RM Area | O L I |

| Revision No. | Date | Approved by | Signature |
|---|---|---|---|
| 00 | 01/04/93 | SM / QA | -sd- |
| 01 | 01/01/95 | SM / QA | -sd- |
| **02** | **24/04/04** | **SDGM /QA** | |

## RECORD OF REVISIONS

| Rev No... | Clause No | Details of revision |
|---|---|---|
| 00 | -- | This document consolidates all the general requirements and technical disciplines covered in the various previous |
| | | |
| 01 | -- | All amendments issued has been regularized and editorial correction made for better clarity. Scope of machining added in this document. |
| | | |
| **02** | | **Shaded clauses are Revised /added** |
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## 1.0 SCOPE

1.1 This procedure details out the process control and quality requirements for manufacture of Non Pressure Parts.

## 2.0 REFERENCE DOCUMENTS

2.1 AWS D.1.1, D1.6, IS 7215 and CE: M&P 5.11.1.1, 5.11.2.1 & 5.11.2.2 as guidelines.

## 3.0 MATERIALS

3.1 CLASSIFICATION OF MATERIALS (commonly used):

| P No. Group | Specifications |
|---|---|
| P1 - Group 1 - 515 Gr 60. | Carbon steel IS 2062 Gr A & B, IS 1239, IS 1161, A 36, SA |
| P1 - Group 2 - IS 8500. | H.Strength CS :SA105, SA 515 Gr 70, SA 299, SA 516 Gr 70, |
| P4 - Alloy Steel | SA 387 Gr 11 & Gr 12, SA 182 Gr F 11 & F 12. |
| P5 – Gr A, | SA 387 Gr 22, SA 182 Gr F 22 |
| P6 - | SA 240-410,429 |
| P8 - Stainless steel | SA 240 - 304 ,309,310, 316, 321, 347 |

Any other materials as specified in the drawings.

3.2 Raw materials used shall conform to the relevant specification as given in drawings and applicable TDC/PO. Any substitution of materi-als shall be done only with prior approval of engineering through applicable documents. Where subcontractors procure the raw materials, the same shall have valid test certificates.

3.3 Raw materials shall be free from visual defects like cracks, seams, laps, laminations,heavy pitting etc. When defects are noticed in visual inspection the same shall be confirmed using appropriate NDE techniques and repaired using applicable approved process .

3.4 All materials are procured with permitted dimensional tolerances of the material speci-fications and / or TDC. Wherever required, the raw materials shall be corrected prior to fabrication to achieve the required product tolerances.

3.5 Customer supplied materials are to be verified as per SP 0626.

3.6 The requirements of material traceability shall be as indicated in the respective drawings.

3.6.1 Product Attest “P” items indicated as in drawings are traceable to the test certificates and identified with material Specification, grade and melt number by stamping.

3.6.2 CERTIFIED items indicated as "C" in drawings are traceable to material Specification / grade only and identified by stamping / engraving / stenciling / painting.

3.6.3 Raw materials not covered by the above shall be identified by its W.O.No / material code / Specification / grade by painting / stenciling / engraving.

3.6.4 All subdeliveries shall be identified by its material code by painting or through name plates / tags.

3.7 When materials ( including stock) are to be upgraded for special contract requirements QC shall ensure that the respective specification / contract TDC ( as applicable) are complied..

## 4.0 FABRICATION

### 4.1 MARKING, CUTTING AND PREPARATION

4.1.1 Raw material shall be marked and cut to size by shearing, machining, saw cutting , flame or plasma (for SS materials) cutting. Flame cut edges shall be cleaned to remove slag. Uneven edges shall be dressed by grinding. Gas cutting notches shall be filled up by welding using compatible electrodes and ground before taking up for further fabrication.

4.1.2 Wherever raw materials supplied / available are not sufficient for the sizes required, the same can be built up using the splicing instructions given in the respective SQPs/ Drawings (Incl. Production Notes) / DCN.

4.1.3 Layout for size and shape shall be marked before cutting (for other than CNC applications) The tolerance for marking shall be maintained within + 2mm unless otherwise specified. The diagonal difference shall be within 3 mm.

4.1.4 The markings shall be punched at convenient intervals and bordered with white paint.

4.1.5 Stainless Steel (SS) materials shall be cut using plasma cutting or shearing only. Any further dressing/ grinding of cut surfaces should be done with separate and clean abrasive wheels.

4.1.5.1 The cut edges should be smoothly ground.

4.1.5.2 Notches above 3 mm or 20 % 'T' shall be thoroughly cleaned and welded by using a qualified WPS and examined visually and by LPI . The repaired surfaces are to be cleaned to bright metal surface.

4.1.6 Clip / Cleat angles above 10mm thick used for beam connections which are sheared to length shall require heat treatment.

4.1.7 Heat treatment shall be done after shearing for P4 materials t>12.5mm and for P5 materials t>10mm.

4.1.8 The requirements of preheat for gas cutting are as follows:

| | | |
|---|---|---|
| Carbon steel | t <= 50mm : | : Nil |
| Carbon steel | t > 50mm : | : 100 º C.min. |
| Alloy steel (P4) | t < =25mm : | : Nil |
| Alloy steel (P4) | t > 25mm : | : 150 º C |
| Alloy steel (P5) | All | : 150 º C |
| Stainless steel | Not applicable | |

4.1.8.1 Stress relieving for gas cut edges shall be as follows.

| Material | Thickness | Heat treatment cycle |
|---|---|---|
| P1 | > 50 mm | 600 º - 650 º C for 30 minutes . Furnace cool (Alternatively, the cut surface can be ground / machined upto 3 mm to remove HAZ) |
| P4 | > 16 mm | 650 º – 700 º C for 30 minutes . Furnace cool |
| P5 | All | 680 º - 730 º C for 30 minutes . Furnace cool |
| SS (plasma) | Any | Not required |

4.1.9 The prepared plates shall be visually inspected and repaired if required as per SIP:NP:06.

4.1.10 The raw materials after cutting shall be identified with relevant WO No., DU No., Part No. and Material Spec / Grade (transferred).

**4.2 FORMING**

4.2.1 Forming shall be done using proper tooling free from damages. Method of forming and work centre shall be identified in OPS / relevant QWI refered in PO.

4.2.2 Forming operations of sheets / plates shall be done by rolling / pressing. Circularity of rolled shells shall be checked using templates (of length > ¼ of ID).

4.2.3 Suitable nonmetallic padding shall be provided while forming of stainless steels to avoid contamination.

4.2.4 All formed components shall be checked for orientation, angle, and other dimensions as per drg. All formed parts shall have smooth finish and shall be free from bends, folds and sudden transitions.

4.2.5 Minimum thickness after forming shall be ensured whenever specified in drg.

4.2.6 Tolerances for formed components when not specified in drg. Shall be as follows

a) St.Length / Dia, Width & Height : + 1 mm / M, 5 mm Max
b) Verticality : 1 mm / M, 5 mm Max
c) Squareness : 1 mm / M of length / Dia
d) Straightness : 1 mm / M, 5 mm Max
e) Radius : + 5 mm
f) Bend Angle : + 2º
g) Ovality : 1%
h) E.P Angle : + 5º / - 2.5º
i) Diagonal diff : 3 mm

**4.3 WELDING**

**4.3.1 WELDING CONSUMABLES**

4.3.1.1 Welding consumables conforming to the qualified welding procedures shall be used. However the following guide lines are provided.

4.3.1.2 Only Basic coated electrodes shall be used in the following cases:-

a. All Strength welds like welds in main ceiling girders, flange butt welds in other beams, columns etc.
b. For all structural welds, or when thickness of any one member of the weld joint is > 12 mm (unless otherwise indicated in the drawings / Qualified WPS).
c. For welding of high tensile steels like IS 8500, SA299, SA515 Gr.70, SA516 Gr.70.

4.3.1.3 Rutile electrodes may be used for other weld joints.

4.3.1.4 All low hydrogen electrodes (EXX 16 & EXX 18) shall be dried in the baking oven at 350 deg.C for 2 hours and the electrodes shall be held at 100 deg.C until they are used.

4.3.1.5 All rutile electrodes (EXX 13) shall be dried at 100 deg. C for 1 hour min. and held at 100 deg.C till use.

4.3.1.6 Fluxes for SAW shall be dried at 200 deg.C for 1 hour min. before use. Height of flux bed while drying in pan or oven, shall not be more than 100mm.

4.3.1.7 Unless otherwise specified , SS consumable shall be baked as per Electrode manufacturer's recommendations and stored at 120 º - 150 º C until use.

**4.3.2 FIT UP**

4.3.2.1 Proper fit up shall be ensured before welding as per Drawing. Tack welding or mechanical clampings shall be used to maintain the fit up requirements before and during welding.Bridge pieces used during fit up shall be of ferritic for ferritic materials and stainless for stainless steel materials.

4.3.2.2 Dimensions of the cross sections of groove welded joint shall be within the following tolerances w.r.t . drawing requirements:

| | Root not back gouged | Root back gouged |
|---|---|---|
| 1. Root face of joint(land) | ± 2 mm | Not limited |
| 2. Root opening of joint (with out backing) | ± 2 mm | + 2 mm<br>- 3 mm |
| Root opening of joint* with backing) | + 6 mm<br>- 2 mm | Not Applicable |
| 3. Groove angle of of joint | + 10º<br>- 5º | + 10º<br>- 5º |

*(NOTE): Root opening wider than permitted by above tolerances but not greater than twice the thickness of the thinner part or 19mm,whichever is less may be corrected by edge buildup to acceptable dimensions prior to welding. Such build up edge shall be MPI / LPI checked.

4.3.2.3 For C. S. fillet welds, the parts shall be as close as practicable and gap shall be limited to 5 mm (If gap exceeds 2 mm, the leg of fillet shall be increased by the amount of gap but in no case shall exceed 4.8 mm). For thickness 75 mm and above gap up to 8 mm can be permitted provided suitable backing is used.

4.3.2.4 For S. S. fillet welds, the parts shall be as close as practicable. Gaps 2 mm and above upto 5mm are acceptable if the fillet size is increased by an amount equal to the gap.

4.3.2.4 Parts to be joined by butt welds shall be properly aligned. An offset not exceeding 10% of the thickness of the thinner part joined can be permitted, but in no case more than 3.2 mm, is permitted.

**4.3.3 PRE HEATING**

4.3.3.1 Pre heating requirements for welding shall be as per Clause 4.6.7 and controls shall be exercised as detailed below. No preheating is required for stainless steels.

4.3.3.2 Preheating shall be maintained during the entire process of welding.

4.3.3.3 Preheating is to be done using gas burner or induction / resistance heating. The temperature must be uniform and verified using thermal chalks or thermocouples prior to start of welding as well as during welding for a width of 't' (maximum) or 75 mm whichever is less.

4.3.3.4 Where interpass temperature control is required during welding, the temperature must be ensured using thermal chalks / thermocouples. Inter pass nitrogen / air cooling can be adopted to maintain inter pass temperature in case of stainless steels.

4.3.3.5 Wherever post heating is specified, the preheating shall be continued after welding till attaining the post heat temperature and maintained for the required time and cooled slowly by wrapping suitable insulating blankets like asbestos.

4.3.4 Welding shall be performed using qualified procedures and qualified personnel. Edge preparation and welding details shall be as per drawing.

4.3.5 For items to be manufactured at subcontractor's works , for requirements of qualification of procedure and personnel as per SIP:NP: 07 shall be followed.

4.3.6 When double bevel welding is adopted, back gouging and grinding is to be done. Back gouged groove shall be checked with PT / MT before welding from second side.

4.3.7 Proper sequence of welding shall be adopted to minimise distortion. The distortion of the finished jobs, if any may be corrected by mechanical means / hot correction.

4.3.7.1 For welding of SS extreme care is to be taken in weld sequencing to minimize the weld distortion and shrinkage. For complex weldments a weld sequence instructions may be prepared by contractor prior to work commencement. Weld joints likely to have high shrinkage should be welded ( with minimum restraints) before welding other joints providing allowance for shrinkage.

4.3.7.2 While cutting long web plates suitable camber may berequired to compensate for the distorion during cutting and welding.

4.3.8 All butt welds of divider plate and guide vanes in ducts shall be flush ground inside.

4.3.9 The use of jigs and fixtures is recommended where ever practicable. Suitable allowances shall be provided for weld shrinkage. Proper sequence of welding shall be followed to control the distortion during welding.

4.3.10 All temporary attachments shall be welded with the required preheat. After their removal welded spots shall be ground flush and LPI checked.

4.3.11 Groove welds shall preferably be made with minimum reinforcement unless and otherwise specified in drawing / SQP. In case of butt welds, reinforcement shall not exceed 3.2 mm. and shall have gradual transition to the plane of the base material surface.

4.3.12 The surface of the welds shall be free from coarse ripples, overlaps, undercuts and abrupt ridges to avoid stress raisers.

4.3.13 Where parts of different thicknesses are welded or surface offset is more, the transition shall be made gradual by grinding / machining with 1: 2.5 taper.

4.3.14 Stray arcs shall be avoided to the extent possible. Arc spots if noticed shall be ground and checked by LPI / MPI. Thickness requirements shall be ensured after grinding.

## 4.4 WELD REPAIRS

4.4.1 Removal of defective weld / portions of the base material may be done by machining, grinding, chipping, gas cutting, oxygen gouging or carbon arc gouging. Defective portions of the weld shall be removed without substantial removal of sound base metal.

4.4.2 For under sized welds additional weld metal shall be deposited using an electrode preferably smaller than that used for making original weld limited to 4mm in diameter. The surfaces shall be cleaned thoroughly before deposition.

4.4.3 Defective welds/base metal shall be repaired by removing or/and rewelding as follows:

4.4.3.1 Overlap / excess weld metal shall be removed by grinding.

4.4.3.2 For excess concavity, crater, undersize & undercuts, deposit additional weld metal after cleaning the weld surface.

4.4.3.3 For Cracks in weld or base metal, ascertain the extent of crack by suitable NDE / acid etching, remove the crack to sound metal upto each end of the crack by arresting the ends for further propagation and reweld.

4.4.3.4 For weld porosity, slag inclusions & lack of fusion remove defective portions & reweld

## 4.5 HOT CORRECTION

4.5.1 Members which require hot correction are to be supported at suitable locations and mark the locations for heating.

4.5.2 Heat the locations marked by using neutral flame. Torches used for heating shall be moved continuously & uniformly over selected area to avoid localised over heating.

4.5.3 For Carbon steels the maximum temperature shall not exceed 650 º C and shall be ensured using thermal chalks / thermocouples.

For alloy steels P4 – 705º C , P5 – 735º C temperatures are to be maintained for hot corrections

4.5.3.1 For Austenitice stainless steels the maximum temperature shall not exceed 430 º C and shall be made known to inspection authorities . Otherwise , after hot correction solution annealing at 1050 – 1100 deg C is to be done.

4.5.3.2 For Ferritic/Martensitic/Duplex stainless steels the maximum temperature shall not exceed 315º C and shall be made known to inspection authorities . The temperature shall be ensured using thermal chalks / thermocouples.

4.5.4 Additional dead weights may be placed over the positive side of the bend depending upon the requirement to accelerate hot correction.

4.5.5 Allow for natural cooling. Accelerated cooling shall not be adopted. Remove the dead weights used after cooling.

4.5.6 Wherever the correction for distortion affects the weld joints, applicable NDE shall be repeated after the correction.

## 4.6 POST WELD HEAT TREATMENT (PWHT)

4.6.1 The process controls ( temperature control and recording) for heat treatment shall cover the activities before, during and after heat treatment.

4.6.2 The weldment shall be cleaned to free of grease, oil etc. prior to heat treatment.

4.6.3 PWHT shall be done in a furnace or by local heating a band ( including the entire weld and adjacent area of the base metal) .

4.6.4 The thermocouples and recording instruments shall be calibrated as per applicable standards and records maintained. The furnace shall have been qualified and calibrated.

4.6.5 All materials to be heat treated in furnace shall be loaded in such a way that they shall not be subjected to direct flame impingement. Jobs shall be preferably loaded on raised plat forms so that no material projects into the plane of burners. Alternatively flame deflectors may be provided in front of the burners to avoid direct flame impingement. Ensure loading of test coupons wherever applicable. The furnace temperature shall not exceed 315 º C at the time of loading material / weldment.

4.6.6 Number of thermocouples and their location shall be decided covering maximum and minimum thickness and covering all the zones. The temperature variation within 5 meters shall not exceed 140 º C during heating period ( above 315 º C).

