1.0 SCOPE

1.1 This Technical Delivery Condition covers the requirements of boiler drum (imported) of materials SA 515 Gr. 70 and SA 299.

2.0 CODE OF CONSTRUCTION

2.1 The boiler drum shall comply with the requirements of Indian Boiler Regulations (IBR). Guidance may be drawn in qualifying welding procedures and NDT examination and evaluation of welds as per ASME Sec. I and IX without violating the IBR.

3.0 GENERAL

3.1 The completed boiler drum shall meet the requirements given in the drawings for the drum.

3.2 Edge preparation of plate shall be subjected to MPI to ensure freedom from excessive laminations or cracks.

3.3 All dimensions shall be checked according to approved drawing. Dimensional tolerances unless otherwise mentioned in the drawing shall be as per BHEL drawing No. 0-03-000-00001 (latest).

3.4 A test plate of sufficient length cut from the parent plate shall be used for each long seam and welded as a continuation of the seam. One test plate shall be welded as a representative of the cir seams using the same WPS and welder for each drum. The test plates shall undergo all the heating and heat treatment operations along with the drum.

3.5 The temperature of the furnace shall not exceed 300 oC at the time of loading the items for heating and heat treatment.

4.0 MATERIAL FOR BOILER DRUM

4.1 Raw material used for making boiler drums shall meet the requirements of SA 299 or SA 515 Gr.70 as specified in drawing. The plates shall meet the requirements given under TDC NO. 0:201 (latest on date of PO) for SA 299 and TDC NO. 0:202/00 (latest on date of PO) for SA 515 Gr.70 material. The details of sources from which plates are procured, must be provided to BHEL well in advance.

4.2 The identification marks shall be located at one end of the plate about 150mm from the edge.

4.2.1 The identification stamping shall contain work order No., plate specification and melt number along with Inspecting Authority's seal.

5.0 FORMING OF DRUM SHELLS

5.1 The drum shells may be made either by hot forming or by cold forming.

5.2 COLD FORMING

5.2.1 For cold forming, only Normalised plates shall be used. If the plates are not already in the normalised condition, separate normalising shall be carried out.

5.2.1.1 Plates can be cold formed to a maximum outer fibre elongation of 3.5% for thickness up to 100mm and 3% for thicknesses above 100 mm without inter stage heat treatment. (% Elongation shall be calculated as per the following formula:

$$\% \text{ Elongation } E = \frac{T * 100}{D + T}$$

where, T=Thickness &
D=Inside diameter).

5.2.2 If the % elongation exceeds the above value, an inter stage heat treatment shall be carried out at 600-620 oC for a soaking time of 30 minutes after forming to such a radius that percentage elongation is below 3.5% or 3% as the case may be, and then further forming is to be carried out.

5.3 HOT FORMING

5.3.1 If hot forming is carried out in the temperature range of 870-900 oC for SA 299 plates and 870-980 oC for SA 515 Gr.70 plates, there is no need for a separate normalising after hot forming. In this case, the holding time at the temperature shall be 0.5 hour per inch of plate thickness and the minimum temperature at the closure of hot forming shall not be below 621 oC. If hot forming is carried out beyond the above specified range, separate normalising shall be carried out at 880-900oC with a soaking of 0.5 hour per inch of plate thickness followed by air cooling.

5.3.2 The shells shall be subjected to inter stage stress relieving at 600-620 oC with a soaking of 1 hour per inch of plate thickness (maximum 4 hours) before final cold calibration, in the following cases:

5.3.2.1 Closing temperature of hot forming falls below 621 oC.
5.3.2.2 Plate thickness exceeds 150 mm.

5.3.3 The shells shall be descaled after hot forming.

6.0 DISHED END FABRICATION

6.1 Dished ends shall be made by hot forming as given in clause 5.3.1.

6.2 The dished ends are to be descaled after completing hot forming and normalising.

6.3 The dished end lay out is to the checked for centre-line, height, location of man hole opening and other dimensions as per drawings. The man hole opening and seating area shall be machined to dimensions shown in the drawing.

6.4 Sharp corners at the manhole opening should be ground smoothly to small radius.

6.5 The man hole cut out shall be tested for tensile strength and micro structure for ensuring conformance to normalised properties, for each dished end per thickness/melt/heat treatment batch and the values shall be reported in TC.

7.0 WELDING

7.1 Welding procedures shall be qualified to meet the requirements of ASME SEC. IX and the welders shall be qualified as per IBR, in the presence of the inspecting authority. The details of welding procedure shall be forwarded to BHEL for approval.

7.2 Welding consumables shall be properly identified and accompanied by certification.

7.3 The welding procedures shall ensure full penetration of butt welds. After back chipping or gouging, MPI or LPI should be carried out to avoid lack of fusion.

7.4 Satisfactory welding techniques as per approved welding procedure are to be employed. The preheating and inter pass temperature shall be maintained during welding and gas cutting in accordance with the material chemistry and thickness. The preheat temp. shall be checked by using thermal chalks. Inspection Records should in-dicate the pre-heating temperature used during welding.

