

	Bharat Heavy Electricals Limited,Piping Centre, Chennai QUALITY CONTROL PROCEDURE FOR FABRICATION OF PIPING	DOC No : QCP : 10 Amendment No : 02 Date : 02/12/2011 Page 1 of 1
---	--	--

Colour code for Pipes & Fittings indicated below supersedes that indicated under Annexure I & II of Rev 00 of QCP10.

ANNEXURE I & II

Sl.No	PIPE / FITTING SPECIFICATION	COLOUR CODE
1	SA 106 Gr.B , SA 234 WPB/WPBW	Red
2	SA 106 Gr.C , SA 234 WPC , SA 105	Blue
3	SA 312 TP 304 , SA 403 WP 304 , SA 182 F304	Blue & Yellow
4	SA 312 TP 304L	Blue, Red & Yellow
5	SA 312 TP 304H	Black, Blue & Yellow
6	SA 312 TP 316, SA 403 WP 316, SA 182 F316	Black & Green
7	SA 312 TP 321, SA 403 WP 321, SA 182 F321	Blue & Brown
8	SA 312 TP 347	Blue, Red & White
9	SA 312 TP 347H	Black & Yellow
10	SA 335 P11, SA 234 WP 11 , SA 182 F11	Green & White
11	SA 335 P12 , SA 234 WP 12, SA 182 F12	Black & Red
12	SA 335 P22 , SA 234 WP 22 , SA 182 F22	Blue & Red
13	SA 335 P91, SA 234 WP 91, SA 182 F91	Brown & Red
14	SA 672 Gr.B 60 Cl 22	Red & White
15	SA 672 Gr.B 70 Cl 22	Red & Aluminium
16	SA 691 Gr.11	Green & White
17	SA 691 Gr.12	Black & Red
18	SA 691 Gr.22	Blue & Red
19	SA 790 S32205 , SA 815 S32205 (Duplex Stainless Steel)	Red , White & Green
20	IS 1239 Heavy (ERW)	Violet
21	IS 3589 (ERW)	Aluminium , Brown & Green
22	DIN 17175 Grade 13 CrMo44	Aluminium & Black
23	API 5L Gr.B	Aluminium
24	X20 Cr Mo V 121	Black

**For other specifications, QA to be consulted.

NOTE : The above colour code also supersedes that indicated in Annexure IA of QCP 07 Rev 02.

Prepared by  VIVEKANANDA YELLU ENGR/QA	Approved by  G.PANNEER SELVAM DGM/QA
---	---



Equipment : Piping

Engineering

Orig. Issue

Distribution :

Page 1 of 38

MASTER COPY

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

1.0 SCOPE

1.1 This procedure details out the requirements for fabrication of piping and associated pressure parts with respect to :

- a. Material identification and traceability
- b. Process controls
- c. Inspection and testing
- d. Calibration / verification of equipments and instruments
- e. Handling, storage and preservation.

1.2 This procedure is applicable for fabrication and inspection of piping both Class-I and Class-II for steam carrying purposes coming under the Indian Boiler Regulations, the parameters of which is given below:

a. Class-I - Pipelines for service conditions in which any one of the following limit is exceeded.

Design temperature	:	218°C (425°F)
Design pressure	:	17.6 kg/cm (250 lbs/sq.in)
Feed water	:	24.6 kg/cm (350 lbs/sq.in)

b. Class-II - Pipelines of service conditions in which none of the foregoing limits is exceeded.

1.3 This procedure is limited to various disciplines to be followed during fabrication. The specific product quality requirements are detailed out in the respective Standard Quality Plans (SQP) / Testing and Inspection Procedures (TIP).

1.4 This QCP is adapted from QCP:2:2:040 and QCP:001/00 issued by Quality Engineering, BHEL Trichy.

2.0 REFERENCE DOCUMENTS

- | | |
|----------------|------------|
| 1. IBR | 5. BS 806 |
| 2. ASME | 6. BS 2633 |
| 3. ANSI B 31.1 | 7. DIN |
| 4. PFI | 8. TEMA |

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

3.0 MATERIALS

3.1 Materials normally used are:

- Pipes
 - SA 106 Gr.B, Gr.C
 - SA 335 P 11, P12, P22, P91
 - BS:3604:HFS:622:31
 - X 20 Cr Mo V 12 1
- Plate Formed Pipes
 - API 5L Gr.B
 - SA 672 Gr.B 60, Gr.B 65, Gr.B 70
- Nipples, Nozzles and forgings
 - SA 105
 - SA 182 F11, F12, F22
 - SA 209 Gr.T1
 - SA 210 A1, Gr.C
 - SA 213 Gr.T11, Gr.T22
- Attachments
 - SA 515 Gr.60, Gr.70
 - SA 516 Gr.60, Gr.70
 - SA 387 Gr.12, Gr.22
 - SA 240 TY 304
- Orifice plate
 - SA 304

3.2 Receipts:

- 3.2.1 The raw materials and sub-deliveries are procured to the requirements as per relevant TDC / specification.
- 3.2.2 On receipt, all materials shall be inspected and test certificates shall be verified.
- 3.2.3 Customer supplied materials shall be verified for the requirements of further processing.

3.3 Issue:

- 3.3.1 The requirements of material traceability shall be met-out by indicating the material identification and study of the respective drawings / material requisition slips/ material issue vouchers as "Attest / Certify" as required.
- 3.3.2 Attested materials marked as "A" shall be traceable to the test certificates and identified with specification and melt number. The identification is stamped in case of

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

pipes $\varnothing \geq 80\text{mm}$, plates and forgings and engraving / stencilling in case of pipes $\varnothing < 80\text{mm}$ and tubes and issued with attestation cards. In addition all pipes and tubes shall have colour codes for specification. Refer Annexure-I and Annexure-II for colour.

- 3.3.3 Certified materials marked as "C" shall be traceable to specification / Grade, identified by stamping/ engraving/ stencilling/ colour coding/ marking.
- 3.3.4 Non attested and non certified raw materials shall be identified by its material code/ specification/ grade by painting or stencilling or engraving. All subdeliveries shall be identified by its material code painted on the material or inscribed on the tag attached to the material.
- 3.3.5 At the time of issue, QC shall ensure the correctness of material to the MIV/ MRS/ CRS.
- 3.3.6 At the time of issue QC shall identify the material, verify the TC and carry out visual inspection.
- 3.3.7 In case, stocked raw materials are to be used for special contract requirements, QC shall ensure that the respective TCs and laboratory reports satisfy specification/special requirements of TDC (TDS), as applicable.
- 3.4 **Process Materials Inspection:**
- 3.4.1 All materials shall be ensured to be free from defects like pittings, dents, laminations, scales, warpages etc. and cleared by issue inspection. When defects are noticed the same shall be confirmed by visual examination or using appropriate NDT techniques and corrected before use in consultation with QC.
- 3.4.2 In case of pipes and tubes, if the deviation from straightness exceeds 1mm/metre length, the same shall be corrected before use.
- 3.4.3 Correctness of raw material identification, heat treatment condition and attestation to drawing requirements shall be ensured as required. Traceability to the contract shall be ensured by stamping or marking/ painting the WO No. and DU/ Part No. as applicable.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

| QCP:10:0

Dt 16.03.94

- 3.4.4 Before marking, cutting or machining, the transfer of material identification shall be ensured. In case of tubes, the colour code shall be transferred.
- 3.4.5 In case of components / part processed items received from subcontracting / other shops the completeness and clearance by QC/ Customer Inspector through IR or Dimensional reports / OPS shall be ensured.
- 3.4.6 Proper care shall be taken during handling of materials / components at any stage of manufacture. Items stored in the shop floor shall be properly identified and preserved to prevent damages / rusting / warpages.
- 3.4.7 Correctness of welding consumables shall be ensured before use. The batch traceability shall be maintained through records.
- 3.4.8 All welding consumables shall be properly identified and stored. Pre-treatment like baking/ drying of welding consumables before use shall be ensured. The issue of welding consumables shall be recorded.

