

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

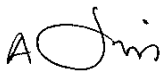
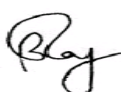
AMENDMENT TO QUALITY WORK INSTRUCTIONS (QWI)

QWI NO: QCP002 REV.: 04 Dt. 08.12.2011

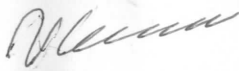
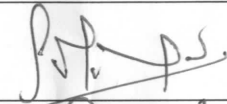
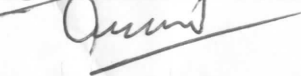
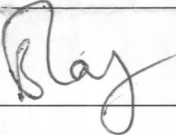
AMENDMENT SL NO: A1 DATE: 13.06.13


Page 1 of 1

DESCRIPTION:

Clause No	The existing points	Amended as...				Basis for amendment
4.6	<p>4.6 Post weld heat treatment</p> <p>Note-1:</p> <p>All fabricated components of P4 materials with any member above 16mm thickness, the entire assembly shall be Post weld heat treated. However when the size of fillet weld is less than 12mm PWHT is not required for non load carrying members..</p>	<p>4.6 Post weld heat treatment</p> <p>In respect of the fabricated components of P4 Materials , PWHT requirement of entire assembly is detailed in the tabulated columns.</p>				CE M&P and collobarator practice.
		Plate thick	Load carrying members (PWHT)		Non-Load carrying members (PWHT)	
			Fillet size >12mm	Fillet size =<12mm	Fillet size >12mm	Fillet size =<12mm
		>16mm	YES	YES	YES	NO
		16mm & below	NO	NO	NO	NO
NOTE	The above-mentioned changes will be incorporated in the relevant QWI during the next revision of the document.					
 Prepared by: A.Francis			 Approved by: Bikramoditya Roy			
Dt: 13-06-2013			Dt: 13-06-2013			

BHARAT HEAVY ELECTRICAL LIMITED**TIRUCHIRAPALLI****QUALITY CONTROL PROCEDURE****For
Non Pressure parts****QCP:002/04**Prepared by A.Francis
Quality assuranceA 

Reviewed by	SIGNATURE
Engineering (Shri.V.Sridharan)	
Out sourcing (Shri.S.Mohanram)	
Quality control (Shri.Amitroy)	
Quality Assurance (Shri.Bikramodityaroy)	

Revision No	Date	Approved	Signature
00	01-04-1993	--SM/QA	--Sd--
01	01.01.1995	SM/QA	--Sd--
02	24.04.2004	SDGM/QA	--Sd--
03	10.06.2010	SM/QA	--Sd--
04	08.12.2011	DGM/QA	

Proprietary data - For internal use

ECORD 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		Editorial correction made for better clarity. Scope of machining added in this document.
03		Shaded clauses & Type of joints for base plates incorporated. Pwht temperature for P4 matl.revised.
04		P91&92 Bar process requirements added (Shaded clauses)

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):

<u>P No. Group</u>	<u>Specifications</u>
P1 - Group 1 - SA 515 Gr 60.	Carbon steel IS 2062/ E250A & E250B , IS 1239, IS 1161, A 36,
P1 - Group 2 -	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.
P5A – Gr 1(LAS),	SA 387 Gr 22 Cl.1 &Cl.2, SA 182 Gr F 22
P5B-Gr.1 (AS)	SA387 Gr5 Cl.1 & SA387 Gr9 CL.2
P15E Gr1	SA182F91, F92 , SA387 Gr.91,GR.92, SA335 P91, P92
	SA213T91, T92, SA234WP91, WP92&SA336F91, F92
P6 -	SA 240-410,429
P8 - Stainless steel	SA 240 - 304 ,309,310, 316, 321, 347 & 253MA
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 materials 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 specifications 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 grinding the notches smoothly for 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 either by groove weld/fillet weld sufficient to hold the parts in place instructions given in the respective SQPs/ Drawings/DCN (Incl. Production Notes)
- 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 $t > 12.5\text{mm}$ and for P5 materials $t > 10\text{mm}$.
- 4.1.8 Shearing /Flame/gas cutting is prohibited on Gr 91 and Grade 92 materials.
- 4.1.9 Use only bandsaw for cutting of Gr91&92 materials. However for plates use plasma/waterjet/bandsaw only
- 4.1.10 The requirements of preheat for gas cutting are as follows:
- | | | |
|--------------------------|----------------------------|---------------------|
| Carbon steel | $t \leq 50\text{mm}$ | Nil |
| Carbon steel | $t > 50\text{mm}$ | 100 ° C.min. |
| Alloy steel (P4) | $t \leq 25\text{mm}$ | Nil |
| Alloy steel (P4) | $t > 25\text{mm}$ | 150 ° C |
| Alloy steel (P5A,B Gr.1) | All | 150 ° C |
| Stainless steel | | Not applicable..... |

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

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

4.1.11.1 For materials other than P5, P15E Gr 1(Grade 91) and Grade 92 this heat treatment may be clubbed with the final heat treatment of the product.