7.5 Surface off-set before starting the weld for longitudinal seam should not exceed 3mm and that of circumferential seam should not exceed 4mm.

7.6 Welders identification for all joints is to be stamped near the weld along with seam number with low stress stamps.

7.7 Before matching the second dished end with the shell, both the man hole doors shall be put inside. The man hole door shall be machined to size as per drawing from normalised plates only.

7.8 If temporary attachments are used for aligning purposes of the seams, necessary preheat should be used to avoid crack and after removal of such temporary attachments MPI should be carried out, to ensure satisfactory surface.

7.9 After welding, the seams shall be ground to smooth contours, to be flush with the adjacent plate surface without undercutting and visually inspected for surface defects.

8.0 TOLERANCE ON SHELL

8.1 The bow in the drum shall not exceed 1 mm per metre length limited to a maximum of 8 mm.

8.2 The internal diameter of the drum measured at any cross section shall be within 1% of the nominal internal diameter of the drum. Difference between the maximum & minimum internal diameters at any cross section shall also be within 1% of the nominal internal diameter.

8.3 Any departure of profile measured on the outside of the drum with a gauge of the designed form of the exterior of the drum and length equal to a quarter of the internal diameter, shall not exceed the percentage given below:

Nominal internal diameter of drum	Percentage of nominal internal diameter
Up to and including 36 inches	0.375
Over 36 up to and including 45 inches	0.35
Over 45 inches	0.30

8.4 Local flatness at the weld joint is not permitted.

9.0 NON DESTRUCTIVE EXAMINATION

9.1 BEFORE HEAT TREATMENT

9.1.1 All the butt weld joints shall be tested by 100% MPI and 100% Radiography. Radiography reports shall be furnished to BHEL.

9.1.2 All weld repairs shall be carried out according to qualified procedures and shall undergo inspection requirements as that of the main seam. All repairs shall be recorded with dimensions of the groove made for repair and shall be furnished to BHEL.

9.1.3 The test plates shall be tested 100% by MPI, RT and UT and the defective area marked with yellow paint, indicating the depth and length of repair from the surface. No repair shall be done on the test plate.

9.2 AFTER HEAT TREATMENT

9.2.1 All the joints including test plates shall be examined by MPI both from in and outside.

9.2.2 Similarly, all temporary attachments and stray arc areas shall be ground and examined by MPI.

10.0 HEAT TREATMENT

10.1 After welding and NDE clearance of all the seams, the drum along with the test plates shall be stress relieved in a furnace at 600-620 oC/30 minutes soaking/ Furnace cool upto 400 oC followed by air cooling. The ROH/ROC shall not exceed 55 oC per hour. Thermocouples are to be attached for measuring the temperature of drum at equal intervals. Thermocouples are to be attached to the test plate also. Location of the thermocouple must be indicated in a neat sketch.

10.2 After SR, each test plate shall be cut into two halves. One half of the test plates shall be additionally stress relieved at 600-620 oC/1 hour per inch of shell thickness soaking/Furnace cool upto 400 oC followed by air cooling. The ROH/ROC shall not exceed 55 oC per hour. The other half of the test plates (without this SR) shall be sent to BHEL along with the drum. The defect free length shall be at least 600 mm in each test plate supplied to BHEL.

11.0 MECHANICAL TESTING

11.1 Mechanical testing on test plate for longitudinal and circumferential seams shall be carried out as per IBR. Please refer Clause 10.2 for heat treatment before mechanical testing.

12.0 PACKING AND DESPATCH

12.1 The completed boiler drum shall be descaled both inside and outside and shall be free from heat treatment scales. The outside of the drum may be given a coat of red oxide zinc chromate primer and another coat of oil base enamel paint (international orange). The inside of the drum and machined surfaces may be protected with rust preventive oil. The drum shall be suitably packed and firmly anchored to prevent any damage during transport.

13.0 INSPECTION AND CERTIFICATION

13.1 The stages of inspection shall be as per Appendix J of IBR and inspection and certification shall be done by an inspecting authority approved under Appendix C of IBR for the plates as well as drum.

13.2 All the relevant test certificates (Manufacturer's certificates as well as Inspecting Authority's certificates) shall be supplied in the relevant forms of Indian Boilers Regulations (II, III and IV as applicable), Test Certificate for plates, dished ends etc.

13.3 All heating cycle and heat treatment cycles are to be recorded and copy must be submitted to BHEL. The details of temperature, soaking time, cooling media, ROH/ROC etc. shall be submitted.

13.4 Dimensional records as a completed drum shall be furnished to BHEL Trichy. This should confirm to the requirements of IBR and drawing.

13.5 The records of Non-destructive examination, welders, welding procedures, consumables and Mechanical testing to be furnished.

14.0 STAMPING

14.1 After Manufacture, the drum shall be stamped at a place indicated in the drawing (details of stamping is shown in the drawing) with seal of Inspecting Authority.