4.0 **FABRICATION**

4.1 **Marking, Cutting and Machining:**

- 4.1.1 The layout marking shall be punched at intervals with proper allowance for cutting / machining / forming / welding. The identification marks of specification/ grade and melt number shall be transferred on the balance materials and certified by QC. Layout inspection shall be performed prior to cutting.
- 4.1.2 Reference line marking shall be ensured at a distance of about 100mm from the free ends. In case of pipes meant for bending and attachment welding, centre line marking shall be done.
- 4.1.3 Cutting may be done by shearing or gas cutting. Shearing can be done for thickness upto 25mm for ferritic material and upto 15mm for stainless steel. Stainless steel above 15mm in thickness shall be plasma cut.
- 4.1.4 During cutting, proper preheating shall be ensured. The requirements of preheating for gas cutting is as follows:

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

Carbon steel upto and incl. 25mm	: Nil
Carbon steel above 25mm	: 100°C min.
Alloy steel (all t) & SA299	: 150°C min.
Stainless steel	: Not applicable

4.1.5 The cut edges shall be ground smoothly to a depth of at least 1-2mm to remove the surface irregularities, work hardening and heat affected zone (HAZ). Deep serrations if any shall be ground shallow without any sharp edges.

4.1.6 The ends prepared for welding shall conform to the relevant drawing. Removal of the burrs, chips etc. shall be ensured. All Edge Preparations (EP) which are gas cut and ground shall be checked by LPI/ MPI.

4.1.7 All drilled / bored holes and machined areas shall be cleaned and deburred.

4.2 **Forming:**

4.2.1 Forming shall be done using qualified toolings. The toolings, rollers and other accessories shall be cleaned and free from high spots. In case of cold forming of stainless steel materials, proper packing like asbestos sheets should be provided to prevent direct contact with forming tools to avoid damages. In case of any hot forming, the material shall be heated all round uniformly to the specified temperature.

4.2.2 The material shall be properly positioned and checked for alignment before forming.

4.2.3 The process / tooling shall have been qualified by a First off trial and the records shall be verified before production.

4.2.4 Plates shall require normalising before cold forming if the material received is in "as rolled condition".

4.2.5 In case of forming of shells, the profile shall be periodically checked using a template of forming radius and chord length shall be at least equal to 1/4 ID.

4.2.6 Wherever cold rerolling of shells is done after welding, the following shall be ensured prior to rerolling.

a. Flush grinding of weld reinforcement on both surfaces

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

- b. Interstage stress relieving, if the thickness exceeds 50mm.
- c. MT, RT/UT shall be done after rerolling.
- 4.2.7 The method of forming - hot or cold and heating parameters shall be as specified in QP unless specified otherwise.
- 4.2.8 Waviness in formed areas shall be merged gradually into the base material surface, limited to the acceptable limits as specified in QP.
- 4.2.9 Heat Treatment shall be done after forming subject to following :
 - 4.2.9.1 Unless otherwise specified, for cold forming,
 - a. No heat treatment is required, if the Fibre elongation is $\leq 5\%$ for all ferritic materials and $\leq 10\%$ for SS.
 - b. If Fibre elongation is more than 5%, the stress relieving (SR) for carbon steel, Normalising / Normalising and tempering for alloy steel and solution annealing for SS materials (if FE $> 10\%$) shall be done to temperatures given in the HEAT TREATMENT TABLE given below.
 - 4.2.9.2 Unless otherwise specified, for hot forming of P1 & P3 materials.
 - a. Normalising is required.
 - b. If heating does not exceed normalising range and termination of forming is above 620°C, no heat treatment is required.
 - c. If termination of forming is below 620°C, stress relieving shall be done.
 - 4.2.9.3 Unless otherwise specified, for hot forming of P4 & P5 materials
 - a. Normalising and Tempering is required.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

b. If heating does not exceed normalising range and termination of forming is above 710°C, tempering alone is required.

c. If termination of forming is below 710°C, normalising and tempering is required.

4.2.9.4 Unless otherwise specified, for hot forming of P8 materials, solution annealing is required.

4.2.9.5 **Heat Treatment Table:**

Material	Type of HT	Temperature
P1	SR Normalising	595-620 880-900
P3	SR/Tempering Normalising	620-650 900-920
P4	SR/Tempering Normalising	650-680 920-950
P5	SR/Tempering Normalising	680-705 920-950
P8	Soln. Annealing	1050-1100

NOTES:

a. Unless otherwise specified, the soaking time shall be as follows:

Hot working/ Normalising: 30 minutes per 25mm
thickness (t)
(15 minutes minimum)
SR / Tempering : 60 minutes per 25mm
thickness (t)
Solution Annealing : 15 minutes

b. For SR of carbon steel materials, minimum soaking time shall be 15 minutes while for alloy steels it shall be 30 minutes.

c. In case of stress relieving, cooling shall be in the furnace upto 400°C (minimum) and further in air.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

where "t" indicates the nominal thickness for plates/ pipes and diameter for bar stock.

- d. In case of normalising and tempering, cooling shall be in still air.
- e. Tempering can be clubbed with final stress relieving of the product / component.
- f. In case of solution annealing shall be as fast as possible.
- g. All heat treatment shall be applied only after the temperature of the component falls below 200°C. The temperature of the furnace during loading shall be below 300°C.

4.3 Welding:

- 4.3.1 The welds shall be free from harmful defects such as cracks, undercuts, folds, burn through etc. and shall have workman like finish. The size of the weld shall not be more than the drawing requirement.
- 4.3.2 When parts of different thickness are welded together the change in thickness shall be made gradual either by grinding or machining to a 1:4 taper.
- 4.3.3 All the bridge on pieces shall be welded only with necessary preheat and matching electrodes.
- 4.3.4 Where tack welds are used in fitup, they should either be removed completely or properly prepared in accordance with detail drawings. In either case, tacks should be suitable so that they may be incorporated into the final weld. Tackwelds which are found to be defective by visual examination shall be removed.
- 4.3.5 Welding shall be performed with qualified procedures using qualified welding personnel. Welding procedures shall be qualified to ASME Sec.IX / DIN. Welders shall be qualified to IBR / ASME Sec.IX / DIN unless specified otherwise..
- 4.3.6 Welding area covering the base material to approximately 15mm on either side shall be thoroughly cleaned and ensured free from oil, grease, rust, scales etc.

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

QCP:10:0

Dt 16.03.94

- 4.3.7 Fitup of the joints shall be ensured as per drawing. All run-in and run-out pieces, bridge on pieces and temporary attachments shall be identified and welded with necessary pre-heat and matching electrodes.

The material for temporary attachments shall be ferritic for ferritic materials and stainless for stainless steel.

- 4.3.8 During matching of circumferential seams, the location and orientation of ells, tees and other fittings shall be checked.

- 4.3.9 Tack welds used to secure alignment shall either be removed completely when they have served the purpose or their stopping and starting ends by grinding or by other suitable means so that they may be incorporated into the final weld.

Tack welds shall be done using qualified procedure and personnel to a sufficient length and width. Tack welds found defective during visual examination shall be removed.

- 4.3.10 The circumferential seams shall be matched for welding as per drawing. Root offset and misalignment shall not exceed 1.6mm for SAW or TIG. When backing rings are used maximum gap between rings and pipes shall be 0.40mm.

- 4.3.11 The general tolerance for alignment (surface mismatch) of butt welds shall be as per table below. However where additional requirements are specified, the same shall be detailed in the respective QP.

In case of single side welding, the maximum misalignment for butt welds shall not exceed 1.6mm. However where backing rings are used, the gap between backing ring and surface shall not exceed 0.4mm.