4.6.7 The **temperature requirements** for Pre heating, Post Weld Heat Treatment(PWHT) & temperatures are as below.( Unless otherwise specified.)

| Material | Thickness | Pre heating | PWHT Temp. | Remarks |
|---|---|---|---|---|
| P1 Gr 1&2 | t < 38 | Nil | 600 – 650 º C | a) For all butt welds in plate welded girders when t > 50mm. |
| | T= 39-62 | 100 º C | | |
| | t> 63 | 150 º C | | |
| P4 Gr 1&2 | All | 150 º C | 680 – 700 º C | a)All butt welds in tension member b)All fabricated components when t>16mm(Note1) |
| P5 Gr 1&2 | All | 150 º C (Note2) | 680 – 730 º C | All welds (Note 3) |
| P8 | 300 type<br>400type | 120 º C<br>205 º C | -<br>- | |

Note 1 All fabricated structural components of P4 materials with any member above 16mm thickness, the entire assembly shall be post weld heat treated. However when size of fillet weld is less than 12 mm, PWHT is not required for non load carrying members.

Note 2 All welds on P5 material shall be post heated at 250 º C for 2 hrs or 150 º C for 4 Hrs, immediately following welding.

Note 3 All welds of P5 material shall be post weld heat treated. In case where the size of fillet is less than 12 mm, PWHT is not required for non load carrying members.

4.6.7.1 The **soaking time** shall be as follows:

a. For P1 materials the soaking time shall be 1 hr/inch of thickness(t) (2.5 mts / mm) upto 2" and 2 hrs + 15 minutes for each additional inch for t > 2".
b. For P4 & P5 materials the soaking time shall be 1 hr/inch of thickness (2.5 mts / mm) upto 5" and 5 hrs + 15 minutes for each additional inch for t > 5".

c. For comb ination cycles mentioned above, calculate the minimum soaking time for individual components as 2.5 minutes/mm of the thickness of weld/material whichever is applicable. Soaking time selected for the cycle shall not exceed the limits given below:

| Material | Thickness (mm) | Max. soaking time (minutes) |
|---|---|---|
| P1 (A,B,C), P4, P5A, P1 (A,B) + P4, P4 + P5A | Up to 25 mm | 125 |
| | 26 - 50 mm | 200 |
| | 51 - 80 mm | 250 |
| | 81 - 150mm | 375 |
| P1C + P4, P1 + P3 | Up to 25 mm | 65 |
| | 26 - 50 mm | 125 |

4.6.7.2 Unless otherwise specified, in case of mixed loads of materials not covered under simulation HT, the following heat treatment temperatures shall be followed. In such cases, guidelines for soaking can be taken from Clause 4.6.9.

For components having butt joint between P1 & P4, or P3 & P4, the cycle shall be 630 - 670º C.

Where a component has a butt joint between P4 & P5A, the cycle shall be 680 - 710º . C.

Where a component has a butt joint between P1 & P3, the cycle shall be 620-660 º. C

For P1+P5A material combination, follow the WPS requirements

The following jobs shall not be combined in the same cycle during PWHT.

Separate jobs of P1 and P4 Separate jobs of P4 and P5

4.6.8 The following rules shall apply to establish the thickness to be used in determining the soaking time for PWHT.

4.6.8.1 For Butt welds, the thickness shall be the thickness of the material at the weld. For bar stock, the thickness shall be the diameter.

4.6.8.2 For fillet welds, the thickness shall be the throat thickness. If a fillet weld is used in conjunction with a groove weld, the thickness shall be the greater of the depth of the groove or the throat thickness.

4.6.8.3 For partial penetration branch welds, the thickness shall be the depth of the groove prior to welding.

4.6.8.4 For repairs, thickness shall be the depth of the groove as prepared for repair welding.

4.6.8.5 For combination of different welds in a component, maximum thickness of weld shall govern.

4.6.9 Requirements of Rate of Heating (ROH) above loading temperature 315 º C and Rate of Cooling (ROC) are as given below. During heating and cooling, variation in temperature between thermocouples shall be 85 º C maximum, unless otherwise specified.

| Thickness | ROH / ROC (Max) Above / upto 315 º C |
|---|---|
| Up to 25mm | 220 º C / hour |
| 26 - 50 mm | 95 º C / hour |
| 50 – 75 mm | 70º C / hour |
| Above 75 mm | 55 º C |
| For S.S Matl | 200 º C / hour min (Forced air cooling) |

4.6.10 In case of interruption during Heat treatment the following action has to be taken depending on the stage of occurrence:

| Type of Heat treatment | Stage of interruption | Action |
|---|---|---|
| Annealing & stress relieving | Heating | Heat treat subsequently as specified |
| | Soaking | Heat treat subsequently for balance soaking |
| | Cooling | If the ROC during interruption period meets the specified rate, cool subsequently at required rate upto 400º C. Otherwise, reheat to the soaking temperature, hold for 15 minutes and then cool at the specified rate |
| | | |
| | | |
| Normalising(N) Tempering (T) &, Soln. annealing (S) | Heating | Heat treat subsequently as specified |
| | Soaking | Heat treat subsequently for full soaking(N,S) / Balance soaking (T) |
| | Cooling | Not applicable |

4.6.11 Local heat treatment can be carried out by Resistance heating or Induction heating. For local heat treatment of weld joints, width of the heated band on either side of the weld must be at least 3 times the width of the weld groove of the thickest part or 3 times the highest section thickness, whichever is greater.

4.6.11.1 The width of the insulation band beyond the heating band shall be at least twice the total width of the heating band.

4.6.11.2 A minimum of three thermocouples shall be placed such that at least one is on the weldment and the other two on the base material on either side of the weldment.

4.6.11.3 The winding arrangement shall be established to attain the required temperature. The initial rate of heating shall be minimum such that it stabilises at the required rate of heating before reaching 400 deg C.

4.6.12 After heat treatment, the charts shall be correlated with the job and cleared by QC. The chart shall contain cycle no, Date, W.O and DU details. Temperature, ROH, ROC and soaking time shall be calculated, entered in the chart and signed off by QC.

4.6.13 Wherever applicable the test coupons shall be tested and reports obtained to complete the clearance of heat treatment operation.

## 5.0 NON-DESTRUCTIVE TESTING

5.1 The requirement of NDE, extent and type of examination shall be as per respective product SQP and / or CQP .Wherever product SQP is not existing the following requirements shall apply.

5.2 Visual inspection shall be performed as per SIP:NP:06

5.3 RADIOGRAPHY.

a. All Butt welds of Carbon steel for thickness t >= 32mm
b. All butt welds of alloy steels for thickness t >12.0mm for P5 and T > 16mm for P4.
c. All butt welds in monorails.
d. SS butt welds of T > 16mm unless otherwise specified.

5.3.1 All radiographic films shall possess Firm code , RT agency, Cust. No, Part No, RT reference No. and weld location reference no. The job shall be numbered with Radiograph no.

5.4 MPI / LPI BEFORE PWHT

a. All flame cut edges of Carbon steel for t > 37.5 mm and alloy steels for t > 12mm.
b. All butt welds joining plate members in which one of the plate member is over 25 mm thick for Carbon steel and over 12 mm thick for alloy steel.
c. All fillet welds between tension flange and web.
d. All fillet welds joining plate members in which both the plate members are over 25 mm thick for Carbon steel and over 12 mm thick for alloy steel.
e. For all butt welds of CS & AS weld groove after back chipping prior to welding from second side.
f. All main fillet welds for SS require LPI
g. MPI/LPI for all fillet welds & HAZ of SA387 Gr.22 materials after HT.

5.5 All NDE shall be carried out by qualified personnel as per BHEL NDT procedures. Where subcontractors use their own procedures for NDE the same shall have the approval of BHEL NDTL.

## 6.0 MACHINING

### 6.1 GENERAL

6.1.1 Ensure of raw material identification throughout the machining process. Traceability to the contract shall be ensured by stamping or marking / painting or by tags( WO No.and DU / Part no.)

6.1.2 Where the material identification is likely to be removed during cutting or machining , the transfer of material identification shall be ensured.

6.1.3 In case of components / part processed items received from Subcontracting / other shops, ensure the completeness and clearance by QC / Customer Inspector through Inspection Reports / OPS.

6.1.4 Proper care shall be taken during handling of materials at all stages of manufacture. Items stored in the shop floor shall be properly identified and preserved to prevent mixup and damages / rusting / warpages.

6.1.5 All Machined surfaces shall be properly protected and stored. Wherever long storage is envisaged, they shall be preserved with grease / rust preventive oils and protected suitably with polythene / gunny bag or plastic peel off coatings.

### 6.2 MARKING

6.2.1 The marking on machined components shall be in such a location which will not be detrimental to the surface finish requirements of the component.

6.2.2 Purpose of marking is to:

1. Ensure availability of machining allowance.
2. Identify locations for machining.
3. Provide reference for setting and inspection.

## 6.3 PROCESS CONTROLS

6.3.1 The following shall be ensured for selection of work centers, tools, jigs and fixtures:

a The work centre for machining shall be identified in OPS / loading sheet based on the process capability of the machine or Machine accuracy established to suit the tolerances.

b Test hardwares (Jigs, Fixtures and Templates) used as a means of inspection / process control shall have been qualified through first off trials and shall be regulated through valid number. The same shall be reflected in the OPS / loading sheet .

c Softwares used in case of CNC / NC machines shall have been validated through trials or inspection of similar components produced and accepted.

d All cutting tools shall have been ensured for its correctness before use. In case of regrinding of tools they shall be verified after regrinding.

6.3.2 The following shall be ensured before setting the job on the machine, during processing and after completion of machining:

a Ensure the verticality and flatness of the job after clamping by using the reference markings or dialing the surfaces. Ensure the adequacy of clamping.

b Ensure proper clamping of the correct tool in to the tool holders.

c After machining the machined surfaces shall be cleaned and all corners shall be deburred. After removing from the machine they shall be properly stored.

d Before starting reaming ensure proper material allowance for finish operation.

e During drilling, reaming and tapping the removal of chips shall be done periodically to prevent clogging of chips. For deep drilling ensure that run out and drill travel are verified in free condition and ensure proper clamping of the tools.

## 6.4 INSPECTION

6.4.1 Ensure completeness of all final machining operations. Dimensional inspection shall be done with relevant drawings. Ensure use of calibrated instruments / gauges.

6.4.2 Unless otherwise specified in the drawing or SQP, the following tolerances can be used for untoleranced dimensions.

1.Linear Tolerance (:millimeters) - Medium

| PERMISSIBLE DEVIATIONS FOR BASIC SIZE RANGE | | | | | | |
|---|---|---|---|---|---|---|
| Up to 6 | From 6 TO 30 | from 30-120 | From 120-400 | From 400-1000 | From 1000-2000 | Above 2000 |
| ± 0.1 | ± 0.2 | ± 0.3 | ± 0.5 | ± 0.8 | ± 1.2 | ± 2.0 |

2. Angular Tolerance

a. Assembly characteristics ± 0.5º
b. Other characteristics ± 1º

## 7.0 FINAL INSPECTION

7.1 All dimension shall be inspected as per relevant drawings. Tolerances for fabricated items when not specified in drawings shall be as per clause 4.2.6.

## 8.0 CLEANING AND PAINTING

8.1 All the temporary cleats, bridge pieces shall be removed carefully so as to avoid damage to parent material. Temporary tack welds shall be ground smooth. Complete assembly shall be cleaned to remove mill scales, spatter, slag, rust, oil or grease.Surfaces shall be prepared and painted as per SIP:PP:22 (latest). Site EPs shall be applied with weldeable primer . All site EP shall be protected suitably from mechanical damage.

8.2 All temporary stiffeners / attachments used for transportation and handling that are removed after site assembly shall be painted with yellow paint.

8.3 Match marking and flow direction for applicable components shall be as per the respective product SQP./Drawing

8.4 The following details shall be clearly marked with relavant details by paint, bordered and covered by one coat of transparent varnish

Project Name :
Work order number :
Component / Assly. Designation :
DU Number :
Weight :
Sub-contractor Name / Code :

8.5 Tension flanges in girders are to be identified by hard punching indicating `TENSION FLANGE'.

8.6 For subcontracted items the firm code shall be punched and bordered with white paint.

**BHARAT HEAVY ELECTRICALS LIMITED**
**TIRUCHIRAPPALLI - 620 014**
**QUALITY ASSURANCE DEPARTMENT**

AMENDMENT TO QUALITY WORK INSTRUCTIONS (QWI)

**QWI NO: QP NO. : SIP:PP: 22 REV.: 03**

**AMENDMENT SL NO: A1 DATE: 01/12/2004**

# PROCEDURE FOR SURFACE PREPARATION AND PAINTING

## (Boilers and Valve Components)

| Clause No | Amended as… | Basis for amendment |
|---|---|---|
| Annexure II & Annexure IV | As below | Decision taken at FB Operations Review meeting on Dt: 01/12/04 |

**ANNEXURE - I I : PAINTING SCHEME FOR FOSSIL BOILER PGMAs**

| PG Description | PGMA(s) | Surface preparation | Painting Scheme |
|---|---|---|---|
| Columns | 35 - 1xx | SSPC SP 3 | 1a |
| Ceiling Girders, Cross Beams | 35 - 2xx | | |
| Columns | 36 - 1xx | | |
| Columns | 38 - 1xx | | |
| Columns | 39- 1 xx | | |

**ANNEXURE - IV : PAINTING SCHEME FOR FBC & HRSG PGMAs**

| PG Description | PGMA(s) | Surface preparation | Painting Scheme |
|---|---|---|---|
| Bunker Structure | 34 - xxx | SSPC SP 3 | 1a |
| Columns | 35 - 1xx | | |
| Ceiling Girders, Cross Beams | 35 - 2xx | | |

| NOTE | The above-mentioned changes will be incorporated in the relevant QWI during the next revision of the document. |
|---|---|

| Prepared by: V Jayaraman | Approved by: V Thyagarajan |
|---|---|
| Signature & Dt: V. Jayaraman 1/12/04 | Signature & Dt: V Thyagarajan 1/12/04 |

| Bharat Heavy Electricals Ltd.<br>Tiruchirappalli 620014<br><br>QUALITY ASSURANCE | |
|---|---|

| SIP:PP:22/03 | PAGE : 1 of 14 |
|---|---|

# PROCEDURE FOR SURFACE PREPARATION AND PAINTING

(Boilers and Valve Components)

| REV | DATE | PREPARED | REVIEWED | APPROVED |
|---|---|---|---|---|
| 03 | 10/05/03 | Manager<br>Plant Lab | DGM/ Plant Lab | AGM /<br>QA & Labs |
| | | | Sr. Manager/PE (FB) | |
| | | | DGM/PE (IPP) | |
| | | Manager<br>Quality<br>Assurance | DGM /PE(Valves) | |
| | | | SDGM/QC | |
| | | | SDGM/QA | |

# RECORD OF REVISIONS

| Rev.No. | Date | Details of revision | Remarks |
|---|---|---|---|
| 00 | 15.07.96 | PR:QE:104/05 was revised totally and renamed as SIP:PP:22. Content of PR:QE:185 /00 is also merged with this document. | |
| 01 | 16.07.98 | The document has been revised to incorporate service condition oriented painting selection scheme for components PGMA wise. SIP : VS : 09 and SIP : VS : 18 are merged with this document. | |
| 02 | 02.08.99 | Editorial changes in several clauses based on feedback. Annexure - VI & VIII of Revn 01 removed. Annexure VII added. Clauses renumbered. Sub clauses added in CL. 5.0 based on feed back. Annexure- III painting schemes changed. | |
| 03 | 23.04.03 | Completely modified | |

## 1.0 SCOPE

1.1 This procedure covers the requirements of Surface preparation and application of Primer and Finish paints for components of FB, IPP, Valves and Spares based on environmental and service conditions.

1.2 **Special Contractual requirements, if any, will be indicated in a) the respective Drawings (when customer approval is required) b) through a separate Contract Specific Document ( with customer approval wherever called for) .** The Contract Specific Document will be initiated by the concerned Engineering/ Commercial/Contracts/ Marketing group and further details filled in by Plant Laboratory). The linkage will be provided in the CQR issued by QA.

## 2.0 GENERAL

2.1 This procedure specifies the painting requirements to a) provide adequate surface protection of components under good storage conditions at Site b) temporary protection for components coming inside the boiler in flue gas path till they are erected inside the boiler and c) protection for a reasonable time till completion of erection for components continuously exposed to atmospheric environment.