Rev 09: 15/02/03: Cl.3.0 revised
Rev 10: 27/01/04 Cl.8.0 Hydraulic test removed , further clauses renumbered. Annexures introduced for cl.11.
In Cl.2.0 limits for carbon in GrC modified.In Cl. 4.0 normalising made mandatory for all pipes of Gr.C& GrB meant for fitting.In Cl.5 0 test coupon for pipes meant for fittings removed.
Rev 11: 29/12/07 Cl 1.0, P92 included.P2,P5,P9,304L,321 Deleted.Cl.4.0,10.0,11.0, modified.

1.0:MATERIAL:

Specification: ASME. (Latest on the date of Purchase Order (PO)):
Carbon Steel(CS) : SA 106 Gr.B & C
Alloy Steel(AS) : SA 335 Gr P11, P12, P22, P91 & P92.
Stainless Steel(SS): SA 312 TP 316, TP 316L.
Additional requirement: As listed below.(Supplementary to Specification).
Pipe Size and Qty.: As per PO

2.0:CHEMICAL COMPOSITION AND PROCESS OF MANUFACTURE:

Ladle and Product Analysis: SA 106 Gr B:Carbon:0.25% Max.
SA 106 Gr C:Thickness </=20mm Carbon:0.25 Max.
Thickness > 20mm Carbon:0.30 Max.

3.0:STRAIGHTNESS:

The pipes shall not deviate from straightness by more than 1mm in any one meter, and shall not be more than 6mm over the entire length. A sharp bend at the end or kink and twist are not acceptable. These limitations are applicable for any given plane..

4.0:HEAT TREATMENT:

4.1: HOT FINISHED PIPES:
CS:(1)Pipes meant for fittings: Normalised condition.
(2)Other Pipes :(a)Diameter </= 219.1mm in Normalised condition.
(b)Diameter > 219.1mm in Hot finished condition.
AS: SA 335 P11, P12, P22 –Either in Normalised and Tempered or Isothermal Annealed condition.
SA 335 P91, P92 –Normalised and Tempered condition.
SA 312 TP 316, TP 316L –Solution Annealed condition.
4.2: COLD FINISHED PIPES:
CS:In sub critical annealed,fully annealed or in Normalised condition.

5.0:MECHANICAL TESTS: As per the Specification.
Number of Tests: (as per IBR) Minimum 2 pipes for first 100 pipes and 1 per 100 or part thereof for pipes over 100 numbers. For alloy steel pipes meant for fitting, in case of isothermal annealed condition test coupon shall be normalized and tempered.

6.0:NON DESTRUCTIVE TEST : On All pipes.
(a)ULTRASONIC TEST : ASTM E213.Calibration: Axial 50 mm long V or Square notch, one in OD and the other in ID. Depth:5% of Max.Thickness.(min of 0.3 mm.max:1.5mm). For OD<30mm one notch in OD is enough. Scanning:Clockwise and Anti clockwise.

7.0:FINISH AND REPAIR:

Free from loose scales and defects like laps, seams, folds,cracks,pittings etc.Repairs by welding is prohibited. The Surface defects can be removed mechanically without affecting the minimum thickness and workmanlike finish.

8.0:MARKING:

Details to be identified.: On Each Pipe.1) PO.Number 2)Maker's emblem/code 3) Specification & grade, 4) Heat number 5) Size. 6) No.of pipes. 7) Inspector's seal.

(a)Upto OD 31.8 (Excl.) – Sl.No: 1 to 7 to be stamped on metal or plastic tag attached to bundle.

(b)OD 31.8 to OD 76.1 (Incl.)– Sl.No:1 to 5,7 to be paint stenciled on each pipe, 1 to 7 to be stamped on metal or plastic tag attached to bundle.

(c)OD > 76.1- Sl.No: 2,3,4& 7 to be hard stamped with round edged stamp at 100mm. from an end of each tube and 1 to 5 to be paint stenciled on each pipe.

(d)Colour Coding on all pipes: As per procedure SIP:PP:21 Latest.

9.0:PRESERVATION:

All pipes except SS shall be applied with resin type rust preventive coating with visibility to stenciled details on outside and either with rust Preventive coating or rust inhibitor inside.SS pipes to be surface treated as per ASTM A380 both inside and outside. Ends to be closed with end caps for secured storage.

10.0:PACKING:

(1)Thickness</=2.5mm in boxes. 2)OD </= 159 mm in bundles.Others in loose condition. Pipe bundles to be < 4 tons of equal no.of pipes,fastened with galvenised strap(1x25mm.min.) for CS & AS and by Nylon strap for SS at 2 ends & at 1m interval. Wooden pallets to cover pipes are not permitted.

11.0:INSPECTION AND CERTIFICATION:

11.1: Products must be inspected at works and the mill test certificate must be countersigned by the Inspecting authority as indicated below.

Imported Items: Inspecting Authority Approved by IBR for the Country of Origin. (To be concurred by BHEL before placing PO.)

Indigenously Supplied Items: Boiler Inspectorate/Directorate of respective state.

1.Mill test certificate (ORIGINAL) in English. for each product with following details shall accompany the product. Mill certified Test certificate in IBR Form-IIID (Annexure-I) sufficient for IBR items from "IBR-Well Known Pipe Maker" and for Others IBR Form-IIIA(i) (Annexure-II) as per the enclosed format.