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

QCP:10:0

Dt 16.03.94

SECTION THICKNESS	JOINT CATEGORIES	
	LONG. SEAM	CIR. SEAM
Up to 13mm	1/4 t	1/4 t
Over 13mm to 19mm	3mm	1/4 t
Over 19mm to 38mm	3mm	5mm
Over 38mm to 51mm	3mm	1/8 t
Over 51mm	Lesser of 1/16t or 9mm	Lesser of 1/8t or 19mm

- 4.3.12 Pre-heating requirements for welding shall be as per the WPS and control shall be exercised as detailed below:
- 4.3.12.1 Pre-heating must be applied before starting each cycle of welding and shall be maintained during the whole process of welding.
- 4.3.12.2 Pre-heating is to be done using gas burner or induction /resistance heating methods. The temperature must be uniform and verified using thermal chinks or thermocouples prior to start of welding as well as at frequent intervals during welding.
- 4.3.12.3 Where inter-pass temperature control is required during welding, the temperature must be ensured using thermal chinks (temperature indicating crayons)/ thermocouples.
- 4.3.12.4 Wherever post-heating is specified, the pre-heat temperature shall continue after welding till attaining the post-heat temperature and maintained for the required time and cooled slowly.
- 4.3.13 The preheat and postheat shall be maintained as per Annexure-V and welding shall be carried out as per the relevant WPS.
- 4.3.14 Use of correct welding consumables during welding with proper baking / drying as applicable shall be ensured.
- 4.3.15 Surveillance shall be carried out for preheat, engagement of welders, consumables, parameters and equipment.

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

| QCP:10:0

Dt 16.03.94

- 4.3.16 After completion of welding visual inspection shall be done to ensure that the final layer fills the weld groove completely and encroaches the base material.
- 4.3.17 The surface of the welds shall be free from coarse ripples, grooves, overlaps, undercuts, abrupt ridges and valleys to avoid stress raisers. Acceptance norms for visual inspection shall be as per TIP:09:0.
- 4.3.18 The maximum permissible reinforcement on the butt welds shall be as follows:

Nominal thickness in mm	Maximum reinforcement in mm	
	Cir. Joint in pipes & tubes	Other welds
Upto 3.2	2.4	2.4
Over 3.2 to 4.8 incl.	3.2	2.4
Over 4.8 to 12.7 incl.	4.0	2.4
Over 12.7 to 25.4 incl.	4.8	2.4
Over 25.4 to 50.8 incl.	6.35	3.2
Over 50.8 to 76.2 incl.	6.35	4.0
Over 76.2 to 101.6 incl.	6.35	5.5
Over 101.6 to 127 incl.	6.35	6.35
Over 127	8.0	8.0

- 4.3.19 All circumferential seams shall be dressed suitably for radiography (including spatter cleaning).
- 4.3.20 Where parts of different thickness are welded or surface offset is observed, the change in thickness shall be made gradual, either by grinding or machining to a 1:4 taper.
- 4.3.21 Stray arcs shall be avoided. Arc spots, if any, shall be ground and checked by LPI/ MPI. Ensure thickness requirements in such cases.
- 4.3.22 After completion of welding, the welder number shall be punched by the side of the weld but away from the HAZ. In case of butt weld joints of diameter more than 108mm the punching shall be done with a low stress stamp having rounded edges. In case of butt welds of tubular products suitable records will be maintained.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

- 4.3.23 Where UT is contemplated for the weld joint, a straight portion shall be ensured for a distance of twice the thickness from the weld centre by buffing/ grinding or machining.
- 4.3.24 Butt welds shall be located at minimum 1.5 times the pipe OD from free end, which is meant for butt weld at a later stage.
- 4.3.25 **Attachments & Nozzles:**
- 4.3.25.1 The grade of material of nozzles attachments, radiographic plugs etc. shall be checked by spark testing and the quality of welds assured by surveillance.
- 4.3.25.2 Carrier plates shall be welded such that they are all in the same level at the contact surfaces with the clamp. The face of the carrier plate shall be perpendicular to the pipe.
- 4.3.25.3 After welding on one side of the carrier plates the other side shall be back ground and tested by MPI/LPI before welding the other side.
- 4.3.25.4 No weld metal shall project out of the carrier plates at the surface of contact with the pipe clamp.
- 4.3.25.5 Weld ends of attachment / nozzles shall be atleast 150mm away from butt welds.
- 4.3.26 After completion of welding of P5 materials postheat shall be maintained at 250°C for 2 hours.
- 4.4 **Bending:**
- 4.4.1 Pipe bending can be done by hot/cold on a bending machine or plate as per Annexure-IV. For hot bending the material shall be heated all round the circumference to the temperature range specified in the Heat Treatment Schedules. Care shall be exercised for minimising ovality and thinning wrinkles, stretch back, buckling, flattening etc. Records for the first off trials are to be maintained by the pipe fabricator for every R/D ratio.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

| QCP:10:0

Dt 16.03.94

4.4.2 All bends shall be checked for arm length, plane of bend and angle either with a template or protractor or layout with reference to centerline of the pipe.

4.4.3 The following tolerances shall apply for bending.

4.4.3.1 **Ovality:**

A. The deviation from circularity in percentage in any cross section of a bend shall be within the value calculated by the following formula, for IBR bends.

$$\frac{D. \text{ Max} - D. \text{ Min}}{D} \times 100 < 20 D/R$$

where

D = OD of pipe

R = Radius of Bend

B. For non-IBR bends, when R/D ratio is less than 5, the ovality should not exceed 8% of the OD. For the other R/D ratios, the above formula shall be followed.

4.4.3.2 **Thinning:**

A. Thinning for seamless pipes shall be 21.5% of the nominal thickness. (since 12.5% negative tolerance is considered for design)

B. For I.D. controlled pipes and plate formed pipes the thinning shall be 10% based on the minimum thickness.

4.4.4 To assess thinning at Tension side of the bend, the entire region shall be scanned with D-meter and the minimum thickness observed shall be recorded.

4.4.5 **Wrinkles:**

4.4.5.1 All bends shall be visually examined for wrinkles, local damage etc. Permissible wrinkles are detailed below:

A. All wave shapes shall blend into the pipe surface in a gradual manner.

B. The maximum vertical height (A in fig.1) of any wave measured from the average height of two adjoining

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

crests to the valley shall not exceed 3% of the specified pipe size.

C. The minimum ratio of the distance between crests (A in fig.1) as compared to the distance (d in fig.1) between average height of crests and the valley shall be 12. $[d = (D_1 + D_2) / 2 - D_3]$.

4.4.5.2 Wrinkles which exceed the above recommended limits shall be rectified to bring them within limits before bends are subjected to the required heat treatment. For alloy steel pipes, the area is to be tested by MPI and LPI.

4.4.5.3 Localised bulging at the start of the bend shall be treated in the same manner as above except that Cl. 4.4.5.1 (c) is not applicable.

4.5 Repair of defects

4.5.1 When defects are revealed by MPI, it shall be ground chipped until it completely disappears as confirmed MPI.

4.5.2 When defects are air arc gouged, the cavity shall be dressed and MPI done on the cavity to ensure the complete removal of defects. This is applicable for defects such as cracks. However for defects which are visible such as slag, pores etc. a thorough inspection is necessary before repair welding.

4.5.3 Repair welds shall be subjected to the same NDE as per original requirements.

4.5.4 Defects noticed shall be removed by air arc gouging or by grinding with suitable bevel as per the repair procedure. When defects are air arc gouged, suitable pre-heat shall be applied and cavity shall be ground to remove black spots. The area shall be free of any irregularities that might trap slag during welding.