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

4.1.13 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 Before forming , proper cutting plan (Drawing dimensions with process allowances) shall be prepared and cleared by the concerned agency. Forming shall be done using proper tooling free from damages. Method of forming and work centre shall be identified in OPS / relevant QWI referred in PO.

4.2.2 Built up (Forming) operations for Beams and columns shall be done by suitable Fixtures,Machines ,WPS & other accessories required for forming. All the Forming operations of sheets / plates shall be done by rolling / pressing. For shell formed components 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 /Built up 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: **Forming of U-ROD(Gr 91 &92)**

4.2.6.1 Identify, mark and cut the rod using bandsaw to a length of equivalent to the arc length indicated in the drawing with two arm length(upto butt joint) +20mm .

4.2.6.2 Mark the centre of the rod with a heat resistant chalk to be visible after heating. For temperature and other details refer the SQP:NP:15(Latest)

4.2.6.3 Remove the “U”rod and air cool to room temperature .

4.2.6.4 Visually inspect the bend surface and check dimensions and ensure no surface imperfections.

- 4.2.6.5 Normalizing and tempering of “U” Rods to be done within 72 hours after pressing/bending operation.(Ref.SQP:NP:15(latest))
- 4.2.6.6 Shot blast the “U” Rod to remove scaling and check the dimension. Conduct LPI/Wet MPI and ensure no surface indications.
- 4.2.6.7 Mark and cut the limbs of “U” rods such that the straight portion shall be as per drawing from the tangent point.
- 4.2.6.8 Edge prepare the “U” rods for butt joint preparation as shown in the drawing by machining No gouging and grinding is allowed.
- 4.2.6.9 For Detailed operation of cold and hot forming of Gr 91 & Gr 92 materials refer SQP:NP:15(latest)
- 4.2.7 Threading of “U” Rods
- 4.2.7.1 Mark and cut the rods equivalent to the straight portions as shown in the drawings.
- 4.2.7.2 Threading to be done on one end of the rod to thread size as mentioned in the drawing/SQP: NP15(latest).
- 4.2.7.3 Edge prepare the other end of the rods by machining for butt welding as shown in the drawing.
- 4.2.8 Tolerances for formed components when not specified in drg. /SQP:NP15(latest). Shall be as follows
- a) St.Length / Dia, : + 1 mm/M, 5 mm Max
 - Width & Height
 - 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 : $+ 2^\circ$
 - g) Ovality : 1%
 - h) E.P Angle : $+ 5^\circ / - 2.5^\circ$
 - 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 (E 7018) shall be used in the following cases:-
- a. All Strength welds in ceiling girders, flange/web butt welds and 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 BSEN 10025 E250A & B, 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 250-300 deg.C for 2 hours and the electrodes shall be held at 120 deg.C until they are used. Electrodes shall not be re-baked more than once and use of electrodes in wet condition is prohibited.
- 4.3.1.5 All rutile electrodes (EXX 13) shall be dried at 120 deg. C for 1 hour min. and held at 120 deg.C till use.
- 4.3.1.6 Fluxes for SAW shall be dried at 250 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 ° - 150 ° C until use.
- 4.3.1.8 The type of welds employed in the structural fabrications (Girders, Columns, Beams & Base plates etc) are identified in the annexure –A along with sketch for better clarity and understanding. For further details the fabricator can refer the engg.dwg. no.3-35-110-00995/00

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. However for P15E Gr.1.(F91 & F92) prepare a fixture for fit-up of butt joint of 'U' rod with Straight rods.
- 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 - 3 mm
Root opening of joint* with backing)	+ 6 mm - 2 mm	Not Applicable
3. Groove angle of of joint	+ 10° - 5°	+ 10° - 5°

*(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 buildup 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.
- 4.3.2.5 The types of weld joints indicated in the fabrication of structural components are identified with symbols in ANNEXUR -A & B .For further details refer the Engg standard drawing no.3-35-110-00995(Latest)

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 chinks or thermocouples prior to start of welding as well as during welding for a width of 't' (maximum) or (100)75 mm whichever is less.
- 4.3.3.4 Where interpass temperature control is required during welding, the temperature must be ensured using thermal chinks / thermocouples with recorder . 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 after welding, the preheating shall be continued 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 (including away centre fabrication) , for requirements of procedure and personnel qualification SIP:NP: 07 (Latest) 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. However for P15E Gr.1.(F91 & F92) Only back grinding to be done after interstage PWHT.
- 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.For further details ref.SQP:NP:20

- 4.3.7.2 While cutting long web plates suitable camber may be provided /required to compensate for the distortion 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.
- 4.3.15 Pre heating of Gr 91 &Gr 92 shall be 220 Deg.C .For other process parameters refer the applicable WPS.