2.Purchase Order No.(BHEL), TDC No.& Test certificate No., Size and Quantity-Melt wise

3.Specification and Grade with year of code, Heat Number, Steel & Pipe making process, chemistry Including incidental elements-Ladle and Product Analysis.

4.Heat Treatment details, Mechanical test Results, NDE results with reference standards.

V.Jayaraman	U.Revisankaran	K.Rengachari	V.Prabhakaran	C.R.Raju
Prepared By	Reviewed by			Approved By

COMPANY EMBLEM AND DETAIL

(As published in IBR)

TEST CERTIFICATE – FORM III D

IBR Approval (Well known) Reference : Certificate No.. **XXX Dt. DD/ MM/YY, Valid upto DD/MM/YY**

TC No. , & Date:		TDC No./Rev :	
PO. No., & Date:		Specification & Grade	
Steel Making Process		Year of Code	
Finishing operation	Hot Finished/Cold Finished	Deoxidation process	

Identification

Supply particulars	PO item No	Size D x T x L	Heat No	Weight (Kgs)	Qty	

Chemical Analysis

Elements N1	C	S	P	Si	Mn	Ni	Cr	Mo	V	Cu	Sn	Al	Cb
min													
max													
Heat													
Product													

Heat treatment details		Type of HT	Soaking Temp° C	Soaking time/cooling media
	Product			
	Test Coupon N2			

Mechanical Properties N3	Longitudinal / Transverse direction						
Specified	YS	UTS	%E	%RA			Hardness
	Kg/mm²	Kg/mm²	GL=50mm				BHN
Min							
Max	---	---	---	---			
Test results							

Flattening test/Bend test N4	
Surface Treatment details(SS only)	

Non destructive tests

Appearance and dimensions	
Hydrostatic test	

N1 : As applicable to the specification	N2 : If the heat treatment condition differs from the pipes
N3 : The tests specified shall be made on minimum 2 pipes for the first 100 pipes and 1 per 100 or part thereof for pipes over 100 numbers	N4 : as applicable

Surface preparation and preservation

Certified that the particulars entered herein are correct. The part has been manufactured to comply with the Indian Boiler Regulations at our Works above named and satisfactorily withstood a water test of _____ on the _____ day of 20 in the presence of our responsible representative whose signature is appended hereunder:

Maker's Representative (Sign. & Name Seal of Quality Control)	Maker (Sign. & Name Seal of Production)

Note : In the case of pipes made from steel, made and certified by well-known Steel Makers in India or other countries, particulars regarding the 'material' as certified by them (in any form) shall be noted in the appropriate columns or paragraphs in this certificate.

COMPANY EMBLEM AND DETAIL

(As published in IBR)

FORM III A (i)
CERTIFICATE OF MANUFACTURE AND TEST

[REGULATION 4(h)]

TC No., & Date:		TDC No./Rev		P.O. No.& Date	
Specification & Year		Finishing Operation		Hot Finished / Cold Finished	

Name of part	
Design pressure	
Design temperature	
Material	
Process of manufacture	
Fully killed/rimmed	
Chemical composition	

Supply particulars	PO item No	Size D x T x L	Heat No	Weight (Kgs)	Qty	

Elements [N1]	C	S	P	Si	Mn	Ni	Cr	Mo	V	Cu	Sn	Al	Cb
min													
max													
Heat													
Product													

Pipes	
Main dimensions	
Tolerances	
Mode of manufacture	
Identification marks	
Drawing numbers	
Bend test on pipe	
Bend test on weld	
Flattening test	

Mechanical Properties [N3]	Longitudinal / Transverse direction						
Specified	YS	UTS	%E	%RA			Hardness
	Kg/mm^2	Kg/mm^2	GL=50mm				BHN
Min							
Max	---	---	---	---			
Test results							

Mode of attachment of flanges	
Flange particulars	
Size of branches	
Mode of attachment of branches	

Heat treatment details		Type of HT	Soaking Temp° C	Soaking time	Cooling medium
	Product				
	Test Coupon				

Surface Treatment Details(SS Only)	
Other tests	
Ultrasonically tested to UTUTUTUTUTUT and found satisfactory to UTAUTAUTA.	
Appearance and dimensions	
Final hydraulic test	
Surface preparation and preservation	

NOTE.- In addition, the following information in respect of the material shall be furnished in a tabular form in conformity with the requirements of regulation 4(c)(vi) or the note thereto, as the case may be. The information may be given from the established test data or if the material is of standard quality an extract from the standard may be furnished instead.

Metal temperature upto °C	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600
E_t															
S_c															
S_r															

Tensile strength at 20°C.

Where

E_t Yield point at temperature t (0.2% proof stress)

**S_c Average stress to produce an elongation of 1% (creep) in 100,000 hours at various working metal temperatures.

**S_r Average and lowest stress to produce rupture in 100,000 hours at the various working metal temperatures.

Temperature range in the table may extend upto the limit of applicability of the material.

The value of Sc and Sr need be furnished only in respect of Pipes/Tubes intended to be used for working metal temperature above 454°C (850°F).

Certified that the particulars entered herein are correct.

The particulars of fabricated component are show in drawing No. _____.