5.0 POST WELD HEAT TREATMENT

5.1 Straightening of the Pipes

Prior to stress relieving, the straightness of the pipe shall be checked so that it can be arranged suitably during heat treatment to reduce out of straightness and avoid further distortion.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

- 5.2 The process controls for heat treatment shall cover the activities before, during and after heat treatment.
- 5.3 The weldment shall be cleaned to ensure free from grease, oil etc. prior to heat treatment.
- 5.4 The weld surface shall be prepared for carrying out NDE, as required before PWHT.
- 5.5 PWHT shall be done in a furnace or by locally heating a circumferential band including the entire weld and adjacent area of the base metal.
- 5.6 The heat treatment time and temperature shall be maintained for hot and cold bends and welded components as per heat treatment schedule. The recorded chart shall be checked and confirmed to the code requirement.
- 5.7 The thermocouples and recording instruments shall be calibrated and records maintained. The furnace shall have been qualified for temperature distribution.
- 5.8 All materials to be heat treated in a furnace shall be loaded in such a manner that they shall not be subjected to flame impingement in case of gas heating. They shall be preferably loaded on raised platforms so that no material projections are in plane of burners. Ensure loading of test plates also, wherever applicable.
- 5.9 Thermocouples shall be attached to the component to be heat treated to measure the temperatures at the anticipated hottest and coldest points on the components. No more than 6 thermocouples shall be required for a furnace charge.
- 5.10 In case of large components, the distance between each thermocouple shall be atleast 15 feet minimum. The maximum temperature variation between any two thermocouples in such cases during heating/ cooling shall be within 20°C.
- 5.11 Local heat treatment can be carried out by one of the following methods;
- a. Resistance heating
 - b. Induction heating

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

- 5.11.1 When heat treating welded joints, width of the heated circumferential band on either side of the weld (W) must be atleast 3 times the width of the widest part of the weld groove, but in no case, less than twice the width of the weld of the weld reinforcement in the case of butt joints. In case of nozzles and attachment welds, the circumferential band shall extend around the entire vessel, shall include the nozzle or welded attachment and shall extend atleast 6 times the base material thickness beyond welding which connects the nozzle or the attachment to the vessel.
- 5.11.2 The width of the insulation band beyond the heating band shall be atleast twice the total width of the heating band.
- 5.11.3 A minimum of three thermocouples shall be placed such that atleast one is on the weldment / HAZ and the other two on the base material on either side of the weldment within the heating band.
- 5.11.4 The winding arrangement shall be established to attain the required temperature. The rate of heating shall be maintained minimum such that it stabilises at the required rate before reaching 400°C.
- 5.12 The following rules shall apply to establish the thickness to be used in determining the soaking time for PWHT.
- 5.12.1 For butt welds, the thickness shall be thickness of the material at the weld. For barstock, the thickness shall be the diameter.
- 5.12.2 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.
- 5.12.3 For partial penetration branch welds, the thickness shall be the depth of the groove prior to welding.
- 5.12.4 For repairs, the thickness shall be the depth of the groove as prepared for repair welding.
- 5.12.5 For combination of different welds in a component, the maximum thickness shall govern.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

5.13 Soaking time is to be reckoned from the time the temperature of the load crosses the minimum of the recommended cycle to the time it leaves the minimum of the recommended cycle of temperature.

5.14 When not specified, the following shall be heating and cooling rates (except for continuous discharge furnace).

Thickness of material	Maximum rate of heating & cooling above 400°C
Upto 25mm	220°C/Hr
Over 25 - 50mm	110°C/Hr
Over 50 - 75mm	75°C/Hr
Over 75mm	55°C/Hr

For tempering, cooling can be in air or in furnace.

5.15 Unless otherwise specified, in case of mixed loads, the following heat treatment temperatures shall be followed. In such cases, guidelines for soaking can be taken from clauses 5.16.

- a. Where P1 materials are loaded with P4 materials or when a component has a butt joint between P1 & P4, the cycle shall be 650-680°C.
- b. Where P4 materials are loaded with P5 materials or when a component has a butt joint between P4 & P5, the cycle shall be 650-705°C.
- c. When a component has a butt joint between P1 & P3, the cycle shall be 620-650°C.

These cycles are not applicable for tubular products.

5.16 For PWHT, calculate the minimum soaking time for individual components as 2.5 minutes/mm of the thickness. The soaking time selected for the cycle shall not exceed the limits given below:

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

QCP:10:0

Dt 16.03.94

Material	Thickness in mm	Max. soaking time (mts)
1	a) upto 25mm	125
	b) 26 - 50mm	200
	c) 51 - 80mm	250
	d) 81 -150mm	375
2	a) upto 25mm	65
	b) 26 - 50mm	125

1 = P1 (A,B,C), P4, P5, P1AB+P4, P4+P5
2 = P1 C+ P4, P1 + P3

- 5.17 In case of interruption during stress relieving of the weld joint, the following action to be taken depending on the stage of occurrence.
- During heating cycle:
The whole operation to be repeated from the beginning.
 - During Soaking:
Heat treat subsequently for the balance left over period.
 - During cooling:
Reheat to the required soaking temperature and cool at the required rate.
- 5.18 After heat treatment, the charts shall be correlated with the job and cleared by QC. The charts shall contain the cycle no., date and Work Order (WO) details. The cycle temperature, Rate of Heating (ROH), Rate of Cooling (ROC) and soaking time shall be calculated from the chart and entered in the chart signed off by QC.
- 5.19 Wherever specified, the test plate shall be tested and reports obtained to complete the clearance of heat treatment operation.
- 5.20 If any hot correction, in case of bow distortion, alignment etc., is required, flame heating may be adopted, provided the maximum temperature is limited to 900°C for carbon steel and 700°C for alloy steel. The metal temperature shall be checked using thermal charks.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

GCP:10:0

Dt 16.03.94

Flame heating shall be avoided in case of pipes, but correction can be done by mechanical means or induction heating limited to the temperature specified above.

- 5.21 If the points of contact during mechanical correction are exactly on the butt joints, such butt joints shall be tested by RT/ UT after correction. MPI of all weld joints shall be done in the zone between all points of contact on the job during mechanical correction.

6.0 INSPECTION

6.1 Layout:

- 6.1.1 The circumferential seams, nozzle openings, radiographic plugs and attachments shall be laid out for machining taking into account the shrinkage allowance, machining allowance and other allowances as per drawing and the main-axes shall be centre punched when necessary.

- 6.1.2 The layout shall be checked as per drawing.

6.2 Edge Preparation:

- 6.2.1 The pipes shall be edge prepared and holes drilled as marked. Removal of burrs, chips etc. from inside of the pipe shall be ensured. The tolerance for edge preparation on diameter D1 and squareness shall be as per Figure-2.
- 6.2.2 Gas cut edges shall be free from slag and scales. The irregularities (drag marks) at the edges shall not be deeper than 3mm. Deeper drag marks shall be ground smooth for welding.
- 6.2.3 When nozzle openings and edge preparation for welding are made by gas cutting MPI/LPI shall be conducted as follows:
C-Mn Steel when thickness > 25mm and
Alloy steel of all thickness.
- 6.2.4 Edge preparation for site weld shall be as per drawing.

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

QCP:10:0

Dt 16.03.94

6.3 **Welding:**

All weld seams shall be visually inspected. Toes of undressed welds should blend smoothly into the parent metal. When toes of welds are dressed, the depth should not exceed 10% of the pipe thickness or 1mm whichever is smaller. External reinforcement of the butt welds shall smoothly merge with the contour of the pipe. Allowable reinforcement is given below:

Thickness of base metal	Thickness of reinforcement for		
	$\geq 400^{\circ}\text{C}$	$175-400^{\circ}\text{C}$	$\leq 175^{\circ}\text{C}$
Upto and incl. of 3mm	2.0	2.5	5.0
Above 3mm to 5mm incl.	2.0	3.0	5.0
Above 5mm to 13mm incl.	2.0	4.0	5.0
Above 13mm to 25mm incl.	2.5	5.0	5.0
Above 25mm to 50mm incl.	3.0	6.0	6.0
Above 50mm	4.0	Greater of 6mm or 3/8 of width of weld	

6.4 **Assembly:**

All pipe bends shall be inspected for arm length, angle of bends and diagonal.