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 ° C and shall be ensured using thermal chinks / thermocouples.

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

4.5.3.1 For Austenitic stainless steels the maximum temperature shall not exceed 430 ° 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 315° C and shall be made known to inspection authorities . The temperature shall be ensured using thermal chinks / 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 ° 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 ° C during heating period (above 315 ° 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	625 +/- 25 ° C	a) For all butt welds in plate welded girders when t > 50mm.
	T= 39-62	100 ° C		
	t> 63	150 ° C		

P4 Gr 1&2	All	150	665 +/- 15 ° C	a)All butt welds in tension member b)All fabricated components when t>16mm(Note1)
P5A Gr 1& P5BGr2	All	150 ° C (Note2)	705+/- 25 ° C	All welds (Note 3)
P15E Gr1	All	220 ° C	760+/- 10 ° C	After welding, cool to below 95 ° C before PWHT. PWHT to be done within 72hrs after completion of welding .(Post heat as perWPS)
P8	300 type 400type	120 ° C 205 ° C	- -	

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 ° C for 2 hrs or 150 ° 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:

- 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".
- 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".
- For combination 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, P1C + P4, P1 + P3 P4 + P5A, P15E Gr1	Up to 25 mm	125
	26 - 50 mm	200
	51 - 80 mm	250
	81 - 150mm	375

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 - 670° C.

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

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

- 4.6.7.3 For PWHT of P15E Gr 1 (Grade 91) & Grade 92 materials, soaking time shall be 1 hour per/inch with minimum soaking of 1 hour. The hardness of the weld metal or heat affected zone after PWHT shall be within 181 BHN to 303 BHN.
- 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 °C and Rate of Cooling (ROC) are as given below. During heating and cooling, variation in temperature between thermocouples shall be 85 °C maximum, unless otherwise specified.

Thickness	ROH / ROC (Max) Above / upto 315 °C
Up to 25mm	220 °C / hour
26 - 50 mm	95 °C / hour
50 – 75 mm	70° C / hour
Above 75 mm	55 °C/hour
For S.S Matl	200 °C / hour min (Forced air cooling)
GR 91 &92	Furnace cooling upto 350 °C

- 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 400° 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.
- All Butt welds of Carbon steel for thickness $t > 32\text{mm}$
 - All butt welds of alloy steels for thickness $t > 12.0\text{mm}$ for P5 and $T > 16\text{mm}$ for P4.
 - All butt welds in monorails.
 - SS butt welds of $T > 16\text{mm}$ unless otherwise specified.
- 5.3.1 All radiographic films shall possess Firm code , RT agency, Cust. No, Part No, RT reference Number. and weld location reference number. The job shall be numbered with Radiograph number.
- 5.4 MPI / LPI BEFORE PWHT
- All flame cut edges of Carbon steel for $t \geq 38\text{ mm}$ and alloy steels for $t > 12\text{mm}$.
 - 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.
 - All fillet welds between tension flange and web.
 - 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.
 - 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 hardware (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.

.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 $\pm 0.5^\circ$
- b. Other characteristics $\pm 1^\circ$

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.

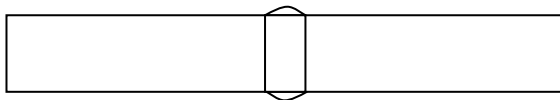
8.0 CLEANING AND PAINTING

- 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 weldable 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.

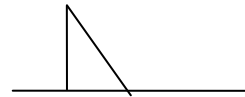
- 8.3 Match marking and flow direction for applicable components shall be as per the respective product SQP./Drawing
- 8.4 The following details shall be clearly marked with relevant details by paint, bordered and covered by one coat of transparent varnish
- Project Name :
 Work order number , DU NO. Weight & Sub-contractor Name/Code:
 Component / Assly. Designation :
- 8.5 Tension flanges in girders are to be identified by hard punching indicating 'TENSION FLANGE'
- 8.6 Apply grease on the threaded portion of "U"Rod and protect the threaded portion from damage with suitable plastic end caps.
- 8.7 For subcontracted items the firm code shall be punched and bordered with white paint.