The part has been designed and constructed to comply with the specifications and the Indian Boiler Regulations for a working pressure of _____ and temperature _____ and satisfactorily withstood a water test of _____ on the _____ day of _____ 20___, in the presence of our responsible representative whose signature is appended hereunder.

Maker's Representative (Name and signature)	Maker (Name and signature)

We have satisfied ourselves that the pipes have been constructed in accordance with chapter VIII and the specifications. The tests conducted on the samples taken from the finished pipes have been witnessed by us and the particulars entered herein are correct.

Place _____

Date _____

Name and signature of
Inspecting Authority.

NOTE (1).- This form is intended for the use of both pipe manufacturers and pipe fabricators. Only such of the columns or paragraphs that are applicable, or information that can be obtained and furnished from other certificates, need be filled or entered in this form.

NOTE (2).- In the case of fabrications made from steel pipes obtained from elsewhere, particulars in regard to the "material" and "pipes" shall be taken from similar forms of certificates obtained in respect of pipes and noted in the appropriate columns or paragraphs.

In the case of pipes made from steel, made and tested by well known Steel Makers in India or other countries, particulars regarding the 'material' as certified by them (in any form) shall be noted in the appropriate columns or paragraphs in this certificate

Revision record:

Rev 08: 21.09.04 : UT as per BS EN 10246-7 , in lieu of ASTM E 213
Rev 09: 31-12-05 : Mention of Shape and size of tensile test specimen on TC introduced. In cl 5.0
Rev.10: 29-12-07 : Cl 1.0, 3.0,6.0,7.0,11.0,and 12.0 modified.
Rev.11: 19-05-09: Cl:1.0 For SA 213 T23 Specification .Code case added: Cl.6.0:On line Testing included. Cl:8.0:Modified: Cl.9.0:Marking Details included in line with material specification

1.0 **MATERIAL:**

Specification: ASME {Latest on date of Purchase Order (PO)}:
CARBON STEEL(CS) : SA 192, SA 210 Gr.A1 & Gr.C
ALLOY STEEL(AS) : SA 209 Gr.T1, SA 213 Gr. T11, T12, T22, T91 ,T92 & T23(Code case:2199-4),
STAINLESS STEEL(SS): SA 213 TP 304 H, 316, 321,321H & 347 H
Additional Requirement : As listed below(Supplementary to Specification)
Size and Qty. :As per Purchase order

2.0 **CHEMICAL COMPOSITION AND PROCESS OF MANUFACTURE:**

Process of Manufacture: CS and AS:- Either cold finished or Hot finished.
SS:- Only cold finished.
Ladle & Product analysis is required for all steels.
Carbon steel: Max .Carbon: SA 210 Gr.A1: 0.25%, SA 210 Gr.C: 0.30%
Stainless Steel(SS): Boron: 0.01% max., Vanadium: 0.10% max.

3.0 **DIMENSIONAL TOLERANCES:**

(a) For cold finished tubes: CS: as per SA 450. For AS & SS as per SA 1016.
Tolerance on thickness shall be: For OD </= 38.1mm :0% to +20%and For OD > 38.1mm. 0% to +22%
(b) For hot finished tubes the tolerance shall be as follows:
For Outside Diameter : $\pm$ 0.4mm.
For Thickness (t) : 0% to +22% for t > 4.5 mm
: 0% to +24% for t between 3.6 and 4.5 mm (both inclusive)
: 0% to +28% for t< 3.6mm

4.0 **HEAT TREATMENT:**

CS. Hot finished : No Heat Treatment required
CS. Cold finished: Subcritical annealed , fully annealed or normalized
AS: Normalized and tempered
SS: Solution Annealed

5.0 **MECHANICAL TESTS:**

Number of Test: (as per IBR) Minimum 2 tubes for first 100 tubes and 1 per 100 or part thereof for tubes over 100 numbers. Tension test required for SA 192 also. Acceptance: explanatory note in Specification.
Hardness for SA 192: 120 HB (max).
For tension tests the shape and size of the specimen shall be mentioned on the Test Certificate.
(viz.,Full tube tensile or strip tensile or round tensile)

6.0 **NON DESTRUCTIVE TEST: (In house Automated On Line Testing Only)** .

(a)**Ultrasonic Testing:** For thickness =/> 3.6 mm to be conducted as per ASTM E213.Calibration: 2 axial 50mm long notches, one in outer surface and the other in inside surface. For OD < 30mm one notch in outer surface only. Notch depth 5% of thickness.(min. of 0.3mm). Scanning: clockwise & anti clockwise.
(b) **Eddy current Test**: For thickness < 3.6mm.as per ASTM E309 / E426 as applicable,
Calibration: Longitudinal notch depth: 5% max. (min. of 0.3 mm.) or drilled hole as per SA 106.

7.0 **HYDROSTATIC TEST:**

Extent of test: Only on tubes thickness < 3.6 mm as per SA 450 Cl 22.3 with S=80% of specified min. yield strength at room temperature. For others if specified in the Purchase Order.