2.2 However, sites shall assess the need and carry out cosmetic re-preservation as required when components are received at site and subsequently, at a predetermined periodicity based on site storage conditions..

2.3 For bought-out items, the painting scheme shall be as specified in Engineering Drawing / Specification. Wherever it is not specified, it shall be as per the painting scheme of the applicable PGMA in this document.

2.4 In case of any non-clarity / missing PGMAs in painting scheme, the concerned Engineering Group may be contacted for clarification.

## 3.0 PAINTING SCHEME

3.1 The surface preparation, primer coat and finish coat requirements for various painting schemes are given in Annexures I to IV

3.2 The Paints envisaged in this document are coded as Pa XX and the details of the paint specification are given in Annexure - I (b).

## 4.0 SURFACE PREPARATION

4.1 Surfaces of components shall be thoroughly cleaned before the application of primer paint and shall be free from grease, oil, dust, rust, weld slag, spatters etc..

4.2 Abrasive blast cleaning to SSPC-SP6 (Sa 2)grade shall be done to prepare the surface of hot worked pipes prior to application of primer.

## 5.0 APPLICATION OF PAINT

5.1 Primer paint shall be applied within 4 hours in the case of shot blast cleaning and within 8 hours for mechanical cleaning.

5.2 Wherever tubes / pipes are not either shot blasted or heat treated during manufacture, the rust preventive coating provided by the tube / pipe mill shall be treated as base for primer coating for subsequent painting of alkyd base paints like one coat of redoxide zinc chrome (when called for). When special paint is specified in the painting scheme, the existing Rust preventive fluid is to be removed by blast cleaning. However, the rusted areas are to be cleaned free of oil, grease, rust etc. thoroughly using emery paper/ wire brush and making the rust preventive coated surfaces coarse.

5.3 Ready mixed paints shall be used as supplied by the supplier **without any addition of thinner unless otherwise specified.** Two pack systems are to be used as per supplier's instructions.

5.4 Wherever Second coat or Finish coat is to be applied in succession, 12 hours minimum drying time shall be provided between each coat for single pack paints. For two pack system refer paint supplier's catalogue.

5.5 No painting is required in case of Stainless Steel, Aluminum and Galvanized components, unless otherwise specified in contracts.

5.6 For all machined components, rust preventive fluids shall be applied .

5.7 All weld edge preparations for site welding shall be applied with one coat of Weldable primer. For small components having weld ends on both sides, full surface can be painted with weldable primer.

5.8 Part processed items meant for shop assembly shall be painted at sub-contractors works with primer / special paints (when called for in the painting scheme) based on the scope of the indent/Purchase Order. Further paint touchup / Coating shall be given appropriately during assembly.

5.9 All threaded components of spring assemblies and turn buckles shall be galvanized and achromatized to 15 microns minimum thickness

5.10 For items meant for Spares and subcontracting where no further processing is involved, , the painting scheme selected shall be the same as that of similar product configuration / description and not with respect to PGMA. All running meter items for spares one coat of Red Oxide primer is sufficient.

5.11 Assemblies consisting of machined components and special equipments shall not be shot blasted wherever it may affect the system. In such cases power tool cleaning may be adopted for the localized areas only.

5.12 In components (For example: Expansion Joints), wherever plates / sheets of thickness less than or equal to 5mm is used, power tool or Sand /emery paper cleaning can be adopted with painting scheme 3, or alternate scheme as specified in the contract painting scheme.

5.13 Wherever inside surfaces of components need protection till erection (for example inside surfaces of ducts and dampers), two coats of primer (Pa 8) are to be applied.

## 6.0 INTERNAL PROTECTION

6.1 For internal protection of Pipes , tubes, headers and other pressure parts , VCI pellets shall be put ( after sponge testing / draining and /or drying ) and subsequently end capped.

6.2 The dosage of Volatile Corrosion Inhibitor (VCI) pellets shall be approximately 100 grams/ $m^3$ For tubes typically 4 -5 tablets per end are to be put.

6.3 For C & I items the dosage of self indicating Silica gel (color less) shall be 250 grams per Cubic meter. (about 2 to 3 bags weighing approximately 100 grams each) .

6.4 **VCI pellets shall not be used for stainless steel components and its composite assemblies**.

## 7.0 CLEANING OF PAINTED & RUST PREVENTIVE COATED SURFACES

Wherever required, paints and rust preventive protection can be removed either by using the following commercial solvents or by flame cleaning/ blasting.

| | |
|---|---|
| For Rust preventive | Acetone, Carbon Tetra Chloride or Tri-Chloro Ethylene |
| For all paints | Alkaline paint strippers or Solvent based paint strippers |

## COMPARATIVE CHART FOR SURFACE PREPARATION SCHEME

| DESCRIPTION | SSPC Scheme | Swedish Standard SIS - 05 - 5900 |
|---|---|---|
| Solvent cleaning | SSPC-SP1 | - |
| Hand tool cleaning | SSPC-SP2 | St2 |
| Power tool cleaning | SSPC-SP3 | St3 |
| Flame cleaning | SSPC-SP4 | Fl |
| Blast cleaning to white metal | SSPC-SP5 | Sa3 |
| Commercial blast cleaning | SSPC-SP6 | Sa2 |
| Brush off blast cleaning | SSPC-SP7 | Sa1 |
| Pickling | SSPC-SP8 | - |
| Blast Cleaning to near white metal | SSPC-SP10 | Sa2½ |

## ABRASIVE BLAST CLEANING

To get a profile of 25-50 microns, the following sand , grit or shot sizes are to be used for getting optimum results.

| ABRASIVE | Size in mm | Proportion by% Mass |
|---|---|---|
| River Sand (ASTM 16-30 mesh) | 0.6 to 1.2 mm | 95 % minimum |
| Cast steel shots to SAE 230 | + 1.00<br>+ 0.85<br>+ 0.60<br>+ 0.50 | 0 %<br><0.10%<br>85.0%<br>97.0% (Cumulative) |
| Steel Grits to SAE G 40 | + 0.425<br>+ 0.30<br>+ 1.00 | >70.0%<br>>80.0% (Cumulative)<br>0.0 % |

## ANNEXURE - I (a) GUIDELINES FOR PAINTING SCHEME SELECTION

| Painting Scheme No | Anticipated Service Condition | Primer Coat | | | Finish Coat | | | Total DFT µm | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | Paint | No. of coats | DFT per Coat-µm | Paint | No. of coats | DFT per Coat-µm | | |
| 1a | Permanently exposed to atmosphere in service - Normal industrial atmosphere | Pa 1 | 1 | 30 | Pa2 | 2 | 20 | 70 | |
| 1b | Permanently exposed to corrosive atmosphere in service- Coastal / refinery environment | Pa3 | 2 | 50 | Pa4 | 2 | 30 | 160 | |
| 1c | Permanently exposed to atmosphere in service, but painting / difficult-to-remove-coatings not preferred. | Pa5 | 1 | -- | -- | -- | -- | -- | |
| 2 | Temporary Protection till erection - exposed to flue gas in service | Pa7 | 1 | 35 | -- | -- | -- | 35 | Dip / Brush Coat |
| 3 | Temporary Protection till erection - fully insulated (not in the flue gas path) high temperature service | Pa1 | 2 | 30 | -- | -- | -- | 60 | |
| 4 | Temporary Protection till erection - where painting is not recommended, but coating of oil is preferred | Pa9 | 1 | 25 | -- | -- | -- | 25 | |
| 5 | Temporary Protection till erection - where painting is not recommended, but rust preventive coating is preferred | Pa9 | 1 | 25 | -- | -- | -- | 25 | |
| 6 | Protection by galvanizing | Galvanizing to 610 gm / $m^3$ (85 µm approximately) | | | | | | | |
| 7 | Protection by Phosphating | Phosphating to 1500 mg/ $ft^2$ (16.15 gm / $m^2$) is recommended by Seven Tank method | | | | | | | |
| 8 | Non-insulated components, externally visible, facing high temperature service upto 200 ° C | Pa10 | 1 | 15 | Pa10 | 1 | 15 | 30 | |
| 9 | Non-insulated components, externally visible, facing high temperature service from 200 ° C to 400 ° C | Pa11 | 1 | 15 | Pa11 | 1 | 15 | 30 | |
| 10 | Non-insulated components, externally visible, facing high temperature service from 400 ° C to 600 ° C | Pa12 | 1 | 15 | Pa12 | 1 | 15 | 30 | |
| 11 | No need for any surface protection | -- | -- | -- | -- | -- | -- | -- | |
| 12 | Sea Water carrying pipes requiring internal protection | Pa13 | 1 | 200 | -- | -- | -- | 200 | |
| 13 | Paints for off-shore applications | Pa14 | 1 | 100 | Pa15 | 1 | 30 | 130 | |
| 14 | Specific painting based on contract requirements | Contract Painting Scheme shall be adopted in total | | | | | | | |
| 15 | Lesiga Practice | Pa 18 | 1 | 35 | Pa 15 | 1 | 30 | 65 | |
| 16 | Permanently exposed to atmosphere in service – Atmospheric Temperature is sub-zero ( as low as – 30 C | Pa 3 | 2 | 50 | Pa 4 | 2 | 30 | 160 | |
| 17 | Permanently exposed to atmosphere in service- Requiring fire retardant protection | Pa 6 | 1 | 40 | Pa 16 | 1 | 40 | 80 | Sub-delivery items |

## ANNEXURE - I (b) : PAINT SPECIFICATIONS

| Paint Specification code | PAINT DESCRIPTION |
|---|---|
| **Pa 1** | Red oxide Zinc phosphate primer (Alkyd Base) to IS 12744 by brush /spray |
| **Pa 2** | Synthetic Enamel long oil Alkyd to IS 2932 (latest) |
| **Pa 3** | High Build Chlorinated Rubber based Zinc Phosphate Primer<br>% Volume Solids = 40 (min), DFT= 50µm / Coat (min) |
| **Pa 4** | Chlorinated Rubber based Finish Paint<br>% Volume Solids = 30 (min), DFT= 30µm / Coat (min) |
| **Pa 5** | Non drying type rust preventive fluid to IS 1154 (latest) |
| **Pa 6** | Inorganic Ethyl Zinc Silicate Primer to IS 14946<br>% Volume Solids = 60 (min), DFT= 65µm / Coat (min) |
| **Pa 7** | Zinc chrome Primer (Alkyd base) by Dip Coat. (Shade : Yellow)<br>BHEL specification PR:CHEM:09-03 (latest)<br>*Red oxide Zinc phosphate primer (Alkyd Base) to IS 12744 by dip coat to BHEL specification PR:CHEM:09-03 (latest) –* ***after consumption / usage of existing paint stocks confirming to Zinc chrome Primer (Alkyd base - Shade : Yellow)*** |
| ***Pa 8*** | *Deleted and replaced by Pa 1* |
| **Pa 9** | Rust preventive fluid by spray, dip or brush.<br>BHEL specification PR:CHEM:09-04 (latest) |
| **Pa 10** | Heat Resistant Aluminum paint to IS 13183 - Grade 3 (latest) |
| **Pa 11** | Heat Resistant Aluminum paint to IS 13183 - Grade 2 (latest) |
| **Pa 12** | Heat Resistant Aluminum paint to IS 13183 - Grade 1 (latest) |
| **Pa 13** | High Build Polyamine cured Coal Tar Epoxy Primer to IS 14948<br>% Volume Solids = 75 (min), DFT= 200µm / Coat (min) |
| **Pa 14** | High Build Aluminum Epoxy Mastic Primer to IS 13184<br>% Volume Solids = 80 (min), DFT= 100µm / Coat (min) |
| **Pa 15** | Aliphatic Acrylic Polyurethane Paint to IS 13213<br>% Volume Solids = 40 (min), DFT= 30µm / Coat (min) |
| **Pa 16** | Epoxy Polyamide cured Finish Paint to IS 14209<br>% Volume Solids = 40 (min), DFT= 35µm / Coat (min) |
| **Pa17** | General Purpose Aluminum Paint to IS 2339(latest) |
| **Pa 18** | Epoxy Zinc rich Primer to IS 14589 Grade. II<br>% VS=35 (min) DFT= 40 mic. (min) |

## ANNEXURE - I I : PAINTING SCHEME FOR FOSSIL BOILER PGMAs

| PG Description | PGMA(s) | Surface preparation | Painting Scheme | Color/Shade (See Note 3) / Remarks |
|---|---|---|---|---|
| Drum & suspension rods | 04-XXX (Except internals) | SSPC SP 3 | 1a | International Orange Shade 592 |
| Drum internals | 04-XXX | SSPC SP 3 | 5 | |
| Loose components in drum & drum transport structure * | 04-1XX, 04-196 * | SSPC SP 3 | 3 | * Finish coat : Yellow enamel |
| Headers & Loose tubes | 05-XXX | SSPC SP 3 | 3 | |
| WW , SH Panels | 06-XXX, 11-XXX | SSPC SP 3 | 3 | |
| DC, Riser, Suction Manifold | 07-1XX, 07-201,215,218 | SSPC SP 3 | 3 | For raisers having RPF one coat of primer is sufficient. |
| Loose Tubes, Pr. Part Seals | 07-2XX , 07-501,601 | SSPC SP 3 | 2 /3* | *07-216, 217 |
| Hanger & Supports - WW | 07-40X,431 07-410 | SSPC SP 6 SSPC SP 10 | 1a, 15 | 15=CLH |
| Buck stays | 08-XXX | SSPC SP 3 | 1a, | 1a=VLH, |
| Seal Boxes | 09-XXX | SSPC SP 3 | 1a | |
| SH Headers & Loose tubes | 10-XXX | SSPC SP 3 | 3 | |
| SH Coils, Elements | 11-XXX,12 XXX | SSPC SP 3 | 2 | |
| SH Lines & Links (Including DESH) | 12-XXX, 12-903 (Other than hangers and Supports) | SSPC SP 3 | 3 | |
| Hanger & Supports - SH | 12-9XX (Except 12-903) | SSPC SP 6 | 1a, | 1a=VLH, |
| Misc. components | 12-903,17-903, 19-903 | SSPC SP 3 | 3 | |
| RH Headers & Loose tubes | 15-XXX | SSPC SP 3 | 3 | |
| RH Coils , Elements | 16-XXX | SSPC SP 3 | 2 | |
| RH Lines and Links (Including DESH) | 17-XXX , 17-903 (Other than hangers and Supports) | SSPC SP 3 | 3 | |
| Hanger & Supports - RH | 17-9XX (Except 17-903) | SSPC SP 6 | 1a, | 1a=VLH, |
| Hanger & Supports - Eco | 19-9XX (Except 19-903) | SSPC SP 6 SSPC SP 10 | 1a, 15 | 1a=VLH, 15=CLH |
| Hanger & Supports - Others | PGs 21,24, 47, 48, 80 *80-8XX* * | SSPC SP 6 SSPC SP 10 | 1a, 15 | 1a=VLH, 15=CLH * *Piping Center scope* |
| Roof Skin casing | 18-XXX | SSPC SP 3 | 3 | |
| Economizer Coils/Elements /Headers , Loose tubes | 19-XXX , 19-903 (Other than hangers and Supports) | SSPC SP 3 | 2,3 | 2=Coils /Elements 3=Headers ,Loose tunes |
| Economizer Links | 19-850,851 | SSPC SP 3 | 3 | |
| S.B. Piping | 21-600 | SSPC SP 3 | 3 | |
| S.B. Piping supports | 21-601 | SSPC SP 3 | 1a | |
| S.B. Components | 21-700 | SSPC SP 3 | 1a | |
| S.B. Valves | 21-800 | * | * | *Refer to valves scheme |
| S.B. Safety Valves | 21-850 | * | * | *Refer to valves scheme |
| Condenser Pipe & Fittings | 24-370 | SSPC SP 3 | 8 | |
| Cooler & Strainer assembly for circulating pump | 24-374 | SSPC SP 3 | 1a | |
| Trim Pipe Supports | 24-X00, 24-X75, 24-X95, 24-X15, | SSPC SP 3 | 1a | |
| Trim Piping , Fittings & Headers & Loose tubes | 24-X00, 24-X75, 24-X95 | SSPC SP 3 | 3 | |
| Valves/Trim pipes/SV/DWLG | 24-X60,X73,X80 | SSPC SP 3 | 3 | |