6.5 **Hydraulic Test:**

6.5.1 Hydraulic test shall be done when specified in the drawing.

6.5.2 Wherever hydraulic test is specified, the same shall be performed in accordance with TIP:05 (latest) or relevant QP.

7.0 **TOLERANCES**

7.1 **Linear Tolerance:**

The tolerance on linear dimensions (for connecting ends)

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

apply to the face to face, face to end and end to end measurements of fabricated straight pipe and headers; centre to end or centre to face of nozzles or other attachments or centre to face of bends as illustrated in Fig.3. The tolerance on linear dimensions is as follows and they are not cumulative:

For sizes (dia) upto 250mm	:	$\pm 3\text{mm}$
For sizes (dia) 250mm - 900mm	:	$\pm 4.5\text{mm}$
Over sizes (dia) 1000mm	:	$\pm 4.5\text{mm}$
+0.8mm for every 300mm		

7.2 Angular Tolerance:

7.2.1 Angle of the bend diameter is to be understood as measured from outside.

7.2.2 Tolerance on the angle of bend $\pm 1/2^\circ$; But in no case the deviation at the angle of the bend shall cause an overall diagonal variation of 6mm for pipes more than 25mm thickness and 10mm for pipes less than 25mm thickness. For intermediate portion of the bends, tolerance of $\pm 1^\circ$ can be allowed provided, the end connections are maintained as given above.

7.2.3 The additional allowance on length given for each bend has to be provided on the clamping side during bending.

7.2.4 For deviations in angle of bend between 0.5° and 2° the taper marking as per Annexure-III shall be carried out.

7.3 Tilting of flanges:

Alignment of facings or ends shall not deviate from the indicated position as shown in Figure-5 measured across any diameter more than 1.2mm per 300mm. Flange axis shall not deviate on any axis from indicated portion by more than 1.5mm. The other tolerances shall be maintained as per Fig.3.

7.4 End Calibration:

Pipe bends intended for butt welding with the mating component shall be machine edge prepared. The diameter and the root land shall be as per drawing. If piping component ends are bored, such boring shall not result in the final

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

wall thickness after welding less than the minimum design thickness. When necessary weld metal of the appropriate composition may be deposited on the inside or outside of the piping components to provide sufficient material to ensure satisfactory fitting of pipes. RT shall be taken for such ID buildup. Hammering for edge calibration is not permitted.

7.5 Intermediate Tolerance:

The following tolerances on bends shall apply unless otherwise specified.

**7.5.1 Bend to bend offset:
(Refer fig.4)**

For single offset bends : $\pm 5\text{mm}$
For compound offset bends : $\pm 10\text{mm}$

**7.5.2 Bend to bend length, but one end is in different plane:
 $\pm 10\text{ mm}$ (Refer fig.5).**

**7.5.3 Linear tolerance inbetween the bends can be adjusted in the same plane or parallel plane length.
Tolerance on straight portion encompassing bends $\pm 10\text{mm}$.
Tolerance on straight portion for end limbs of multiplane bends $\pm 25\text{mm}$.**

7.5.4 Intermediate tolerance of 'U' shape bends with bends for different planes: $\pm 10\text{mm}$ (Refer fig.6).

**7.5.5 Tilt in the same plane for single 'U' bends and others:
 $\pm 5\text{mm}$ (Refer fig.7).**

**7.5.6 Twist gap permissible using straight edge and plumb :
1mm/mtr subject to 10mm max.**

8.0 NON DESTRUCTIVE EXAMINATION

8.1 NDE shall be performed using qualified procedures and personnel only. NDE techniques are based on ASME Sec.V unless specified otherwise. The acceptance norm shall be based on the relevant code of construction and built into the respective NDE procedures.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

- 8.2 The extent and type of NDE are specified in the respective QPs (QPG:01 and QPG:02).
- 8.3 Butt joints shall be subjected to radiography as given below:
- 8.3.1 IBR Piping:
- a. 100% radiography for all alloy steel pipes and carbon steel pipes of NB > 100mm.
 - b. 10% radiography for carbon steel pipes of NB $\leq$ 100mm, subject to a minimum of 2 welds per welder selected at random.
- 8.3.2 NON-IBR Piping:
- a. 100% radiography for pipes of NB > 100mm.
 - b. 10% radiography for pipes of NB $\leq$ 100mm, subject to a minimum of 2 welds per welder selected at random.
- 8.4 Butt joints of pipings shall be subjected to visual and mechanical tests as given below:
- a. On completion of the first ten production welds made by each welder, one of the welds shall be cut out for test purposes or alternatively, the welder shall prepare a test specimen made up of two similar lengths of piping representative of a selected production weld as practicable. The specimens shall be subjected to visual examination and bend tests.
 - b. Two percent of the reminder of welds made by each welder shall be selected at random and cut out for test purposes or alternatively the welder shall prepare a test specimen made up of two similar lengths of piping welded in a position as closely representative of a selected production weld as is practicable. The test specimen shall be subjected to visual examination and bend tests.
 - c. The radiographs shall be evaluated as per IBR and ANSI:B:31:1 and defects marked.
- 8.5 The repair weld should be subjected to the same NDE as per the original requirement.

MASTER COPY

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

- 8.6 Defects noticed in the test plates shall not be repaired; defect free portion can be used for testing.
- 8.7 After all welding and successful weld repairs the welds shall be visually inspected for completeness and cleared for heat treatment.
- 8.8 The welder number, radiography number and reference access marks shall be punched in case of radiography joints. In case of other welds and tubular joints, suitable records can be maintained co-relating the NDE report and the weld joint.
- 8.9 After three consecutive repairs on the same weld, if any defect is still found, the complete seam will be cut and rewelded.
- 8.10 After all welding and successful weld repairs, the welds shall be visually inspected for completeness and quality and cleared for heat treatment.
- 8.11 MPI shall be conducted on the cavity to ensure complete removal of defects, in case of cracks, incomplete penetration and lack of fusion. For other defects such as slag, pores etc. a thorough visual inspection is necessary before repair welding. The acceptance norms shall be as per ASME B31.1
- 8.12 The extent and type of NDE for X-20 material shall be as follows :
- A. Butt joints : 100% UT and 100% wet MPI.
 - B. Fillet and Attachment Welds : 100% wet MPI.
 - C. All saw cut edges : 100% LPI.
- 8.13 **NDE after PWHT**
- 8.13.1 The welds intended for MPI shall be prepared by grinding/wire brushing.
- 8.13.2 MPI shall be conducted on nozzle and attachment welds as given in QPG:01 and QPG:02.
- a. 10% for Carbon Steels.
 - b. 100% for Alloy and Stainless Steels.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

| QCP:10:0
|
Dt 16.03.94

9.0 CLEANING AND PAINTING

- 9.1 Completeness of all final machining and EP shall be ensured. Dimensional inspection shall be performed in accordance with the relevant tolerance drawing. Usage of calibrated instruments/ gauges shall be ensured.
- 9.2 All loose foreign materials such as scales, sand, weld spatter particles, cutting chips etc. shall be removed from the inside of the piping assembly by any suitable means. All hot formed/normalised pipe bends shall be shot blasted both inside and outside or acid pickled. (This is subject to special contract condition).
- 9.3 Surface preparation, painting and preservation shall be in accordance with QCP:09:0 and SPS:01 (latest), unless otherwise specified.
- 9.4 **Identification:**
- 9.4.1 All the pipes shall be hard stamped with in 200mm from the free end with the following details:
- a. Work Order No. and DU No.
 - b. Orientation of the part (left or right).
 - c. Specification and melt no. of the pipe.
 - d. The arrow mark indicating the flow direction.
 - e. Boiler Inspector's Stamp.
- 9.4.2 The work order number and DU number shall also be painted.
- 9.4.3 The pipe shall be colour coded as per the Annexure-I. Colour coding by paint to a width of approximately 25mm on either ends to the entire circumferences of the pipe beyond end caps and site EP ends of tube, nozzle and fitting welded on pipes.
- 9.5 Edge preparations for site weld shall be protected with weldable primer.