8.0 **FINISH AND REPAIR**

Inside and outside free from loose scales and defects like laps, seams, folds, cracks, pitting etc. Repairs by welding is prohibited. Surface defects can be removed mechanically maintaining Specified thickness without affecting the workmanlike finish.

9.0 **MARKING:** (in English only)

Details to be identified.: 1) PO Number, 2) Maker's emblem/code3) Specification & grade, 4) Heat number 5) Size, 6) No. of tubes,7) Inspector's seal 8) Condition:Hot finished or Cold Finished 9) Tube Minimum Wall Thickness Designation. (For SA213 Specification.only).

Below OD 31.8mm.(Excl.)- Sl.No:1 to 9 to be stamped on metal/plastic tag attached to bundle.
OD 31.8-76.1mm.(Incl.) - Sl.No: 1 to 5,8 and 9 to be paint stenciled on each tube, Sl.No:1 to 9 to be stamped on Metal/Plastic tag attached to bundle.
OD>76.1 mm. - Sl.No: 2,3,4 &7 to be hard stamped with round edge stamp at 100mm from both ends and Sl.No:1 to 5 ,8 and 9 to be paint stenciled on each tube.
Color Coding (longitudinally) on all tubes: As per procedure SIP:PP:21 (latest)

10.0 **PRESERVATION:**

All tubes, except SS to be applied with resin type rust preventive coating with visibility to stenciled details on outside and either with rust preventive coating or rust inhibitor inside. SS tubes to be surface treated as per ASTM A380 both inside and outside. Ends to be closed with plastic end caps / plugs secured for storage.

11.0 **PACKING:**

Thickness < or = 2.5mm. in boxes and others in bundles. Tubes of thickness >/= 6.5mm and OD>/=88.9 can be shipped loose. Bundles to be </=4 tons of equal no. of tubes, fastened with galvanized strap(1x25mm.min.) or annealed wire for CS & AS and by Nylon strap for SS at both ends & at 1m interval in between. Wooden pallets to cover tubes are not permitted.

12.0 **INSPECTION AND CERTIFICATION**

12.1:Products must be inspected at works and the mill test certificate must be countersigned by the Inspecting authority as indicated below.

Imported Items: Inspecting Authority Approved by IBR for the Country of Origin. (To be concurred by BHEL before placing PO.)

Indigenously Supplied Items: Boiler Inspectorate/Directorate of respective state.

1.Mill test certificate (ORIGINAL) in English. for each product with following details shall accompany the product. Mill certified Test certificate in IBR Form-IIIE (Annexure-I) sufficient for IBR items from "IBR-Well Known Tube Maker" and for Others IBR Form-IIIB(i) (Annexure-II) as per the enclosed format.
2.Purchase Order No.(BHEL), TDC No.& Test certificate No., Size and Quantity-Melt wise.
3.Specification and Grade with year of code, Heat Number, Steel & Pipe making process, chemistry Including incidental elements-Ladle and Product Analysis.
4.Heat Treatment details, Mechanical test Results, NDE results with reference standards.

V.Kalyanaraman	S.Selvarajan	V.Jayaraman	S.R.Govindarajan
PREPARED BY	REVIEWED BY		APPROVED BY

COMPANY EMBLEM AND DETAIL

(As published in IBR)

TEST CERTIFICATE - FORM III E

IBR Approval (Well known) Reference : Certificate No.. **XXX Dt. DD/ MM/YY, Valid upto DD/MM/YY**

TC No. , & Date:		TDC No./Rev :	
PO. No., & Date:		Specification & Grade :	
Steel Making Process		Year of code:	
Finishing operation	Hot Finished/Cold Finished	Deoxidation process	

Identification

Supply particulars	PO item No	Size D x T x L	Heat No	Weight (Kgs)	Qty	

Chemical Analysis

Elements [N1]	C	S	P	Si	Mn	Ni	Cr	Mo	V	Cu	Sn	Al	Cb
min													
max													
Heat													
Product													

Heat treatment details		Type of HT	Soaking Temp° C	Soaking time
	Product			

Mechanical Properties [N2]	Longitudinal / Transverse direction						
Specified	YS	UTS	%E	%RA			Hardness
	Kg/mm^2	Kg/mm^2	GL=50mm				BHN
Min							
Max	---	---	---	---			
Test results							

Flattening test/Bend test [N3]		Flaring test	

Surface Treatment Details(SS Only)	

Non destructive tests

Appearance and dimensions	
Hydrostatic test	

N1 : As applicable to the specification
N2 : The tests specified shall be made on minimum 2 tubes for the first 100 tubes and 1 per 100 or part thereof for tubes over 100 numbers
N3 : as applicable

Surface preparation and preservation	

Certified that the particulars entered herein are correct.
The Tubes have been manufactured to comply with specifications and the Indian Boiler Regulations at our works above named and satisfactorily withstood a water test of _____on the _____day of _____ 20___ in the presence of our responsible representative whose signature is appended hereunder:

Maker's Representative (Sign. & Name Seal of Quality Control)	Maker (Sign. & Name Seal of Production)

Note:	In the case of tubes made from steel, made and certified by the Well-known Steel Makers in India or other countries, particulars regarding the 'material' a certified by them (in any form) shall be noted in the appropriate columns or paragraphs in this certificate.