| PG Description | PGMA(s) | Surface preparation | Painting Scheme | Color/Shade (See Note 3) / Remarks |
|---|---|---|---|---|
| Silencer * S.V. Escape Pipes | 24-X20, 24-X85 & 24-X90 | SSPC SP 6 | 9 | *Refer to valves scheme |
| Manhole Doors | 28-220 | SSPC SP 3 | 10 | |
| Fixing components (Boiler) | 30-XXX | SSPC SP 3<br>SSPC SP 3 | 3<br>5 | Threaded portions / Fasteners are to be applied with Rust preventive coating |
| Boiler Skin casing | 31-XXX | SSPC SP 3 | 3 | |
| Fixing components (Auxiliaries) | 32-XXX | SSPC SP 3<br>SSPC SP 3 | 3<br>5 | Threaded portions / Fasteners are to be applied with Rust preventive coating. Outer casing sheets of GI/Aluminium should both be painted. |
| Woven Wire cloth | 33-970 (Stain less steel) | -- | 11 | |
| Columns | 35-1xx (Except 35-190) | SSPC SP 6 | 1a | |
| Ceiling Girders, Cross Beams | 35-2xx | SSPC SP 6 | 1a | |
| Foundation materials | 35-010, | -- | 11 | |
| Boiler Supporting Structures (Other than columns ,ceiling girders, Floor grills, stairs, ladders hand rails/posts, and foundation materials) | 35-XXX , 36-XXX, 38-XXX, & 39-XXX | SSPC SP 3 | 1a | |
| Boiler Roof Sheeting (Vendor Item) AC Sheets / GI Sheets | 35-611 | -- | 11 | |
| Burner Roof Sheeting (Vendor item) AC Sheets / GI Sheets | 36-611 | -- | 11 | |
| Floor grills (Including Guard plates), | 35-811,<br>36-811,813,814<br>38-810 & 39-810 | SSPC SP 3 | 1a | Black Shade |
| Stair and Ladders | 35-822 ,823 ,36-820<br>38-820,39-820 | SSPC SP 3 | 1a | Black Shade ( for step threads) |
| Hand rails and posts | 34-850, 35-851<br>36-850,851,852,853<br>38-850, 39-850 | SSPC SP 3 | 1a | Black Shade |
| Columns | 36-1xx | SSPC SP 6 | 1a | No painting required below “0” level. |
| Galleries and stair-ways | 36-XXX (Except 36-8XX & 36-611) | SSPC SP 3 | 1a | |
| Boiler outer casing components | 37-010 | SSPC SP 3<br>SSPC SP 3 | 3<br>5 | Threaded portions / Fasteners are to be applied with Rust preventive coating |
| Columns | 38-1xx | SSPC SP 6 | 1a | No painting required below “0” level. |
| Foundation Material | 38-010 | | 11 | |
| Interconnecting Walkways | 38-XXX (Except 38-010) | | 1a | |

| PG Description | PGMA(s) | Surface preparation | Painting Scheme | Shade/Shade (See Note 3) / Remarks |
|---|---|---|---|---|
| Columns | 39-1xx | SSPC SP 6 | 1a | No painting required below "0" level. |
| Foundation Material | 35-010, 38-010, 39-010,39-012, | -- | 11 | |
| Floor grills (Including Guard plates), ID System | 39-810 | SSPC SP 3 | 1a | Black shade |
| I.D. System structures | 39-XXX (Except 39-010 & 39-8XX) | SSPC SP 3 | 1a | |
| Recovery Boiler System Components | 40-XXX | SSPC SP 3 | 1a | |
| Oil & Gas burners and ignitors & scanners | 41-XXX | SSPC SP 3 | 1a | |
| Oil & Gas System | 42-XXX (Except 42-030) | SSPC SP 3 | 1a | |
| Oil preheating system | 42-030 | SSPC SP 3 | 3 | |
| Ignitor , Scanner & Seal air system | 43-XXX | SSPC SP 3 | 1a | |
| Coal Burner System | 45-XXX | SSPC SP 3 | 3 | |
| Stoker system | 46-XXX | SSPC SP 3 | 3 | |
| Pulverized fuel piping | 47-XXX | SSPC SP 3 | 1a | |
| Expansion Joints | 48-XX4 | SSPC SP 3 | 3 | |
| Duct Supports | 48-XX5 | SSPC SP 3 | 3 | |
| Cold air Ducts/<br>Cold air Dampers<br>Dampers<br><br>Gates | 48-0X2, 48-1X2<br>48-013, 033,113,143<br>48-XX3 (except 48-013,033,113,143)<br>48-XX0 | SSPC SP 3<br>SSPC SP 3<br>SSPC SP 3<br><br>SSSP SP3 | 1a<br>1a<br>3<br><br>1a | |
| Hot air/Flue Ducts/ | 48-2X2 ,48-3X2, 48-4X2 ,5X2 ,6X2 | SSPC SP 3 | 3 | |
| Foundation Material | 48-019 | -- | 11 | |
| Gravimetric Feeders | 65-XXX | SSPC SP 3 | 1a | Admiralty Gray |
| Coal Valve / feeder | 67-XXX | SSPC SP 3 | 1a | |
| *MS/HRH/ CRH/Aux./Feed lines* | 80-3XX | *SSPC SP 3* | 3 | See Clause 4.2 |
| *HPBP/LPBP** | *80-733* | *SSPC SP 3* | *3* | ** Piping Center scope* |
| Feed / Condensate lines | 80-4XX,5XX,6XX | SSPC SP 3 | 3 | |
| *CLH* | *80-8XX,9XX* | *SSPC-SP10* | *15* | ** Piping Center scope* |
| *VLH* | *80-8XX,9XX* | *SSPC-SP6* | *1a* | ** Piping Center scope* |
| *Auxiliary Structure* | *80-8XX,9XX* | *SSPC-SP6* | *1a* | ** Piping Center scope* |
| *Service water and condensate* | *80-400 to 418,429, 436, 457 to 499* | *SSPC SP 3* | *1a* | ** Piping Center scope* |
| *Acid cleaning lube oil* | *80-600,601,604,673* | *SSPC SP 3* | *1a* | ** Piping Center scope* |
| *IBD, CBD tanks* | *81-XXX* | *SSPC SP 3* | *3* | ** Piping Center scope* |
| *Storage tanks(Un insulated)* | *81-XXX* | *SSPC SP 3* | *1a* | ** Piping Center scope* |
| *Fuel Oil piping* | *80-650* | *SSPC SP 3* | *3* | ** Piping Center scope* |
| Supports for cable trays | 95-091,092 | SSPC-SP 3 | 1a | |
| Pressure vessel for DL Water level gauge | 97-195 | SSPC-SP 3 | 9 | |
| Hoist - Grey, Hook - Black | 99-XXX | SSPC SP 3 | 1a | |
| Erection materials | XX-993 | SSPC-SP 3 | 3 | If RPF is available one coat is sufficient. |

**NOTES:**

1. Rust Preventive Coating to be applied on HSFG Bolt threads and other threaded portions.
2. Machined surfaces are to be applied with a coating of Rust Preventive Oil .
3. All shade numbers are as per IS 5. Unless otherwise specified Color/Shade shall be Smoke gray Shade No. 692 of IS5.

## ANNEXURE - III : PAINTING SCHEME FOR VALVES

| COMPONENTS | Painting Scheme | Shade/ Shade**/ Remarks |
|---|---|---|
| All API Valves | 10 | Aluminum |
| Cast carbon steel Valves(Conventional) | 10 | Aluminum |
| Cast alloy steel Valves (Conventional ) | 10 | Aluminum |
| Stainless Steel Valves | NO PAINTING IS REQUIRED | |
| Forged Valves | 7 | Phosphating |
| QC NRV | 10 | Aluminum |
| HP/LP System | 10 | Aluminum |
| Soot Blower Components | 1a | Verdigris Green, Shade 280 |
| SV & SRV | 10 | Aluminum |
| Silencers | 10 | Aluminum |
| Water Level Gauge | 10 | Aluminum |
| On Shore OFE Items | 1b | French Blue Shade 166 |
| Off Shore OFE Components | 13 | French Blue Shade 166 |
| Arrow | * | Post Office Red Shade 538 Painting Spec - Pa2 |
| Hand Wheels | * | Aluminum Painting Spec - Pa17 |

* - As per Valve Scheme
** - All shade numbers are as per IS 5.

**NOTES**

i. Machined surfaces and threads are to be applied with a coating of Rust Preventive Oil .
ii. All shade numbers are as per IS 5. Unless otherwise specified Color/Shade shall be Smoke gray Shade No. 692 of IS5.

## ANNEXURE IV –
## PAINTING REQUIREMENTS FOR FBC & HRSG

| PG Description | PGMA(s) | Surface preparation | Painting Scheme | Shade/Shade (See Note 3) / Remarks |
|---|---|---|---|---|
| Drum & suspension rods | 04-XXX (Except internals) | SSPC SP 3 | 1a | International Orange Shade 592 |
| Drum internals | 04-XXX | SSPC SP 3 | 5 | |
| Loose components in drum & drum transport structure * | 04-1XX, 04-196 * | SSPC SP 3 | 3 | * Finish coat : Yellow enamel |
| Drum saddle bearing plate | 04-156 | SSPC SP 3 | 1a | |
| Headers & Loose tubes | 05-XXX | SSPC SP 3 | 3 | |
| WW , SH Panels | 06-XXX, 11-XXX | SSPC SP 3 | 3 | |
| DC, Riser, Suction Manifold | 07-1XX, 07-201,206,207,208 | SSPC SP 3 | 3 | For raisers having RPF one coat of primer is sufficient. |
| Loose Tubes, Pr. Part Seals | 07-2XX , 07-501,601 | SSPC SP 3 | 2 /3* | *07-216, 217 |
| WW, Hanger, Headers, DC, Raiser Supports | 07-4XX | SSPC-SP3 | 1a | |
| Module supports | 07-504, 505, 506 &510 | SSPC SP 3 | 1a | |
| Buck stays and roof supports | 08-XXX | SSPC SP 3 | 1a, | 1a=VLH, |
| Seal Boxes | 09-XXX | SSPC SP 3 | 1a | |
| SH Headers , Loose tubes | 10-XXX | SSPC SP 3 | 3 | |
| SH Coils, Elements | 11-XXX,12 XXX | SSPC SP 3 | 2 | |
| SH Lines & Links (Including DESH) | 12-XXX, 12-903 (Other than hangers and Supports) | SSPC SP 3 | 3 | |
| Hanger & Supports - SH | 12-9XX (Except 12-903) | SSPC SP 6 SSPC SP 10 | 1a, 15 | 1a=VLH, 15=CLH |
| Misc. components | 12-903,17-903, 19-903 | SSPC SP 3 | 3 | |
| RH Headers , Loose tubes | 15-XXX | SSPC SP 3 | 3 | |
| RH Coils, Elements | 16-XXX | SSPC SP 3 | 2 | |
| RH Lines and Links (Including DESH) | 17-XXX , 17-903 (Other than hangers and Supports) | SSPC SP 3 | 3 | |
| Hanger & Supports - RH | 17-9XX (Except 17-903) | SSPC SP 6 | 1a, | 1a=VLH |
| Hanger & Supports - Eco | 19-9XX (Except 19-903) | SSPC SP 6 SSPC SP 10 | 1a, 15 | 1a=VLH, 15=CLH |
| Hanger & Supports - Others | PGs 21,24,47, 48, 80 *80-8XX* * | SSPC SP 6 SSPC SP 10 | 1a, 15 | 1a=VLH, 15=CLH * *Piping Center scope* |
| Roof Skin casing | 18-XXX | SSPC SP 3 | 3 | |
| Economizer Coils/Elements /Headers | 19-XXX , 19-903 (Other than hangers and Supports) | SSPC SP 3 | 2,3 | 2=Coils /Elements 3=Headers |
| Economizer Links | 19-7xx,8xx | SSPC SP 3 | 3 | |
| S.B. Piping | 21-600 | SSPC SP 3 | 3 | |
| S.B. Piping supports | 21-601,725 | SSPC SP 3 | 1a | |
| S.B. Valves | 21-800 | SSPC SP 3 | 3 | |
| S.B. Safety Valves | 21-825, 850 | SSPC SP 3 | 3 | |
| Trim Pipe Supports | 24-X01,X25,X40, X75,X95, | SSPC SP 3 | 1a | |
| Trim Piping , Fittings & Headers | 24-X00,X40,X73, X75, X95 | SSPC SP 3 | 3 | |

| PG Description | PGMA(s) | Surface preparation | Painting Scheme | Colour/Shade (See Note 3) / Remarks |
|---|---|---|---|---|
| Valves/Trim pipes/SV/DWLG | 24-X60,X73,X80 | SSPC SP 3 | 3 | |
| * Silencer/S.V. Escape Pipes | 24-X20,X85 & X90 | SSPC SP 6 | 9 | *Refer to Valves scheme |
| Water Washing piping | 24-466 | SSPC SP 3 | 1a | |
| Manhole Doors | 28-220 | SSPC SP 3 | 10 | |
| Fixing components (Boiler) | 30-XXX | SSPC SP 3<br>SSPC SP 3 | 3<br>5 | Threaded portions / Fasteners are to be applied with Rust preventive coating |
| Boiler Skin casing | 31-XXX | SSPC SP 3 | 3 | |
| Fixing components (Auxiliaries) | 32-XXX | SSPC SP 3<br>SSPC SP 3 | 3<br>5 | Threaded portions / Fasteners are to be applied with Rust preventive coating. Outer casing sheets of GI/Aluminum should both be painted. |
| Bunker Structure | 34-XXX | SSPC SP 6 | 1a | |
| Columns | 35-1xx (Except 35-190) | SSPC SP 6 | 1a | No painting required below “0” level. |
| Ceiling Girders, cross beams | 35-2xx | SSPC SP 6 | 1a | |
| Foundation materials | 35-010,38-010, 39-01X | -- | 11 | |
| Boiler Supporting Structures (Other than columns ,ceiling girders, Floor Grills, Step Threads, roof sheetings, hand rails/posts, and foundation materials) | 35-XXX , 36-XXX 38-XXX, & 39-XXX | SSPC SP 3 | 1a | |
| Boiler Roof Sheeting (Vendor Item) AC Sheets / GI Sheets /Meta Poly sheets | 35-611,36-611 | -- | 11 | |
| Transportation structure for modules | 35-390,391,392 | SSPC SP 3 | 1a | |
| Floor grills (Including Guard plates), | 36-81X 38-810 & 39-810 | SSPC SP 3 | 1a | Black Shade |
| Stair and Ladders | 35-822 ,823 ,36-820 38-820,39-820 | SSPC SP 3 | 1a | Black Shade ( for step threads) |
| Hand rails and posts | 36-85X | SSPC SP 3 | 1a | Black Shade |
| Boiler outer casing components | 37-010 | SSPC SP 3<br>SSPC SP 3 | 3<br>5 | Threaded portions / Fasteners are to be applied with Rust preventive coating |
| Oil & Gas burners and ignitors & scanners | 41-XXX | SSPC SP 3 | 1a | |
| Oil & Gas System | 42-XXX | SSPC SP 3 | 1a | |
| Ignitor , Scanner & Seal air system | 43-XXX | SSPC SP 3 | 1a | |
| Ash Cooler | 44-402,403` | SSPC SP 3 | 1a | |
| Distributor plate | 45-450 | SSPC SP 3 | 3 | |
| Fuel piping | 47-XXX | SSPC SP 3 | 1a | |
| Expansion Joints | 48-XX4 | SSPC SP 3 | 1a | |
| Duct Supports | 48-XX5 | SSPC SP 3 | 1a | |

| PG Description | PGMA(s) | Surface preparation | Painting Scheme | Colour/Shade (See Note 3) / Remarks |
|---|---|---|---|---|
| Cold air Ducts/ Dampers/ | 48-0XX, 44-49X, | SSPC SP 3 | 1a<br>3 | All Exterior surfaces<br>All Interior surfaces |
| Gates | 48-XX3, 48-XX0 | SSPC SP 3 | 3 | |
| Hot air/Flue Ducts/ Dampers/Gates | 48-2XX ,48-3XX,<br>48-4XX ,48-7XX<br>44-432,48X<br>48-1xx | SSPC SP 3 | 1a<br><br>3 | Exterior of HRSG casings.<br>FBC (both sides), HRSG (Interior) |
| Coal Feeders | 47-953 | SSPC SP 3 | 1a | |
| Bunker | 66-XXX<br>(except 66-125) | SSPC SP 3 | 1a | |
| Coal gate | 67-252 | SSPC SP 3 | 1a | |
| Boiler feed piping | 80-085 | SSPC SP 3 | 3 | |
| *HPBP, LPBP* | *80-7XX* | *SSPC SP 3* | *3* | **Piping Center scope* |
| *CLH* | *80-8XX,9XX* | *SSPC SP 10* | *15* | **Piping Center scope* |
| Feed / Condensate lines | 80-4XX,5XX,6XX | SSPC SP 3 | 3 | |
| *Auxiliary Structure* | *80-8XX,9XX* | *SSPC-SP6* | *1a* | ** Piping Center scope* |
| *Acid cleaning lube oil* | *80-600,601,604,673* | *SSPC SP 3* | *1a* | ** Piping Center scope* |
| *IBD, CBD tanks* | *81-XXX* | *SSPC SP 3* | *3* | ** Piping Center scope* |
| Trim pipe Headers, fittings and Supports | 80-,145,273, 274, 421, 600 & 601 | SSPC SP 3 | 1a | |
| Hoist - Grey, Hook - Black | 99-100 | SSPC SP 3 | 1a | |
| Supports for cable trays | 97-457 | SSPC-SP 3 | 1a | |
| Loose components (PR Parts) | HL- 097 | SSPC SP 3 | 3 | |
| Loose components (Ducts) | HL-098 | SSPC SP 3 | 1a | |
| Spool Duct | HL-7XX | SSPC SP 3 | 1a | |
| Loose components Structures) | HL- 099 | SSPC SP 3 | 1a | |
| Modules | HV-1XX, HL-1XX | SSPC SP 3 | 3,<br>5 | 3:headers<br>5:Fined tubes (PWHT area) |
| Links | HV-2XX, HL-2XX | SSPC SP 3 | 3 | |
| Module components | HL-3XX, HV-3XX | SSPC SP 3 | 3 | |
| L Frame and Insulation | HV-4XX | SSPC SP 3 | 3 | |
| Side Casing for modules | HV-5XX, HL-5XX | SSPC SP 3 | 1a | |
| Top and bottom casings | HV-6XX, HL-6XX | SSPC SP 3 | 1a | |
| Loose Casings | HL-7XX | SSPC SP 3 | 1a | |