ANNEXURE - A

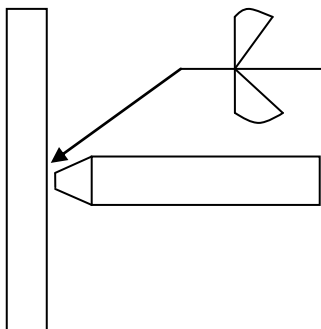
SQUARE BUTT WELD



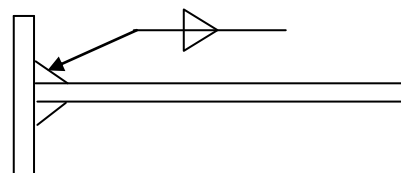
BEVEL WELD



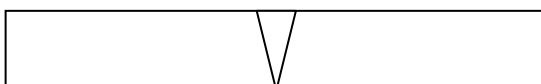
K WELD



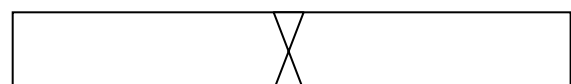
FILLET WELD



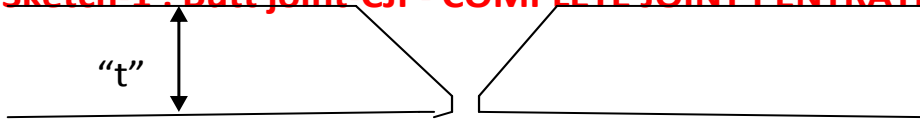
SINGLE V JOINT



DOUBLE V JOINT

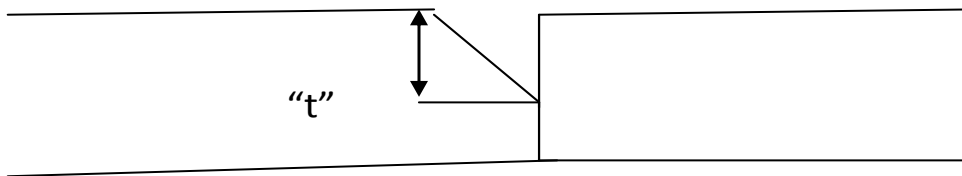


ANNEXURE-B

Sketch-1 : Butt joint-CJP- COMPLETE JOINT PENTRATION

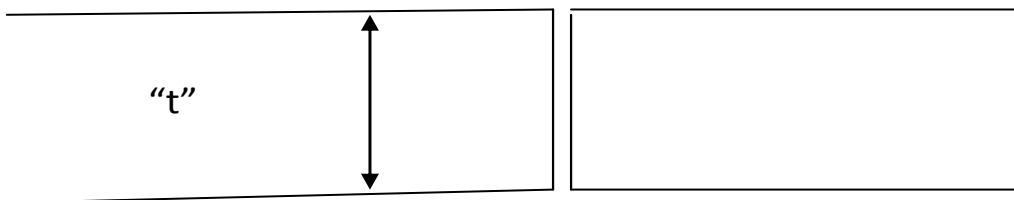
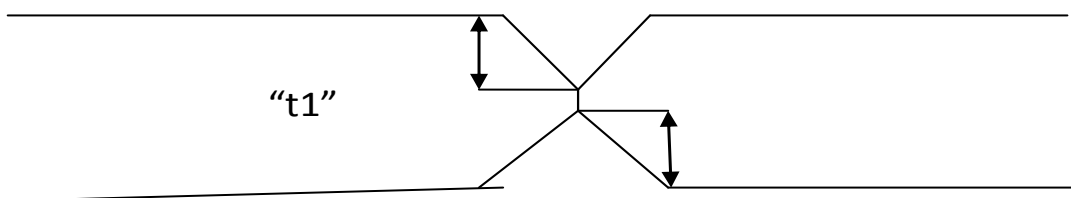
Where “t” is base metal thickness . If “t” is > 50mm PWHT to be done.

If “t” is > 32mm RT to be done.

Sketch: 2 GROOVE Butt joint-PJP- PARTIAL JOINT PENTRATION

Where “t” is weld metal thickness. If weld depth is >50mm PWHT to be done

RT: is not applicable.

Sketch:3 - SQUARE BUTT JOINT PWHT & RT is not applicable in this case**Sketch:4 - DOUBLE “V” GROOVE BUTT JOINT –PARTIAL PENTRATION JOINT**

Where “t” is equal to $t_1 + t_2$. If “t” is > 50mm PWHT to be done. RT is not applicable

Sketch:5 – “K” GROOVE WELD BUTT JOINT –PJP-PARTIAL PENTRATION JOINT