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

10.0 CERTIFICATION AND DOCUMENTS

- 10.1 The jobs shall be stamped, certified and data folder prepared as per the requirements of the QP.
- 10.2 The pipes shall be manufactured under the inspection of the Boiler Inspector and shall be stamped before despatch and necessary statutory certificates shall be submitted to BHEL.

11.0 PACKING

- 11.1 End caps, thermowell plugs and RG plugs shall be fitted and tack welded at four places to a length of 10mm before handing over to shipping.
- 11.2 The pipes shall be packed with wooden crate and arrestors at proper location to avoid movement and subsequent damage of the pipe during transit.

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

QCP:10:0

Dt 16.03.94

ANNEXURE-I

COLOUR CODES FOR SEAMLESS STEEL TUBES

	<u>SPECIFICATION</u>	<u>COLOUR CODE</u>
01.	ASTM A268 TP 410	Yellow and brown
02.	ASTM A268 Type 443	Green and white
03.	BMC 20 (Structural quality)	Silver and brown
04.	DIN 2391 St.35.4	Green and black
05.	SA 192	White
06.	SA 199 Grade T5	Black and brown
07.	SA 209 Grade T1	Red and silver
08.	SA 210 Grade A1	Yellow
09.	SA 210 Grade C	Blue
10.	SA 213 Grade T11	Yellow and silver
11.	SA 213 Grade T22	Red and green
12.	SA 213 Grade T5	Black and brown
13.	SA 213 Grade T9	Brown and white
14.	SA 213 Grade TP 304, 304H, 304L	Blue and yellow
15.	SA 213 Grade TP 321	Blue and white
16.	SA 213 Grade TP 347H	Yellow and black
17.	SA 213 T2	Green and brown
18.	SA 213 T91	Yellow and green
19.	SA 334 Grade A	Yellow and white
20.	SA 334 Grade B	Red and silver
21.	SB 163 MONEL	Green
22.	BS 3602 ST 27	Red
23.	BS 3602 ST 35	Blue

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

QCP:10:0

Dt 16.03.94

ANNEXURE-II

COLOUR CODES FOR SEAMLESS STEEL PIPES

	SPECIFICATION		COLOUR CODE
01.	SA 106 Gr.B		Red
02.	SA 106 Gr.C		Blue
03.	SA 312 TP 304		Yellow and blue
04.	SA 312 TP 316		Blue and black
05.	SA 312 TP 321		Blue and brown
06.	SA 335 Grade P11	Blue & Red	Black and red
07.	SA 335 Gr.P12		Yellow and silver
08.	SA 335 Gr.P22		Red and green
09.	SA 335 Gr.P5		Black and brown
10.	SA 335 P91		Yellow and green
11.	ST 35 of DIN 1629		White
12.	X20 Cr Mo V 121		Black
13.	BS 3604 HFS 660/CD 660		White and Silver
14.	BS 3604 HFS /CDS/622/27		Yellow and Green
15.	BS 3604 HFS /CDS/622/31		Red and Green

ANNEXURE-III

TAPER MARKING PROCEDURE

1.0 **SCOPE**

1.1 This procedure is applicable for taper marking of pipe bends when the angular deviation of the bend exceeds $1/2^\circ$ but within 2° (including). This is also applicable for bend arms not having any nipples or nozzles exceeding diameter 76.1mm.

2.0 **METHOD**

- 2.1 When the bend is having two different arm lengths, the longer arm length is to be taken as the reference axis. When the arm lengths are equal, any arm can be taken as reference.
- 2.2 The axis of the pipe bend is to be centre punched at 100mm from end of the pipe as well as at the working point (tangent point).
- 2.3 Place straight edges on both the axis of longer as well as shorter arm.
- 2.4 At the intersection of the straight edges, the external angle θ_1 shall be measured as shown in Figure.
- 2.5 The straight edge is to be pivoted about the centre punches at the shorter arm near the end of the pipe. The other end of the straight edge is to be moved until the desired angle θ_2 is obtained at the intersection point.
- 2.6 The arm lengths L_1 and L_2 shall be marked from the intersection point.
- 2.7 After marking, the ends are to be chamfered normal to the new axis, such a way that the resulting face angle θ_3 is the required angle.

Note:

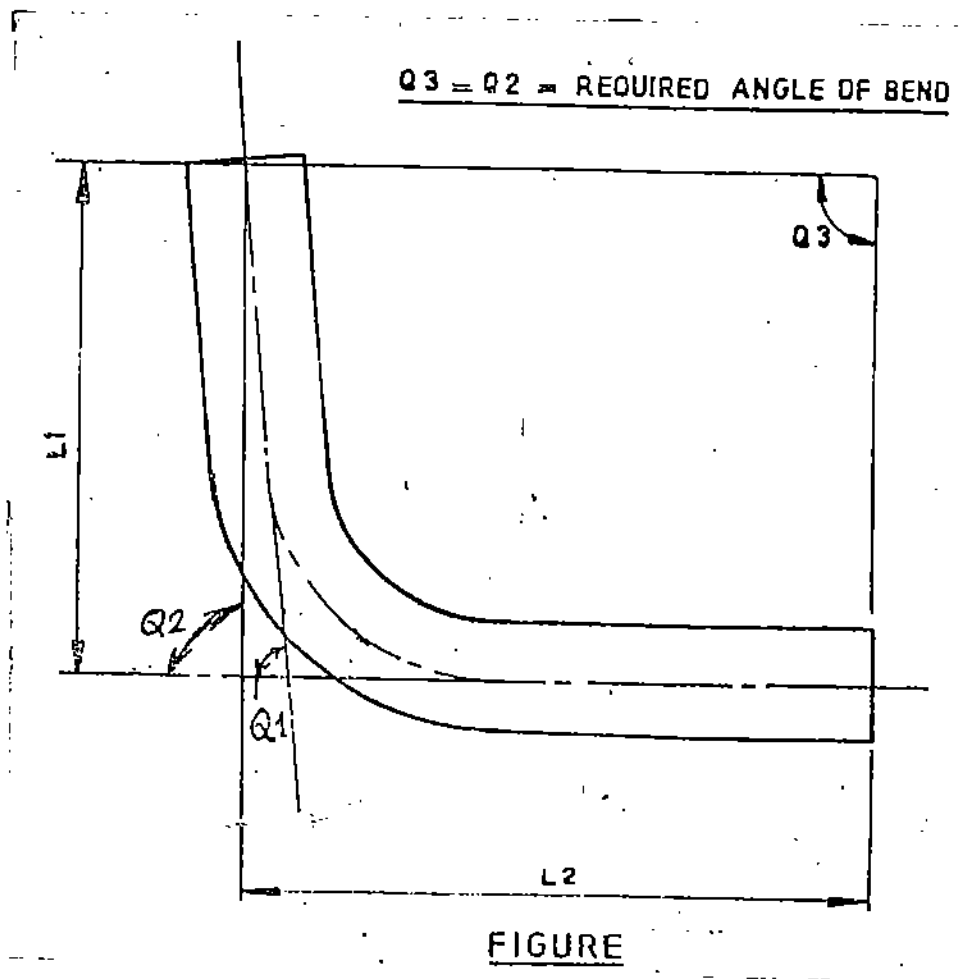
1. The thickness of the taper edge prepared end should in no case be reduced more than the existing norms given in QCP.