**NOTES:**

1. Rust Preventive Coating to be applied on HSFG Bolt threads and other threaded components.
2. Machined surfaces are to be applied with a coating of Rust Preventive oil.
3. All shade numbers are as per IS 5. Unless otherwise specified Color/Shade shall be Smoke gray Shade No. 692 of IS5.

BHARAT HEAVY ELECTRICALS LIMITED
TIRUCHIRAPALLI 620 014

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SIP:NP:05/01 PAGE : 1 Of 3

# PROCEDURE FOR KEROSENE LEAK TEST

| REV. | DATE | PREPARED | REVIEWED | APPROVED |
|---|---|---|---|---|
| 00 | 12/07/96 | P.S.Narayanan | A.R.Reddy | V.Raghavendran |
| 01 | 25/03/04 | A Francis | GSN Murthy | C R Raju |

REVISION STATUS

| REVISION NO | CLAUSE NO | DETAIL OF REVISION |
|---|---|---|
| 00 | -- | I)PR:QE:002/04 renumbered as SIP:NP:05.<br><br>II)Editorial corrections for clarity. |
| 01 | -- | Editorial corrections done for clarity. high lighted text (Clause 3.1, 3.2 modified. 3.1.1 & 3.2.1 added.) |

1.0 **SCOPE**

1.1 This procedure details out the requirements of kerosene leak test for single sided / single layer weld joints that are accessible from back side for visual examination.

2.0 **PRE-REQUISITES**

2.1 Weld shall be thoroughly cleaned by hand wire brush or rotary wire brush to remove oil, grease, slag and rust.

2.2 Weld shall be visually inspected and unacceptable defects if any shall be repaired by grinding / grinding and welding.

2.3 Kerosene leak test shall be carried out only at room temperature.

3.0 **TESTING**

3.1 The weld surface shall be applied with wet/pasty chalk (mixed with water) and dried.

3.1.1 Kerosene shall be sprayed on the other (root) side of weld. The kerosene penetrates through crevices or cracks/ pin holes and is absorbed by dry chalk powder showing up as a dull patch/indication on the bright chalk surface.

3.2 Alternatively weld surface may be wetted with wet (soaked in kerosene) cotton waste or cloth.

3.2.1 In such cases wet/pasty chalk shall be applied on the other (root) side of the weld. This shall be completed before applying kerosene.

3.3 The side on which chalk is applied shall be visually examined for indications of kerosene absorption (sweating/wetting) after 5 minutes of kerosene application. Indications noticed if any shall be repaired as given below.

4.0 **REPAIRS**

4.1 Leaking spots (indication) shall be marked for repair.

4.2 Repairs shall be carried out by grinding and welding.

4.3 Repaired areas shall be retested as above.

5.0 **CLEANING**

5.1 After testing / retesting is completed the chalk powder and traces of kerosene shall be cleaned off from the welds.

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# PROCEDURE FOR VISUAL INSPECTION OF NON PRESSURE PARTS

| REV. | DATE | PREPARED | REVIEWED | APPROVED |
|---|---|---|---|---|
| 00 | 15/07/96 | P.S.Narayanan | A.R.Reddy | V.Raghavendran |
| 01 | 28/03/04 | A Francis | G S N Murthy | C R Raju |

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|---|---|---|
| 00 | ---- | 1)PR:QE:021/02 renumbered as SIP:NP:06.<br><br>2)Editorial corrections for clarity.<br><br>3)Clause 3.1 modified. |
| 01 | 3.1 | Code related change |
| | 3.2 | For better clarity |
| | 3.2.1 | -do- |
| | 3.2.3 | Code related change |
| | 3.2.5 | For better clarity |
| | 4.4 | Code related change |

## 1.0 SCOPE

1.1 This procedure details out the visual inspection of all base metal surfaces and weld joints of Non pressure parts.

## 2.0 REFERENCE DOCUMENTS

AWS D 1.1 & Relevant drawings

## 3.0 VISUAL INSPECTION OF GAS CUT EDGES

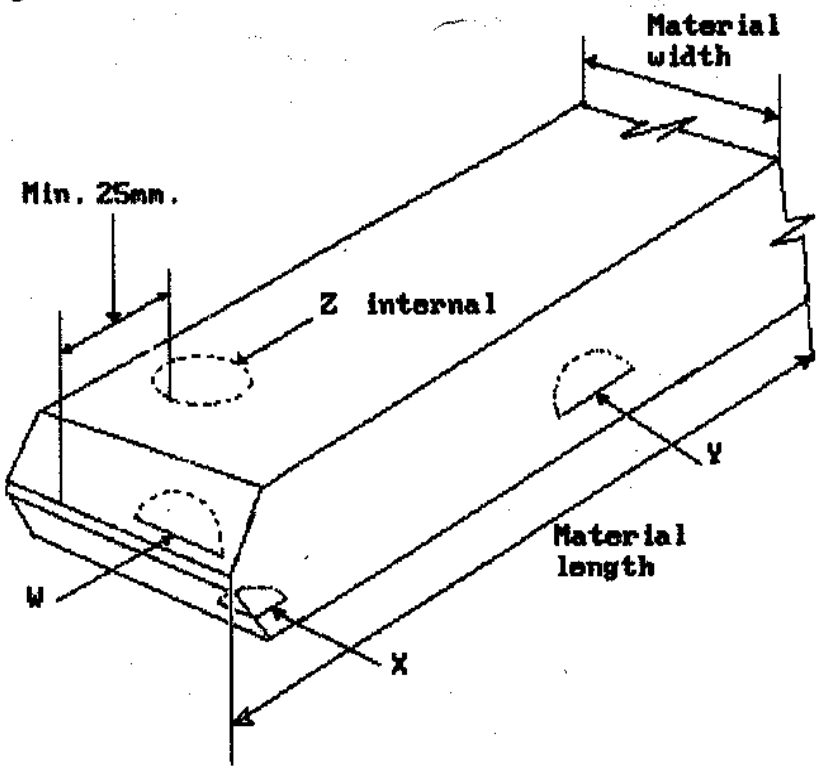
3.1 Acceptability and repair of mill induced laminar discontinuities in cut surfaces

| Description of Discontinuity | Repair Required |
|---|---|
| Any discontinuity 25mm in length or less | No repair . |
| Any discontinuity over 25mm in length and 3mm max. depth (after grinding & confirmation of depth on 10% of total such locations) | No repair |
| Any discontinuity over 25mm in length with depth over 3mm but not greater than 6mm. | Remove by grinding and weld |
| Any discontinuity over 25mm in length with depth over 6mm but not greater than 25mm. | Completely remove and weld. |
| Any discontinuity over 25mm in length with depth greater than 25mm. | See Cl.3.2 |

3.2 For discontinuities over 25mm in length with depth greater than 25mm, discovered by visual inspection(and subsequent grinding for depth assessment) of plate cut edges/ bevel edges before welding or during examination of welded joints by radiography or ultrasonic inspection, following procedure shall be followed:

3.2.1 Prior to completing the weld joint, the discontinuities such as (W),(X) or (Y) shall be determined visually (for length) and by NDT (UT, and /or MPI) for depth and recorded for the size and shape of discontinuity as per Fig.1.

Fig.1 EDGE DISCONTINUITIES IN CUT PLATE




3.2.2 The repair of the discontinuity by welding shall be allowed in case area of discontinuity does not exceed 4% of the cut area with the following exceptions. If the width of the discontinuity or the aggregate width of discontinuities on any transverse section, as measured perpendicular to the plate length, exceeds 20% of the plate width, the limit of 4% area shall be reduced by percentage amount of the width exceeding 20% (e.g., if the discontinuity is 30% of plate width, the area of discontinuity cannot exceed 3.6% of the plate area). The discontinuity on the cut edge of the plate shall be gouged out to a depth of 25mm beyond its intersection of the surface by chipping, or carbon arc gouging, or grinding and blocked off by welding with manual shielded metal arc process in layers not exceeding 3mm in the thickness.

3.2.3 If discontinuity (Z) not exceeding the allowable area is discovered after the joint has been completed and is determined to be 25mm or more away from the face of the weld, as measured on the plate surface, no repair of discontinuity is required. If the discontinuity (Z) is less than 25mm away from the weld, it shall be gouged out to a distance of 25mm from the fusion zone of the weld by chipping, air carbon arc gouging or grinding. It shall then be blocked off by welding with low hydrogen SMAW process for at least four layers not to exceed 3mm thickness per layer. Submerged arc or other welding process may be used for remaining layers.

3.2.4 If the area of discontinuity (W), (X), (Y) or (Z) exceeds the allowable limits of Cl.3.2.2, the plate or sub-component shall be rejected.

3.2.5 The aggregate length of weld repair shall not exceed 20% of length of plate surface being repaired.

## 4.0 VISUAL INSPECTION OF WELDS

4.1 Visual examination of welds shall be performed after completion of welding and subsequent cooling to room temperature. However for ASTM A514 and A517 steels visual examination of welds shall be performed only after 48 hours of completion of welding.

4.2 All welds shall be cleaned to remove slag, spatter etc. and visually examined for defects like crack, undercut, porosity, lack of fusion etc.

4.3 The welds shall also be examined for size, shape and reinforcement.

4.4 **ACCEPTANCE CRITERIA AND DISPOSITION DETAILS ARE AS FOLLOWS**

| **Nature of defects** | **Acc. norms** | **Disposition** |
|---|---|---|
| 1) Crack, Lack of fusion, Overlap | Not accepted | Confirm by LPI/MPI, repair and retest. |
| 2) Crater(Except at the ends of stitch welds outside the required length) | Not accepted | Fill by weld deposit. |
| 3) Undercut | | |
| For T < 25.mm | Up to 1.0 mm accepted. (Upto 2.0 mm if within 50mm for any 300 mm weld Length.) | To be ground & merged/ welded otherwise. |
| For T => 25.4 mm | Up to 2 .0 mm accepted. | >2.0mm to be ground and merged/welded |
| 4) Porosity- Transverse Butt Welds | Piping porosity not permitted | |
| Porosity for other Butt/Fillet welds | One pore of <= 2.5 mm for Each 100 mm of Weld length is permitted.(*) | (*)Combined length of pores in fillet welds in web to stiffener: 10mm for 25 mm weld & 20mm for 300mm weld is however acceptable. |
| Weld contour | | |
| 1) Face of fillet | Flat or concave(meeting the throat) accepted. convexity is acceptable as below. 2mm for weld width <= 8mm 3mm for weld width > 8mm < 25 mm 5mm for weld width >= 25 m | |
| 2) Size (Minimum) | As per drawing. Under size permitted as below(*) 2mm for nominal size ≤ 5mm 2.5mm for nominal size 6mm 3mm for nominal size ≥ 8 mm * if undersized weld length is less than of 10% of the total weld length. | |
| 3) Reinforcement (groove | Max. 3 mm | |

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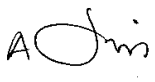
# WELDING QUALIFICATION FOR STRUCTURAL APPLICATIONS

| REV. | DATE | PREPARED | REVIEWED | APPROVED |
|---|---|---|---|---|
| 00 | 15/07/96 | P.S.Narayanan | A.R.Reddy | V.Raghavendran |
| 01 | 13/10/03 |  A Francis |  GSN Murthy |  C R Raju |

REVISION STATUS

| REVISION NO: | CLAUSE NO | DETAIL OF REVISION |
|---|---|---|
| 00 | ---- | 1)PR:QE:172/00 renumbered as SIP:NP:07.<br><br>2)Editorial corrections for better clarity. |
| 01 | | |

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) Performance Qualification tests for welders and welding operators in carbon steel and alloy steel and Stainless steel welding.

1.2 **REFERENCE DOCUMENTS**

1.2.1 AWS D 1.1 (2004)

1.2.2 ASME Sec 1X *(as an alternative)*

2.0 **MATERIALS to be used for qualification:**

| | |
|---|---|
| a) Carbon steel plates/sheets | IS 8500,IS 2062 Gr A&B<br>ASTM A36,SA 515 Gr.70 |
| b) Alloy steel plates/sheets | Carton SA588 Gr.A,<br>SA387 Gr12 & 22. |
| c) Pipes/Tubes (carbon steel) | SA 106 Gr.B,<br>SA 210 Gr.A1 |

2.1.1 *Other* materials with equivalent chemical composition also may be used.

3.0 **WELD PROCEDURE SPECIFICATION ( WPS) QUALIFICATION**

3.1 The document shall cover requirements of Table I & II showing relevant essential variables.

3.2 **Preparation of test coupons**:

3.2.1 Size : 400 x 250 of required thickness

Sizing: Gas cutting or Shearing.

Position: As per rolling direction of plates (See Fig 1 )

Bevelling: By gas cutting and grinding or edge planning.

Bevel angle: As per applicable draft WPS .

Single “V” angle 60° + / - 10°

root gap : 0 to 3mm

land thickness : 0 to 3mm

3.2.2 Consumables selection : As per applicable draft WPS.

3.2.3 Test Coupons shall be welded in the presence of Inspecting Engineers.

3.2.4 Weld cleaning shall be done in the same position as the weld is being qualified.

3.2.5 Test Coupons shall have stamp of the Inspecting Engineers on all the test-pieces prior to cutting specimens from test coupons.

3.3 NDE of test welds before specimen preparation. : RT or UT (Witness by Inspection Engineer )

3.4 Radiography shall be evaluated as per BHE:NDE:S:RT5.

3.6 **Mechanical Tests:**

Tensile test ( on Reduced section).
(Root & face)/Side bend tests.
Macro etch tests .