COMPANY EMBLEM AND DETAIL

(As published in IBR)

FORM III B (i)
CERTIFICATE OF MANUFACTURE AND TEST

[REGULATION 4(e)]

TC No. , & Date:		TDC No./Rev :		P.O No. & Date	
Specification & Year		Finishing Operation	Hot finished/Cold Finished		
Name of part					
Intended working pressure					
Maximum recommended metal temperature					

Material

Process of manufacture	
Fully killed/rimmed	
Tubes	
Main dimensions	
Tolerances	
Mode of manufacture	
Identification marks	
Drawing numbers	

Supply particulars	PO item No	Size D x T x L	Heat No	Weight (Kgs)	Qty	

Chemical composition

Elements [NT]	C	S	P	Si	Mn	Ni	Cr	Mo	V	Cu	Sn	Al	Cb
min													
max													
Heat													
Product													

Heat treatment details		Type of HT	Soaking Temp° C	Soaking time	Cooling medium
	Product				

Mechanical Properties [N2]	Longitudinal / Transverse direction						
Specified	YS	UTS	%E	%RA			Hardness
	Kg/mm²	Kg/mm²	GL=50mm				BHN
Min							
Max	---	---	---	---			
Test results							

Bend test on tube	
Bend test on weld	
Flattening test	
Crushing test	
Flare test	
Flange test	
Surface Treatment Details(SS Only)	
Appearance and dimensions	
Hydrostatic test	

N1 : As applicable to the specification
N2 : The tests specified shall be made on minimum 2 tubes for the first 100 tubes and 1 per 100 or part thereof for tubes over 100 numbers

Surface preparation and preservation	

Other tests															
Ultrasonically tested to UTUTUTUTUTUT and found satisfactory to UTAUTAUTA. Eddy current tested to EDEDEDEDE and found satisfactory to EDAEDAEDAEDA Dimensions satisfactory.															
Final hydraulic test															
NOTE.- In addition, the following information in respect of the material shall be furnished in a tabular form as indicated. The information may be given from the established test data or if the material is of standard quality, an extract from the standard may be furnished instead.															
Metal temperature upto °C	250	275	300	325	350	375	400	425	450	475	500	525	550	575	600
E_t															
S_e															
S_r															

Tensile strength at 20°C.

Where

E_t Yield point at temperature t (0.2% proof stress)

**S_e Average stress to produce an elongation of 1% (creep) in 100,000 hours at various working metal temperatures.

**S_r Average and lowest stress to produce rupture in 100,000 hours at the various working metal temperatures.

Temperature range in the table may extend upto the limit of applicability of the material.

The value of Sc and Sr need be furnished only in respect of Pipes/Tubes intended to be used for working metal temperature above 454°C.

Certified that the particulars entered herein are correct.

The part has been designed and constructed to comply with the variations from the standard conditions laid down in the Indian Boiler Regulations, 1950, for material, design and construction features which have been permitted by the Board or the Inspecting Authority under the Indian Boilers Act, 1923 and satisfactorily withstood a water test of _____ on the _____ day of _____, 20__, in the presence of our responsible representative whose signature is appended hereunder.

Maker's Representative (Name and Signature)	Maker _____

We have satisfied ourselves that the tubes have been constructed in accordance with the variations from the standard conditions laid down in the Indian Boiler Regulations, 1950 and Specifications, for material, design and construction permitted by the Board. The tests conducted on the sample taken from the finished tubes have been witnessed by us and the particulars entered herein are correct.

Place_____ Name and Signature of
Date _____ Inspecting Authority

Note (1) This form is intended for the use of the both tube manufacturers and tube fabricators. Only such of the columns or paragraphs that are applicable, or information that can be obtained and furnished from other certificates, need be filled or entered in this form.

Note (2) In the case of fabrications made from steel tubes obtained from elsewhere, particulars in regard to the "material" and "Tubes" shall be taken from similar forms of certificates obtained in respect of tubes and noted in the appropriate columns or paragraphs.

In the case of tubes made from steel, made and tested by Well Known steel makers in India or other countries particulars regarding the 'material' as certified by them (in any form) shall be noted in the appropriate columns or paragraphs in this "certificate".

Approval Date: April 15, 2009

The ASME Boiler and Pressure Vessel Standards Committee took action to eliminate Code Case expiration dates effective March 11, 2005. This means that all Code Cases listed in this Supplement and beyond will remain available for use until annulled by the ASME Boiler and Pressure Vessel Standards Committee.

Case 2199-4
2.25Cr-1.6W-V-Cb Material
Section I

NOTE: Code Case 2199-4 supersedes Code Cases 2199, 2199-1, 2199-2, and 2199-3. This modifies the requirements for chemical composition to ensure that the microstructure needed to achieve the specified mechanical properties is developed. Therefore, Code Case 2199-4 should now be used, and the use of Code Cases 2199, 2199-1, 2199-2, and 2199-3 should be discontinued immediately.

Inquiry: May 2.25Cr-1.6W-V-Cb material with the chemical analysis shown in Table 1, and minimum mechanical properties as shown in Table 2, that otherwise conform to the specifications listed in Table 3 be used for Section I construction?