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

QCP:10:0

Dt 16.03.94

2. The weld end diameter (d1) should be concentric with the internal diameter of the pipe.



**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

ANNEXURE-IV

COLD & HOT BENDING OF PIPES (Ø 108mm and above)

MATL	COLD BENDING	HOT BENDING *	INCREMENTAL BENDING @
P1	When t > 19mm SR at 610±15°C	Heating : 900-1010°C SR Nil	Heating : 900-1010°C t≤40mm SR Nil t>40mm SR at 610±15°C
P4	t > 13mm SR at 665±15°C	Heating : 920-1010°C SR at 665±15°C	Heating : 920-1010°C t≤40mm-SR at 665±15°C t>40mm, Norm at 920-960°C and temper at 665±15°C
P5	t > 13mm SR at 695± 15°C	Heating : 920-1010°C SR at 695±15°C	Heating : 920-1010°C t≤40mm-SR at 695±15°C t>40mm, Norm at 920-960°C and temper at 695±15°C
X20 CrMo 121 #	N.A.	Heating : 850-1100°C Norm. at : 1020-1050° Temper at: 740-760°C	Heating : 850-1010°C Norm. at : 1020-1050°C Temper at: 740-760°C

* Bending shall be completed above 850°C.

@ For incremental bending, the parameters shall be suitably selected to ensure uniform heating of the entire thickness.

For X20 material, the temperature after hot bending shall not be cooled below 80°C before normalising and shall be brought within 80-100°C from normalising before tempering. Tempering shall not be clubbed with PWHT. Ensure pipes for bending are in normalised condition or else they shall be normalised before bending. Heating and Cooling rate shall be as per Clause 5.14 Soaking time shall be as per Clause 5.16

**QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING**

QCP:10:0

Dt 16.03.94

ANNEXURE-V

**PRE HEAT, POST HEAT & POST WELD HEAT TREATMENT TEMPERATURES (°C)
FOR PIPING**

B.31.1

U 132.

Pipe Material	Code	Thickness in mm	Pre- heat °C	Post Heat temp.-time °C	POST WELD HEAT TREATMENT TEMP. in °C		
					Butt Welds	Snub and Attachment Welds Throat ≤ 19mm	Throat > 19mm
P1 (*)		t < 19	Nil	Nil	Nil	Nil	620±15
		t 19-25	Nil	Nil	620±15	Nil	620±15
		t 25-75	150	Nil	620±15	Nil	620±15
		t > 75	150	Nil	620±15	620±15	620±15
P4	IBR	all t	150	Nil	665±15	665±15	665±15
P4+P1Grp1	ANSI B31.1	all t	150	Nil	700-730	700-730	700-730
P4+P1Grp2(GrC)		all t	150	260- 300 4Hrs	665±15	665±15	665±15
P5, P5+P4	IBR	all t	@150	260- 300 4Hrs	695±15	695±15	695±15
	ANSI B31.1	all t	@150	260- 300 4Hrs	700-730	700-730	700-730
P5+P1		all t	@150	260- 300 4Hrs	690±10	690±10	690±10
12 X 1MØ		Upto 52mm	220		725±15	725±15	725±15
X20CrMoV 121	for GTAW		250- 300	80- 90 100 mts.	740-760	740-760	740-760
#	for SMAW		400- 450	80- 100 min.			

* For P1Grp2 (GRC) : All thickness are to be pre heated when carbon content is above 0.25%. Post heating to be done at 150°C for 2 hrs or 260°C for 4 hrs irrespective of carbon content and thickness.

Dt 16.03.94

- ## Notes

X20 CrMoV 121 : 2.5mts/min - 2 hrs min. for t ≤ 60mm
- 3 hrs min. for t > 60mm

Other matls : As per clause 5.16

150°C/hr for $t < 40$
100°C/hr for $40 \leq t \leq 70$
80°C/hr for $70 > t \leq 95$

200°C/hr max. for $t < 40$
120°C/hr max. for $40 \geq t \leq 70$
85°C/hr max. for $70 \geq t \leq 95$