3.7 Test Specimens: As per Table III & IV and Fig. 1 & 2,(as applicable)

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.

| SlNo | Welding variable | variation | SMAW | SAW |
|---|---|---|---|---|
| 1. | filler metal | Change to higher strength | Yes | Yes |
| 2. | low Hydrogen type electrode | change to non-low hydrogen type | Yes | Yes |
| 3. | Flux wire combination | | | |
| 4. | weld amperage , voltage | exceeding the recommendation of weld consumable manufacturer | Yes | Yes |
| 5. | No. of passes for Weld groove | +/- 25% of specified no. of passes | Yes | Yes |
| 6. | Groove type (V,U) | V to U or U to V | Yes | Yes |
| 7. | Groove angle | decrease | | |
| 8. | Root gap | decrease | | |
| 9. | groove face width | Increase | | |
| 10. | Backing plate | omission | | |
| 11. | Welding position | | | |
| 12. | Electrode/wire dia | Increase > 1mm of qualified dia | Yes | Yes |
| 13. | Preheat | Decrease > 13 deg C of specified range. | | |
| 14. | Weld progression | Change from top to bottom or vice versa | | |
| 15. | PWHT | Addition or deletion | | |

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 c 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 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 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. decrease of included angle of the groove.

b. decrease in root opening of the groove.

c. 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 arcs.

3.9.2.10 A change of more than 10% or 1.6mm whichever is greater in the lateral spacing of the arcs.

3.9.2.11 A change of more than ±10° 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) ±3° in the direction of travel
b) ±5° normal to the direction of travel

3.9.2.13 For a specified groove, a change of more than ±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 IG (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 & | Position of welding qualified | |
|---|---|---|---|
| Weld plate groove | Plate positions | Groove | Fillet |
| | 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 note be considered.

4.3.10.2 For Radiographic test, the acceptance requirements are as per BHE:NDE: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.

4.3.10.3.2 A 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.

# TABLE - I

**WELDING PROCEDURE SPECIFICATION (WPS) Yes ( )**
**PREQUALIFIED _____ QUALIFIED BY TESTING _____**
**or PROCEDURE QUALIFICATION RECORD (PQR) Yes ( )**

Company Name _____ Identification # _____
Welding Process(es) _____ Revision _____ Date _____ By _____
Supporting PQR No.(s) _____ 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 _____

**BASE METALS**
Material Spec. _____
Type or Grade _____
Thickness Groove _____ Fillet _____
Diameter (Pipe) _____

**FILLER METALS**
AWS Specification _____
AWS Classification _____

**SHIELDING**
Flux _____ Gas _____
Composition _____
Electrode-Flux (Class) Flow Rate _____
_____ Gas Cup Size _____

**PREHEAT**
Preheat Temp., Min. _____
Interpass Temp., Min _____ Max _____

**POSITION**
Position of Groove _____ Fillet _____
Vertical Progression: Up ( ) Down ( )

**ELECTRICAL CHARACTERISTICS**
Transfer Mode (GMAW) Short-Circuiting ( )
Globular ( ) Spray ( )
Current: AC ( ) DCEP ( ) DCEN ( ) Pulsed ( )
Other _____

**TECHNIQUE**
Stringer or Weave Bead _____
Multi-pass or Single Pass (per side) _____
Number of electrodes _____
Electrode Spacing Longitudinal _____
Lateral _____
Angle _____
Contact Tube to Work Distance _____
Peening _____
Interpass Cleaning: _____

**POSTWELD HEAT TREATMENT**
Temp. _____
Time _____

**WELDING PROCEDURE**

| Pass or Weld Layer(s) | Process | Filler Metals | | Current | | Volts | Travel Speed | Joint Details |
|---|---|---|---|---|---|---|---|---|
| | | Class | Diam. | Type & Polarity | Amps or Wire Feed Speed | | | |
| | | | | | | | | |

# TABLE – II

**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 _____

Other Tests

Radiographic-ultrasonic examination
RT report no: _____ Result _____
UT report no: _____ Result _____

**FILLET WELD TEST RESULTS**

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

Maximum size single pass
Macroetch
1. _____ 3. _____
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.
year

Signed _____
Manufacturer or Contractor
By _____
Title _____
Date _____

## TABLE -III (PLATES)

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 | | | | |
|---|---|---|---|---|---|---|---|
| | | | REDUCED SECTION TENSION | ROOT BEND | FACE BEND | SIDE BEND | PL.THICKNESS QUALIFIED |
| Upto 10 | 1 | Yes | 2 | 2 | 2 | - | 2T |
| > 10< 25 MM | 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 RT/UT tested 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 Thickness (T) | NO. OF SAMPLE WELDS PER POSITION | NDT* | TEST SPECIMENS REQUIRED | | | | QUALIFICATION RANGE | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | REDUCED SECTION TENSION | ROOT BEND | FACE BEND | SIDE BEND | DIA NESS | THICK |
| D<610 | 3< T = 10 | 1 | Yes | 2 | 2 | 2 | - | D&above | 3mm to 2T |
| | 10< T <19 | 1 | Yes | 2 | - | - | 4 | -do- | T/2 to 2T |
| | T = 19 | 1 | Yes | 2 | - | - | 4 | -do- | Above 10 |
| D= 610 | 3< T = 10 | 1 | Yes | 2 | 2 | 2 | - | Above 10 | 3mm to 2T |
| | 10< T < 19 | 1 | Yes | 2 | - | - | 4 | Above 610 | T/2 to 2T |
| | T = 19 | 1 | Yes | 2 | - | - | 4 | Above 610 | Above 10 |

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

## TABLE-V

### PROCEDURE QUALIFICATION - TYPE AND POSITION LIMITATION

| WELD | QUALIFICATION TEST POSITION | TYPE OF WELD AND POSITION OF WELDING QUALIFIED | | | |
|---|---|---|---|---|---|
| | | 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 | ---- | Vertical | | |
| | 4F | ---- | Over head | | Over head |
| Pipe-groove | 1Grotated | 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

### PROCEDURE QUALIFICATION --- FILLET WELD

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 thickness | Fillet size |
| 'T' Test Fig.2 | Single pass max. size to be used in construction | 1 in each position to be used | 3 Faces | Unlimited | Max.tested single pass & smaller |
| | Multi pass - min. 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 fillermetal(ifnot 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._____

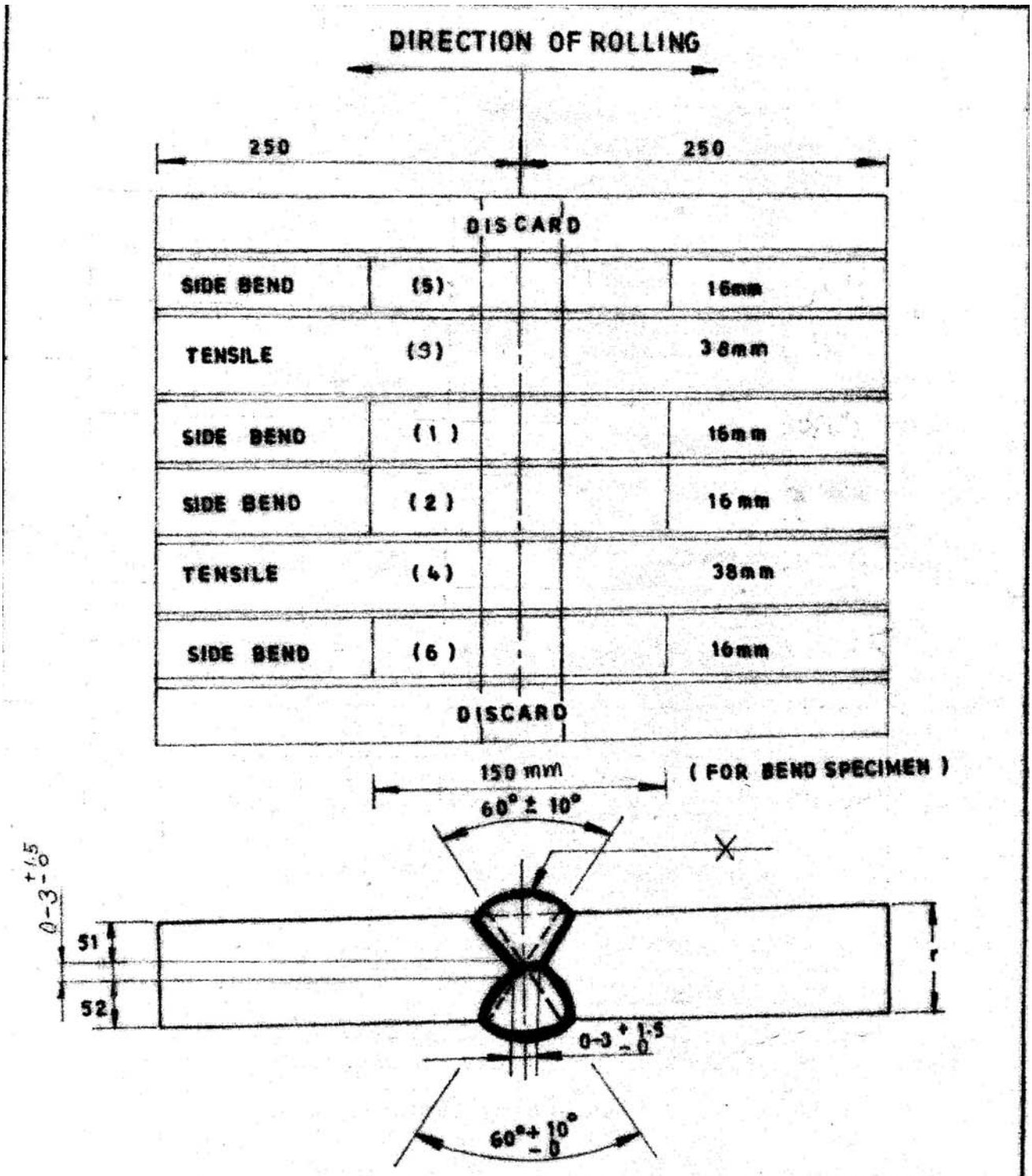
**RADIOGRAPHIC TEST RESULTS**

| 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 D1.1Structural 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

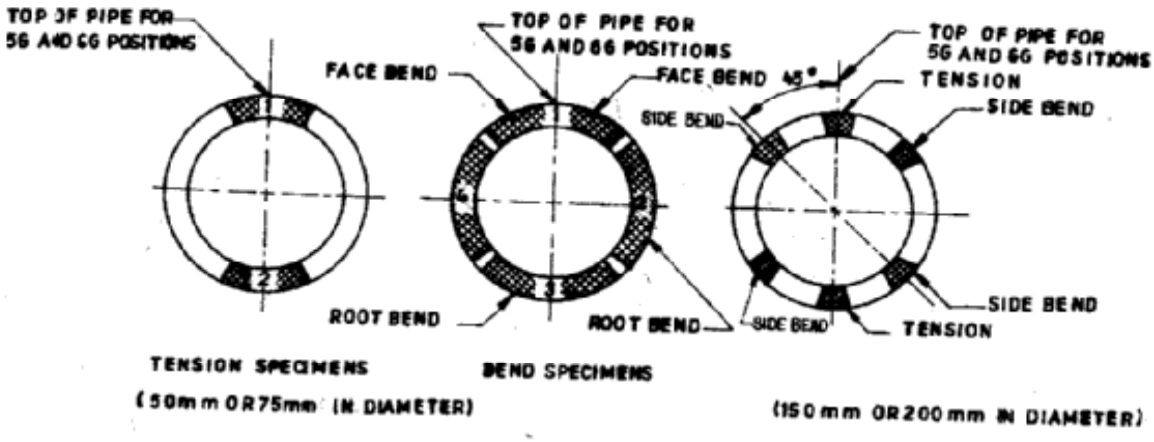
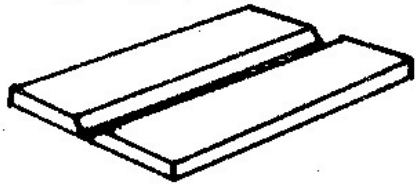



FIG-2

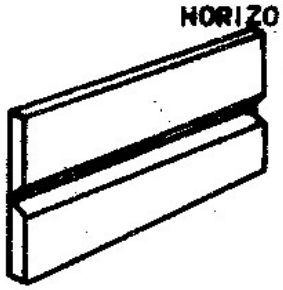
## TEST POSITION OF TEST PLATES FOR GROOVE WELDS

PLATES HORIZONTAL

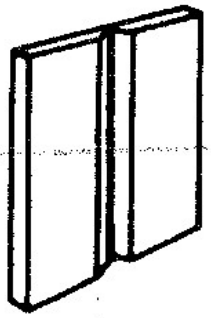


(A) TEST POSITION 1 G

PLATES VERTICAL AXIS OF WELD HORIZONTAL

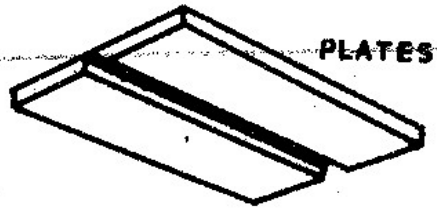


(B) TEST POSITION 2 G.



(C) TEST POSITION 3 G

PLATES HORIZONTAL



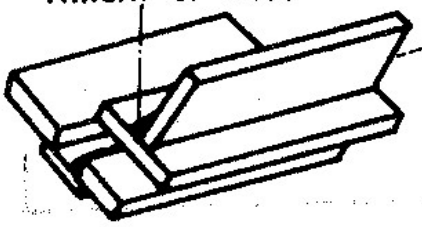
(D) TEST POSITION 4 G.

FIG.3

## TEST POSITIONS OF PLATES FOR FILLET WELDS

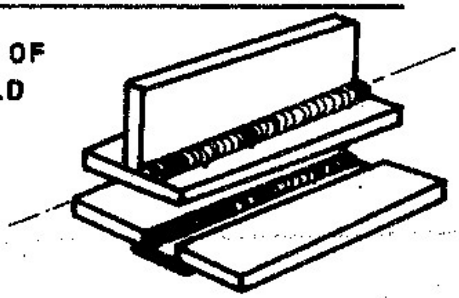
THROAT OF WELD

AXIS OF WELD



(A) FLAT POSITION 1F

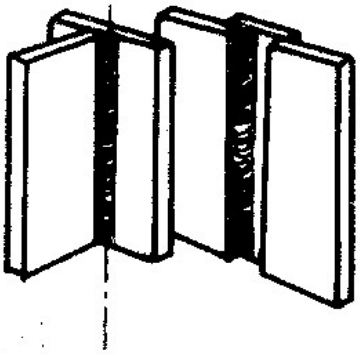
AXIS OF WELD



NOTE: ONE PLATE MUST BE HORIZONTAL

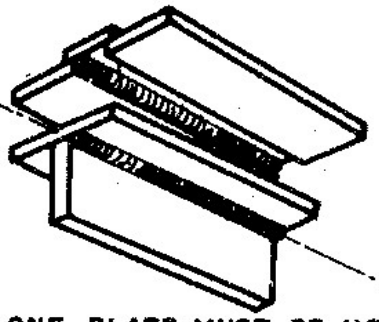
(B) HORIZONTAL POSITION 2F

AXIS OF WELD



(C) VERTICAL POSITION 3F.

AXIS OF WELD



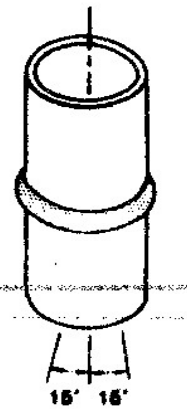
NOTE: ONE PLATE MUST BE HORIZONTAL.

(D) OVERHEAD POSITION 4F

FIG – 4


PIPE HORIZONTAL AND ROTATED.
WELD FLAT (±15°). DEPOSIT
FILLER METAL AT OR NEAR THE TOP.

(A) TEST POSITION 1G ROTATED

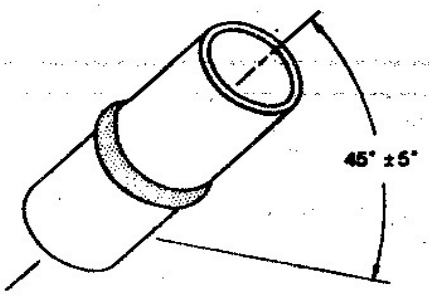



PIPE OR TUBE VERTICAL AND
NOT ROTATED DURING WELDING
WELD HORIZONTAL (±15°).

(B) TEST POSITION 2G


PIPE OR TUBE HORIZONTAL FIXED (±15°) AND NOT ROTATED DURING WELDING.
WELD FLAT, VERTICAL, OVERHEAD.

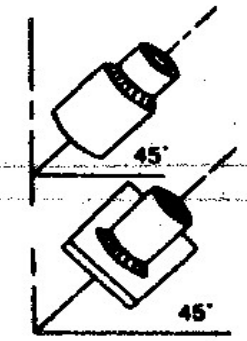
(C) TEST POSITION 5G




PIPE INCLINATION FIXED (45° ±5°) AND NOT
ROTATED DURING WELDING.