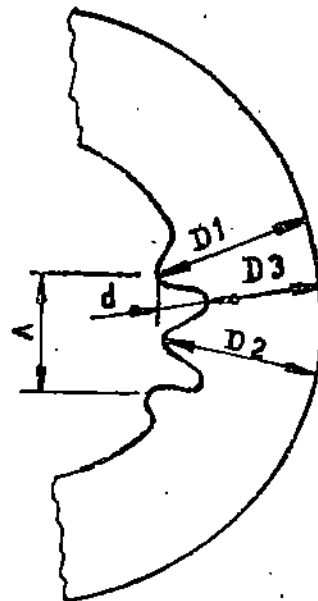
Page 34 of 38

MASTER COPY

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

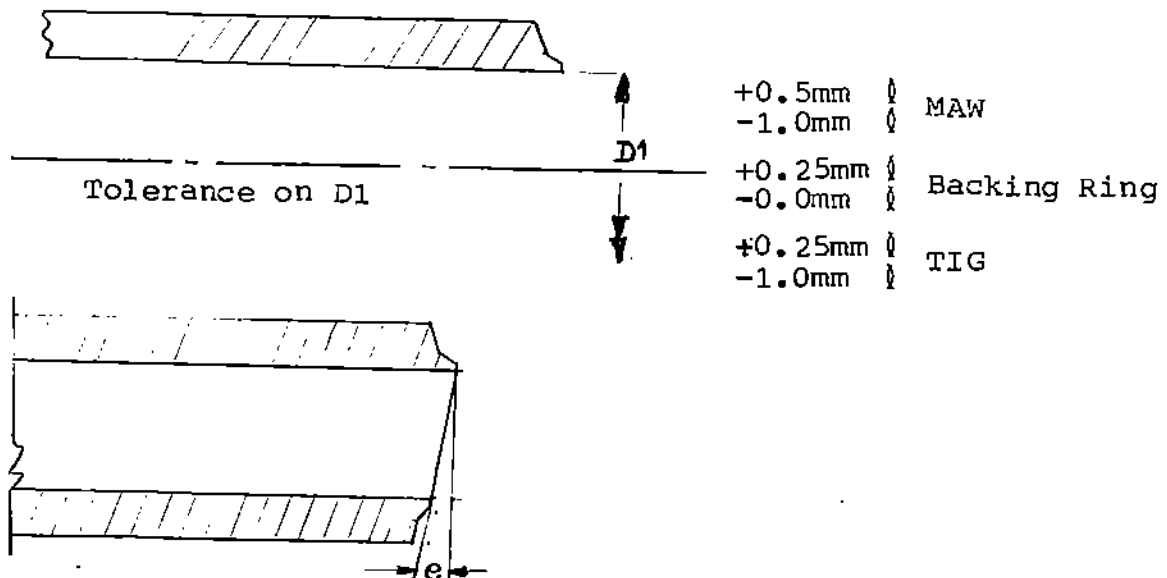
QCP:10:0

Dt 16.03.94



D-Nominal OD of pipe

FIGURE -1



Tolerance on End Squareness

FIGURE - 2

e = 2.25mm for MAW
0.75mm for TIG

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

QCP:10:0

Dt 16.03.94

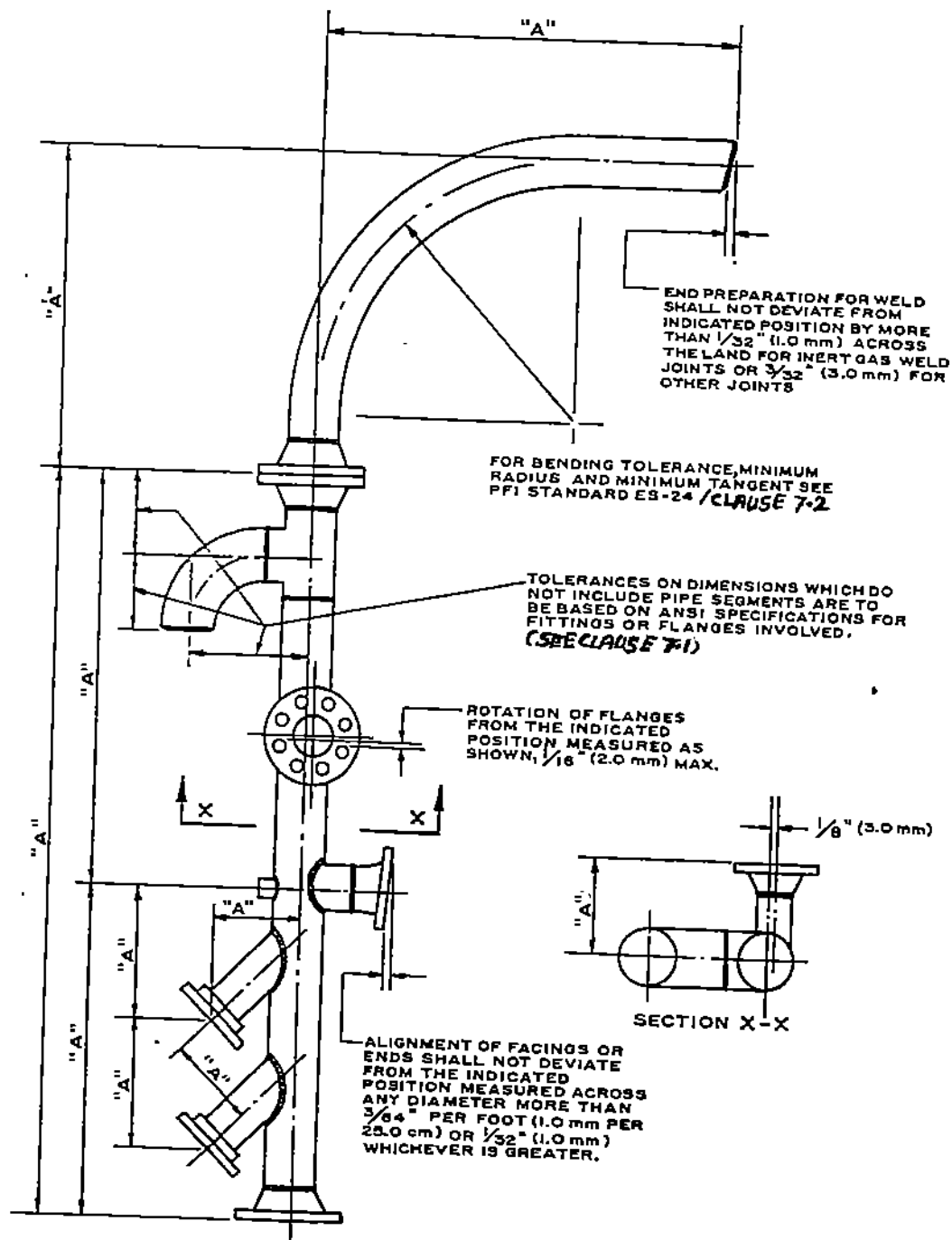


FIGURE-3
APPLICATION OF PIPE FABRICATION TOLERANCES



FIGURE-4

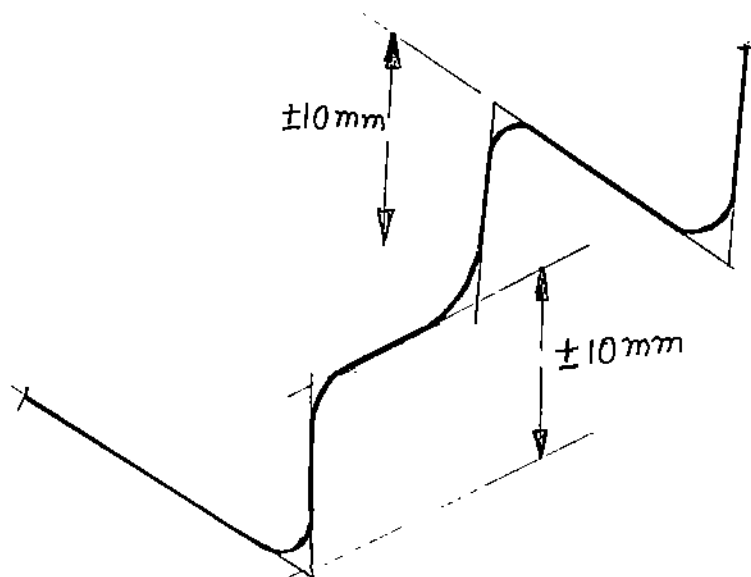


FIGURE - 5

QUALITY CONTROL PROCEDURE FOR
FABRICATION OF PIPING

QCP:10:0

Dt 16.03.94

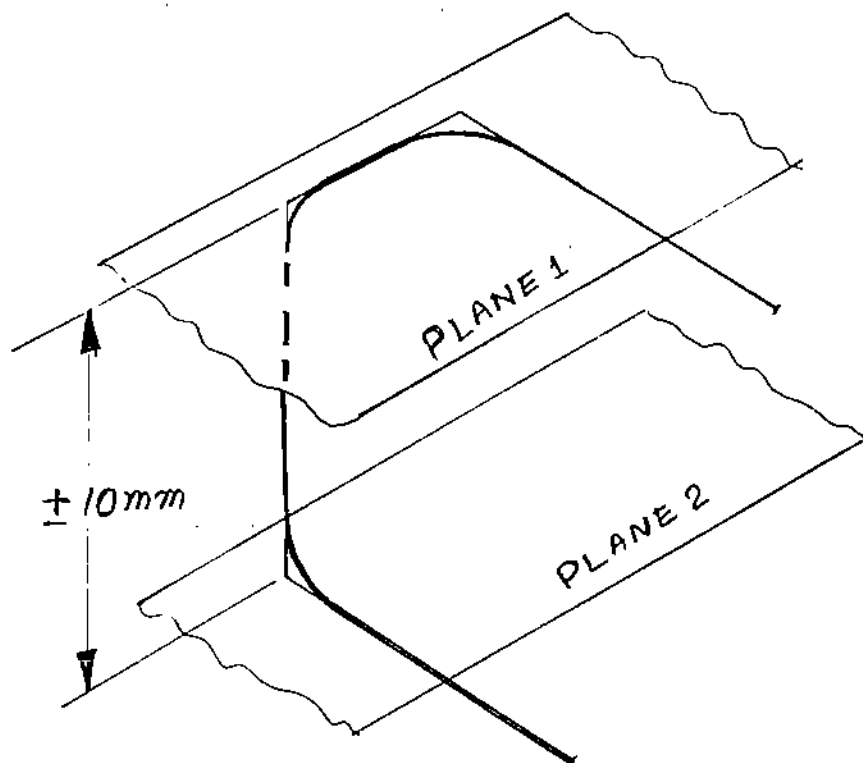


FIGURE-6

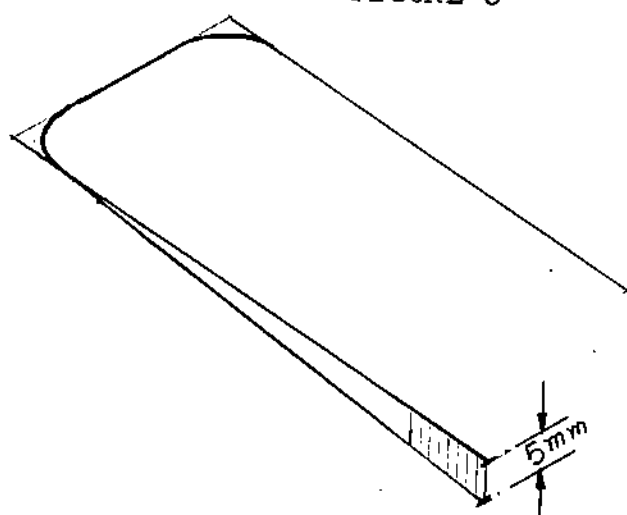


FIGURE-7