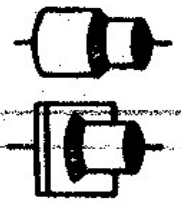
(D) TEST POSITION 6G

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



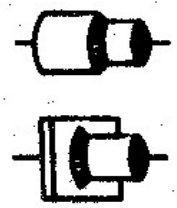

(A) TEST POSITION 1F
FOR FLAT POSITION
(ROTATED)

(B) TEST POSITION 2F
FOR HORIZONTAL POSITION
(FIXED)



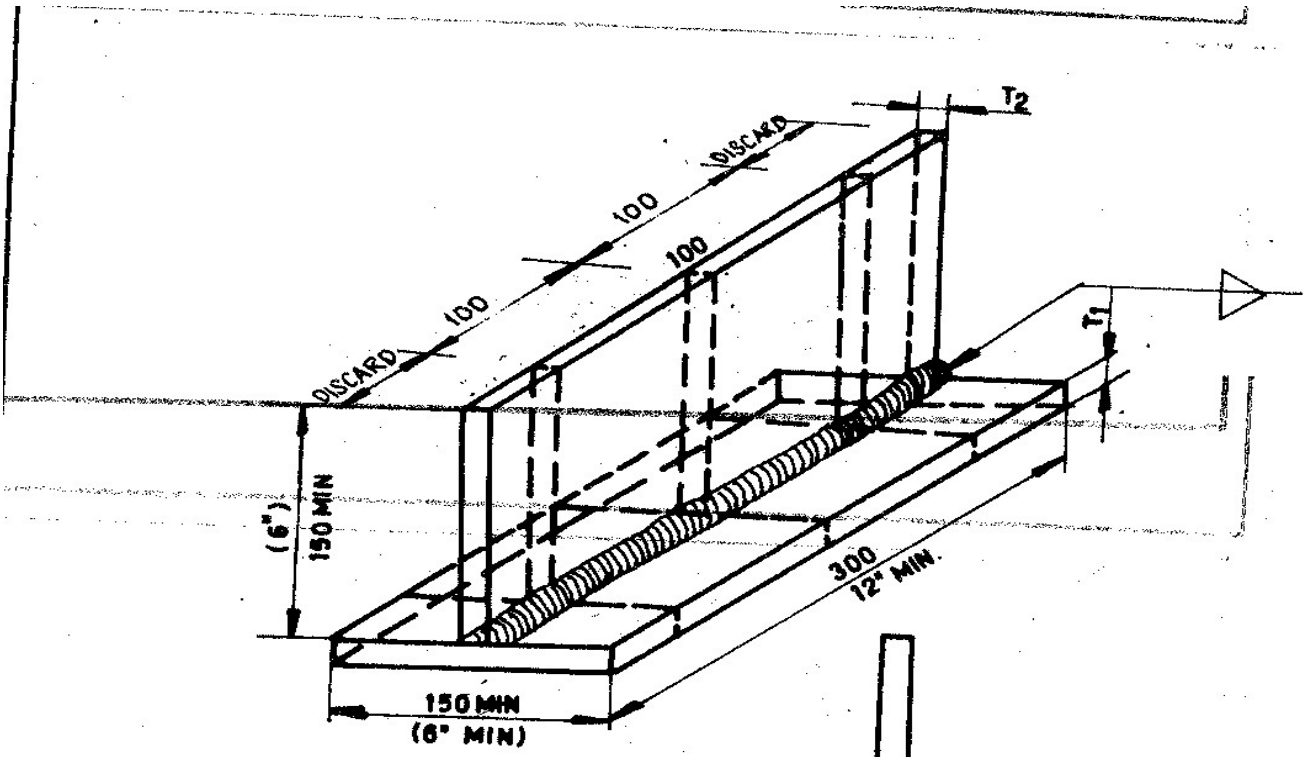
(C) TEST POSITION 2F
FOR HORIZONTAL
POSITION (ROTATED)

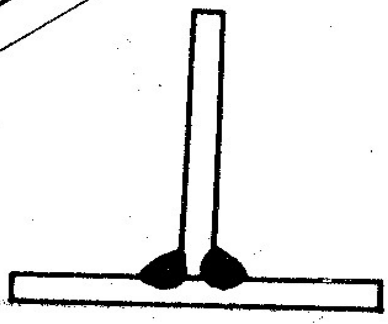
(D) TEST POSITION 4F
FOR OVERHEAD POSITION
(FIXED)



(E) TEST POSITION 5F
FOR MULTIPLE POSITION
(FIXED)

**Figure .6 — Positions of Test Pipes for Fillet Welds**



MACRO ETCH TEST SPECIMEN.

| WELD 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.

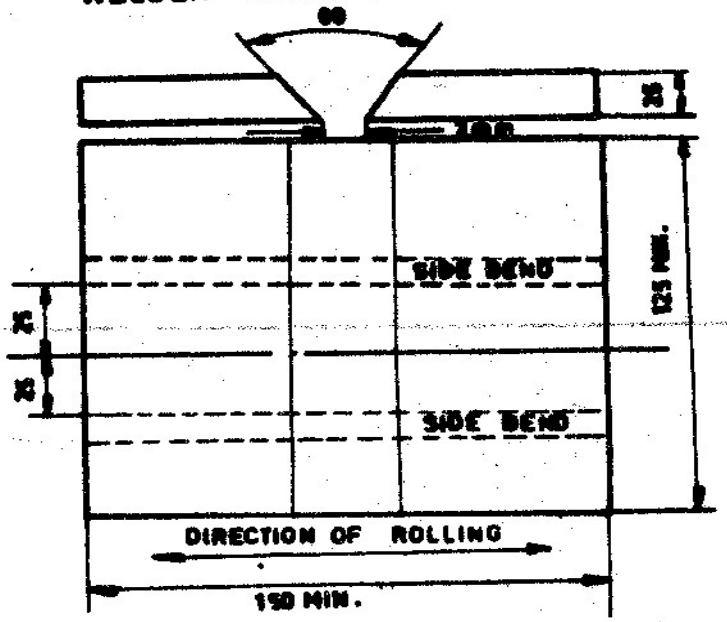



FIGURE-8

TEST PLATE FOR UNLIMITED THICKNESS WELDING OPERATOR QUALIFICATIONS.

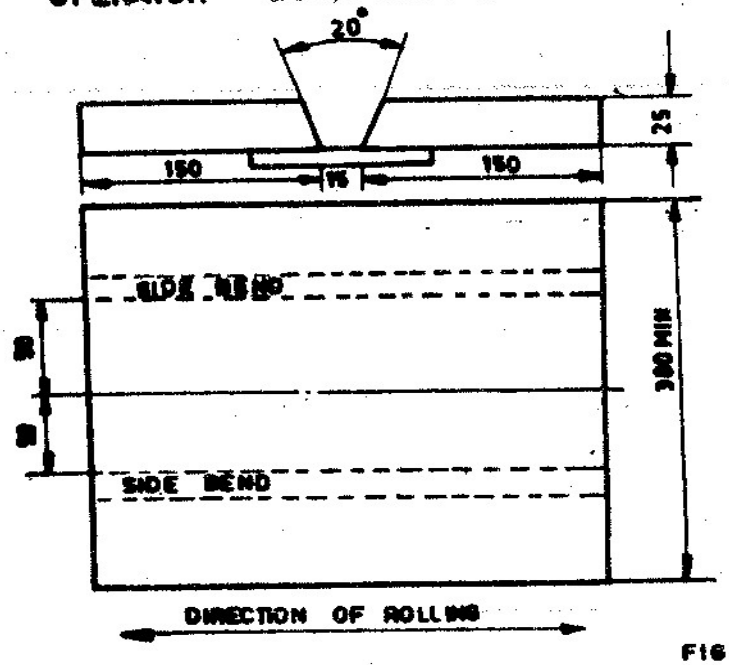
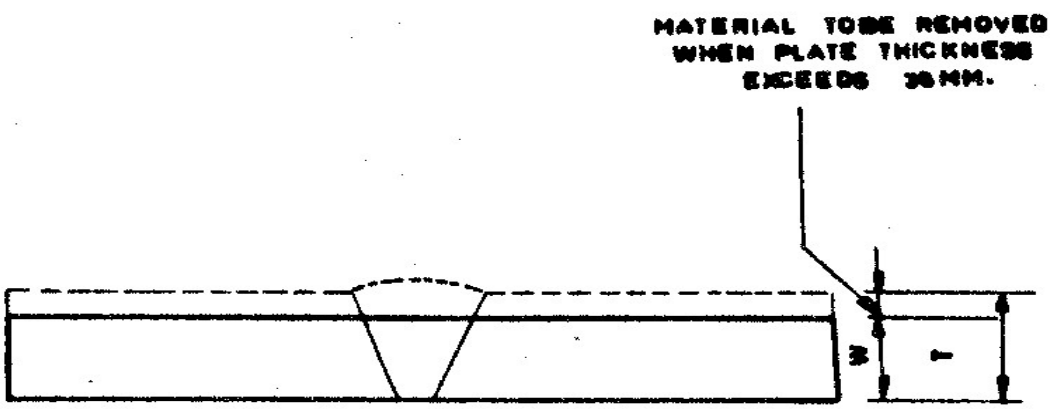
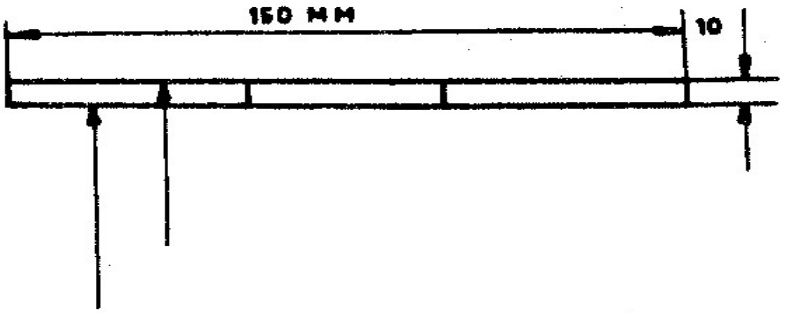



FIGURE-9

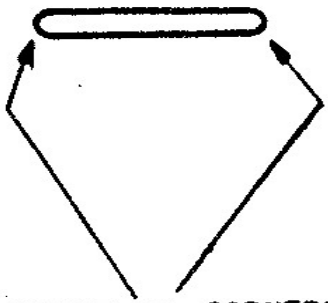
## SIDE BEND SPECIMENS




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




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



RADIUS ALL CORNERS 10MM MAX.

FIGURE-10

| Tiruchirappalli | QUALITY ASSURANCE | STANDARD QUALITY PLAN<br>BOILER DUCTS & HOPPERS | QP NO. : SQP:NP: 01 REV.: 02<br>DATE : 01/04/2003<br>PAGE : 1 |
|---|---|---|---|

| SL. NO. | COMPONENT AND OPERATION | CHARECTERISTICS | Cl. | TYPE OF CHECK | Quantum of Check | REF.DOCUMENT/ ACCEPTANCE STD. | TYPE OF RECORD | D | Agency ** M | TPI | C | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.0 | MATERIAL *<br>Plates,Sheets &<br><br>Rolled Sections<br><br>IS 2062 Gr.A & B,<br>IS 1079<br>IS 513 Type D,<br>SA 387 Gr.12 & 22,<br>ASTM A588 Gr.A<br>ASTM A240 TP 316<br>& TP 321 | Chemical &<br><br>Mechanical<br><br>Properties | | Review of<br><br>documents | 100% | As per Matl Spec. | TC | | QC | | | The material used shall be as per Drg. |
| 2.0 | INPROCESS CONTROL# | | | | | | | | | | | # (Ref. QCP 002 for details) |
| 2.1 | Marking, Cutting and preparation | Shape, Size and EP | | Measurement | 100% | Drawings<br>Note - 1 | R | | QC | | | |
| 2.2 | Welding | Procedure and Personnel Qlfn | | Review of Documents | 100% | SIP:NP:07 | R | | QC | | | |

**LEGEND:** Cl: Class (A: critical, B: Major, C: Minor
** TPI: Third Party Inspection, C: Customer.
H: Hold Point, W: Witness,
V: Verification of Test reports/certificates
M: Performed by BHEL (For bought out items
M: Performed by Vendor)
QC: Quality Control. ND: NDT Lab, SH: Shops
* D: Records for Data folders. R: Records

| Prepared: | Reviewed: | | | | | Approved: |
|---|---|---|---|---|---|---|
| R.Arthanareeswaran | C.R.Raju<br>QA | K.Nagarajan<br>Engineering | S.Anbalagan<br>OP & C | A.Kalyanaraman<br>Production | N.G.Mohan<br>QC | S.Viswanathan<br>Head/QA |

| SL. NO. | COMPONENT AND OPERATION | CHARECTERISTICS | Cl. | TYPE OF CHECK | Quantum of Check | REF.DOCUMENT/ ACCEPTANCE STD. | TYPE OF RECORD | D | Agency ** M | TPI | C | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.3 | Weld Inspection | Weld size<br>Weld quality | | Visual<br>LPI | 100%<br>10% @ | Drawing/SIP:NP:06<br>BHE:NDT:PB:PT1 | -<br>R | | QC<br>QC | | | @ 100% for SS |
| | | Leak test * | | Kerosene leak test | 100% | SIP:NP:05 | R | | QC | | | *For single Side welds |
| 3.0 | FINAL INSPECTION | | | | | | | | | | | |
| 3.1 | Trial Assembly | Dimensions<br>Match marks | | Measurement | 100% | Drawings<br>Note - 2 | R | | QC | | | |
| 3.2 | Painting and Preservation | Paint finish<br>coat thickness | | Visual<br>Measurement | --<br>Random | SIP:PP:22 | - | | QC | | | |
| 3.3 | Identification | WO No., DU No.<br>Match marks<br>Flow direction for aerofoil | | Visual | | Drawings<br>Note - 3 | - | | QC | | | |

## RECORD OF REVISIONS

| Rev. No. | Clause No. | Details of revision |
|---|---|---|
| 00 | -- | This document consolidates all requirements of various previous SQPs. |
| 01 | -- | All amendments issued has been regularised editorial correction made for better clarity Latest applicable TDC Nos incorporated. |
| | 3.3 | Modified and corresponding sketch removed. |
| | 5.5.2.7 | Modified and corresponding sketch Removed. |
| | -- | Sketch nos 3,4a,4b,4c renumbered as 2,3a,3b,3c |
| | 4.5.5.5 | Added |
| | 4.5.5.6 | Added |
| 02. | | SIP Nos up dated. Note-1 & 3 Deleted. Remaining Notes renumbered Materials listed in Note -1 are included in Clause 1.0 |
| | 1.1 | Modified |
| | 1.1.1 | Added |
| | 2.2 | Added |
| | 2.2.1 | Added. Other clauses re numbered. |

NOTE - 1

1.1 The following are the norms applicable for splicing. Any deviation from the same shall have the approval of Engg.,.

1.1.1 For duct stiffeners, No joint is permitted upto 2.5M length. Above 2.5M length, splicing can be done at a length of L/5 to L/3 from ends provided the length of the smallest piece is 500mm min.( L = Length of the stiffener)

1.1.2 The number of joints in duct walls shall be as given below:

| Duct wall area in Square metre | No of joints max. |
|---|---|
| Up to and including 2 | NIL |
| Above 2 upto and including 5 | 2 |
| Above 5 upto and including 10 | 4 |
| Above 10 upto and including 15 | 6 |
| Above 15 upto and including 20 | 8 |
| Above 20 upto and including 25 | 10 |
| Above 25 | 15 |

1.1.3 For aerofoil of flowmeter no vertical joints are permitted in the inlet region (leading edge of flow meter).Joint can be

permitted beyond 250mm from tapping points on downstream side.Refer figure 1.

1.1.3.1 If required horizontal joints, shall be permitted beyond 250mm from the tapping points.

1.1.3.2 The weld reinforcement on outside surface of aerofoil shall be ground flush so as to avoid any resistance to flow.

1.1.4 For despatchable rectangular/square wall of size 2M x 2M or smaller, smallest dimension of any piece shall be 300mm. For despatchable rectangular/square wall of size greater than 2M x2M, the smallest dimension shall be 500 mm. However in case of transition, hopper and chimney walls,for triangular and trapezium shapes the smallest dimension can be Zero.

1.1.5 Plus joints can also be permitted in layout / cutting plan.

1.1.6 All welds shall be backgouged and backgouged grooves shall be 100% LPI tested (and shall be free from slag inclusion & crackes etc) before welding from second side.

1.1.7 The joints shall be located in such a way that the nearest stiffener is minimum 50 mm away from the joint and parallel to it. The butt welds shall be ground flush before placing the stiffener where they are crossing the welds.

1.1.8 Joints parallel to the bend shall be at least 100 mm away from the bend.

1.1.9 Butt welds including divider plate & guide vanes and aerofoil shall be flush ground on inside the duct..

NOTE 2 TRIAL ASSEMBLY

2.1 Trial assembly shall be performed for all ducts, hoppers, transitions, chimney shells, elbows and flowmeters to ensure correct matching of walls at site.

2.2 For the purpose of stabilirty and safety, horizontal trial assembly can be done in the following cases.

a) Guide van ducts.
b) Elbow ducts where the hight exceeds 5 metres.

2.2.1 Transition ducts and all odd shaped ducts can be trial assembled in such a way keeping the stability of the assembly into consideration.

2.3 During trial assembly, all segments shall be assembled together using temporary bolts,tack welds or other suitable means and held in position.

2.4 All dimensions after trial assembly shall be checked and recorded.The tolerances given in the drawing shall be followed. Whenever not specified in drawing tolerances given in clause 2.6 shall be followed.

2.5 Before dismantling the assembly, the match marks shall be clearly punched, stenciled and bordered with white paint as shown in figure 2.

2.6 INSPECTION AND TOLERANCES

2.6.1 All the assemblies shall be inspected as per drawing. Dimensional variations shall not exceed the limits given below:

2.6.2 DUCTS/HOPPERS/CHIMNEY SHELLS

2.6.2.1 The variation in length and width of the rectangular sections and dia of circular section of openings shall not exceed ±2 mm/metre of nominal dimensions limited to Max. 5 mm. the difference between diagonals shall not exceed 1.5 mm/ metre of nominal diagonal length limited to 5mm Max.

2.6.2.2 Ovality (difference between max. and min.diameter at a section)at the ends of circular ducts and chimney shells with/without flanges shall be within 2mm/metre limited to 10 mm Max.

2.6.2.3 Out of squareness of duct end shall not exceed 2mm /mtr. of the nominal dimension limited to maximum 10mm. Refer figure 3a.

2.6.2.4 Length of the duct shall be within ± 5mm for duct length upto 5 metres and ± 10mm for length above 5 metres.

2.6.2.5 The height of hopper & chimney shall be within ± 5mm.

2.6.2.6 The deviation from flatness of contact face of the flange shall be within 2mm.

2.6.2.7 Twist of sections shall not exceed 3mm/M limited to 10mm Max.

2.6.2.8 Permissible shift in stiffener location of walls shall be within ±10mm.

2.6.2.9 Permissible shift in guide vane shall be within ±5 mm.

2.6.3 ELBOWS

2.6.3.1 In addition to the above tolerances, the arm length of elbows shall be as per fig.3b.

2.6.4 TRANSITION

2.6.4.1 In addition to the above tolerances,Centre offset of transition top and bottom openings shall not be more than 3 mm/metre height limited to 10 mm max. Refer figure 3c.

2.6..5 FLOW METERS

2.6.5.1 Profile shall be checked using a template to cover the leading edge upto lower tapping points and the gap between profile and template shall not exceed 2mm. Ref fig.1

2.6.5.2 Throat distance shall be within ± 2mm.

2.6.5.3 The position of metering holes w.r.t.leading edges shall be within ± 2mm.

2.6.5.4 Out of straightness of aerofoil shall be within 1mm/metre limited to 3mm max.

2.6.5.5 Metering tubes shall be assembled separately outside maintaining the distance of tapping points and matched with tapping points on aerofoils.

2.6.5.6 Assembled tubes shall be kerosene leak tested for leak tightness and fitted with profile.

2.6.6 FLANGES

2.6.6.1 Permissible deviation on nominal inside dimensions of rectangular/circular flanges shall be as given below.

| Nominal dimension range in mm | upto 1000 | above 1000 upto 2000 | above 2000 |
|---|---|---|---|
| Permissible deviation in mm | +1.0<br>-0.0 | +2.0<br>-0.0 | +4.0<br>-0.0 |

The difference between diagonals shall not exceed 1.5 mm / M of nominal diagonal limited to 5 mm max. Ovality in ID of the circular flanges shall be within 2 mm / M of nominal ID limited to 10mm max.

2.6.6.2 For flanges the center line of the bolt holes in opposite face shall be parallel within ± 2 mm.

2.6.6.3 Individual pitch of holes shall be within ± 1mm. However for rectangular flanges the cumulative variation in hole pitches shall not exceed ±2 mm.

2.6.6.4 Holes shall be made only by drilling. Tolerance on hole size shall be within ± 1mm.

2.6.6.5 The waviness in walls shall be checked with thread & by placing at the extreme point of the wall with equal thickness spacers placed in position Maximum waviness shall not be more than 6mm/M subject to 10mm max.

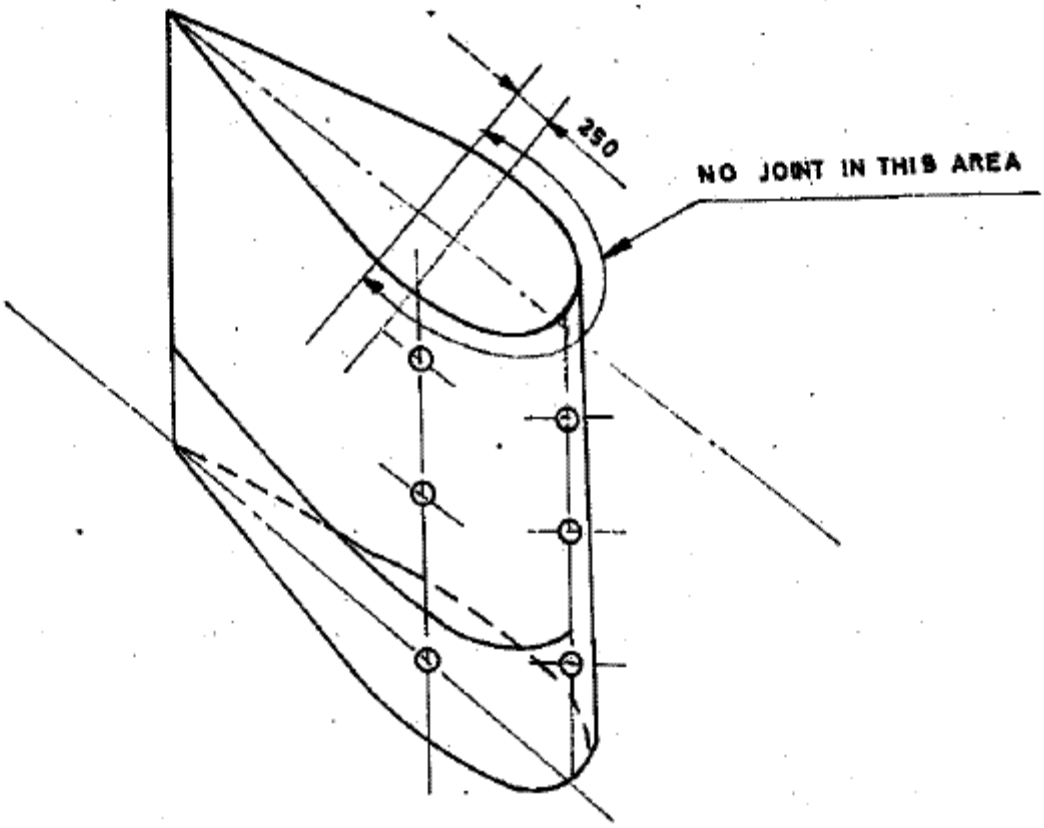
NOTE - 3

3.1 Surface preparation,Painting and Identification

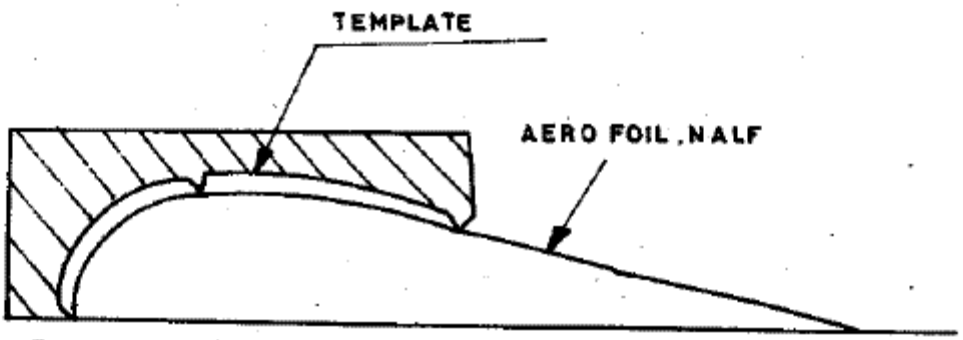
3.1.1 Temporary cleats, bridge-on pieces shall be removed carefully so as to avoid damage to parent material. Temporary tack welds shall be ground smooth. The completed assembly shall be thoroughly cleaned to remove spatter, slag, rust, oil or grease.

3.1.2 Surface preparation, painting and Identification shall be as per SIP:PP:22 & QCP 002.

Fig. 1 : Splicing detail of Aerofoil and Profile Template

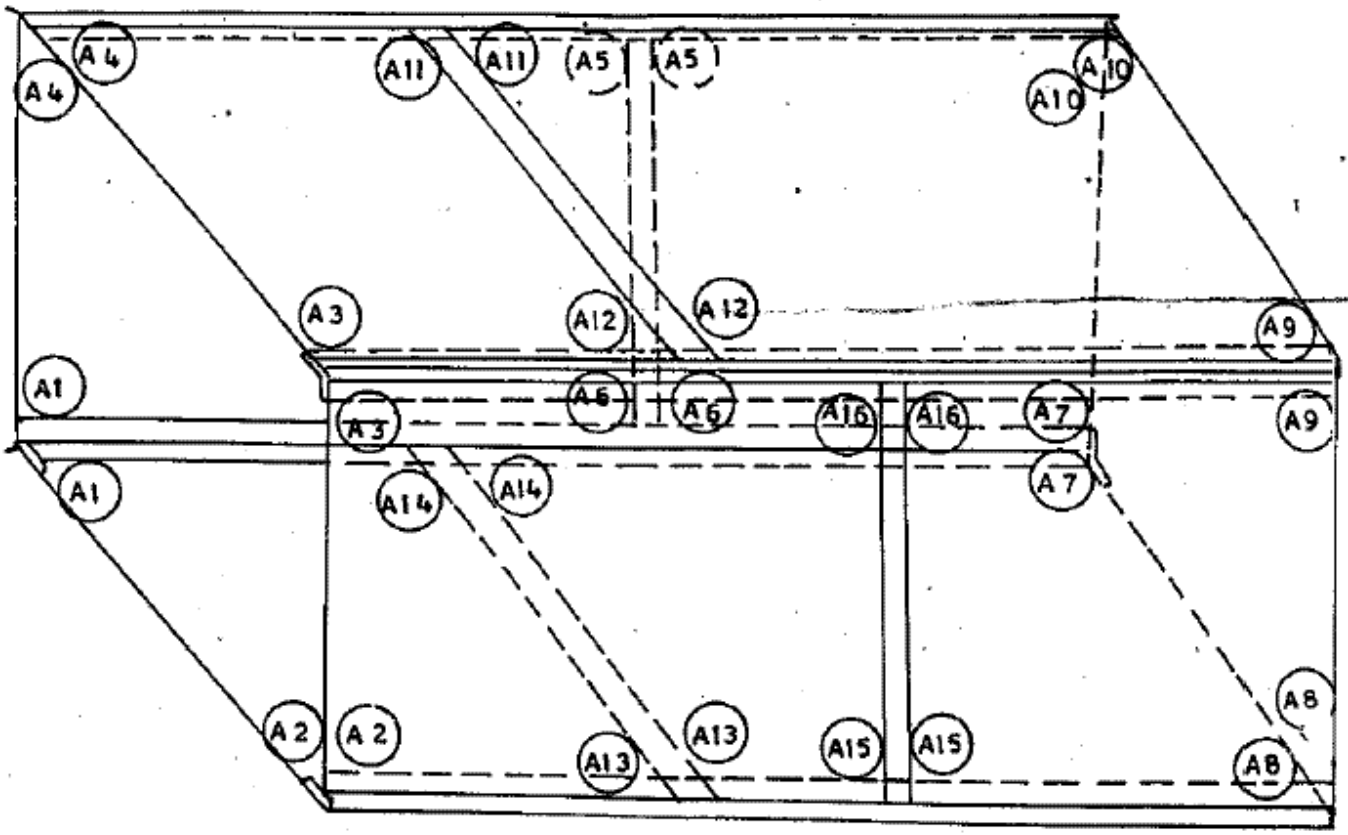



1. NO VERTICAL JOINT IS PERMITTED IN THE LEADING END MARK.
2. HORIZONTAL JOINT SHALL BE 250 MM AWAY FROM TAPPING POINTS.
3. FORMATION OF PLUS JOINTS SHALL BE AVOIDED




4. TEMPLATE SHALL BE MADE FROM 5MM. PLATE
5. VARIATION IN GAP BETWEEN TEMPLATE AND AERO FOIL SHALL BE LESS THAN ± 2.00 MM

Fig.2 : Match marking after trial assembly

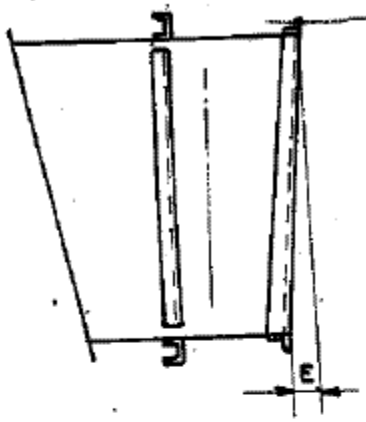



(X)-FARSIDE

(X)-NEARSIDE

Fig. 3a,3b and 3c :Tolerances

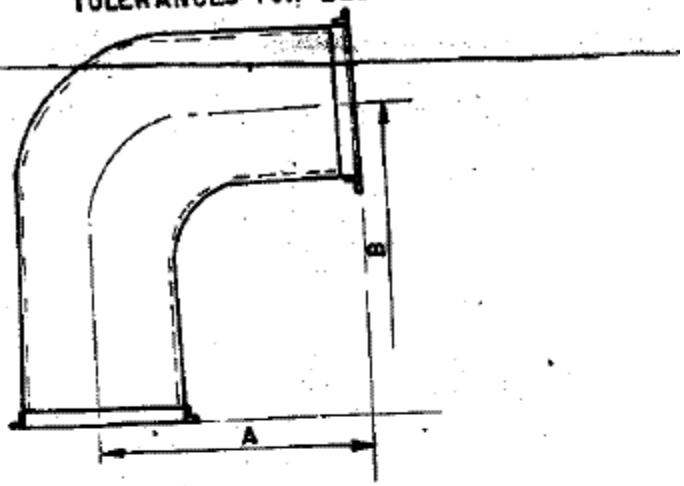
END OUT OF SQUADNESS




END OUT OF SQUARENESS 'E' SHALL NOT EXCEED 2MM PER METRE OF DIAMETER OR THE DEPTH OF THE SECTION

3a

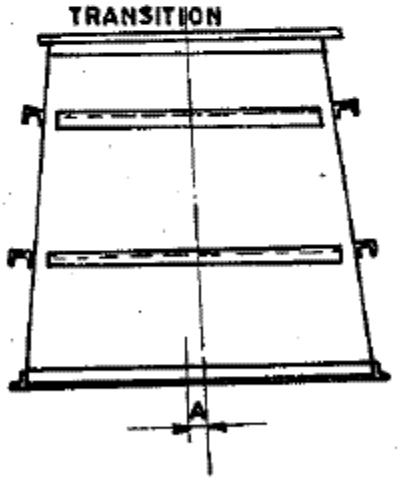
TOLERANCES FOR ELBOW




TOLERANCE ON A : ± 2 MM/M NOT EXCEEDING 3MM

3b

TOLERANCE ON B : 2MM/M NOT EXCEEDING 5MM




3c. AXES SHIFT 3MM M/OF NOMINAL HEIGHT NOT EXCEEDING 5MM.