Reply: It is the opinion of the committee that 2.25Cr-1.6W-V-Cb material with the chemical analysis shown in Table 1, and minimum mechanical properties as shown in Table 2 that otherwise conform to the specifications listed in Table 3 may be used for Section I construction, provided the following requirements are met:

(a) The material shall be austenitized within the temperature range of 1900°F to 1975°F (1040°C to 1080°C), followed by air or accelerated cooling, and tempered within the range of 1350°F to 1470°F (730°C to 800°C).

(b) The material shall not exceed a Brinell Hardness Number of 220 (Rockwell B 97, 230 HV) after tempering.

(c) The maximum allowable stress values for the material shall be those given in Table 4.

(d) Separate weld procedure qualification shall be required for this material. The welding procedure qualification shall be conducted as prescribed in Section IX. Exemptions to postweld heat treatment for this material shall be in accordance with the rules for P-No. 5A materials in PW-39. When postweld heat treatment is required, the time requirements shall be in accordance with the rules for P-No. 5A materials in PW-39, and the PWHT temperature range shall be 1325°F to 1470°F (720°C to 800°C). For the purposes of performance qualification, the material shall be considered P-No. 5A. The performance qualification shall be conducted as prescribed in Section IX.

(e) Except as provided in para. (f), if during the manufacturing any portion of the component is heated to a temperature greater than 1470°F (800°C), then the component must be reaustenitized and retempered in its entirety in accordance with (a) above, or that portion of the componentheated above 1470°F (800°C), including the Heat-Affected Zone created by the local heating, must be replaced, or must be removed, reaustenitized, and retempered, and then replaced in the component.

(f) If the allowable stress values to be used are less than or equal to those provided in Table 1A of Section II, Part D for Grade 22 (SA-213 T22, SA-335 P22, or equivalent product specifications) at the design temperature, then the requirements of (e) above may be waived provided that the portion of the component heated to a temperature greater than 1470°F (800°C) is reheat treated within the temperature range 1350°F to 1425°F (730°C to 775°C).

(g) This Case number shall be shown on the Manufacturer's Data Report.

TABLE 1
CHEMICAL REQUIREMENTS

Element	Composition Limits, %
Carbon	0.04–0.10
Manganese	0.10–0.60
Phosphorous, max.	0.030
Sulfur, max.	0.010
Silicon, max.	0.50
Chromium	1.90–2.60
Molybdenum	0.05–0.30
Tungsten	1.45–1.75
Vanadium	0.20–0.30
Columbium	0.02–0.08
Nitrogen, max.	0.015
Aluminum, max.	0.030
Boron	0.0010–0.006
Nickel, max.	0.40
Titanium	0.005–0.060
Titanium/Nitrogen Ratio, min.	3.5 [Note (1)]

NOTE:
(1) Alternatively, in lieu of this ratio minimum, the material shall have a minimum hardness of 275 HV in the hardened condition, defined as after austenitizing and cooling to room temperature but prior to tempering. Hardness testing shall be performed at midthickness of the product. Hardness test frequency shall be two samples of product per heat treatment lot and the hardness testing results shall be reported on the material test report.

TABLE 2
MECHANICAL PROPERTY REQUIREMENTS

Tensile strength, min., ksi	74
Yield strength, min., ksi	58
Elongation in 2 in., min., % [Note (1)]	20

NOTE:
(1) For longitudinal strip tests, a deduction from the basic values of 1.00% for each $\frac{1}{32}$ in. decrease in wall thickness below $\frac{5}{16}$ in. shall be made. The following table gives the computed values.

Wall Thickness, in.	Elongation in 2 in., min., %
$\frac{5}{16}$ (0.312)	20.0
$\frac{9}{32}$ (0.281)	19.0
$\frac{1}{4}$ (0.250)	18.0
$\frac{7}{32}$ (0.219)	17.0
$\frac{3}{16}$ (0.188)	16.0
$\frac{5}{32}$ (0.156)	15.0
$\frac{1}{8}$ (0.125)	14.0
$\frac{3}{32}$ (0.094)	13.0
$\frac{1}{16}$ (0.062)	12.0
0.062 to 0.035, excl.	11.6
0.035 to 0.022, excl.	10.9
0.022 to 0.015, incl.	10.6

GENERAL NOTE: The above table gives the computed minimum elongation vallues for each $\frac{1}{32}$ in. decrease in wall thickness. Where the wall thickness lies between two values shown above, the minimum elongation value shall be determined by the following equation:

$$E = 32t + 10.0$$

where

E = elongation in 2 in., %
t = actual thickness of specimen, in.

TABLE 3
SPECIFICATION

Forgings	SA-182
Pipe	SA-335
Plate	SA-387
Tube	SA-213

TABLE 4
MAXIMUM ALLOWABLE STRESS VALUES

For Metal Temperature Not Exceeding, °F	Maximum Allowable Stress Values, ksi [Note (1)]	
	Tubes	Forgings, Pipe, Plate
−20 to 100	21.1	21.1
200	21.1	21.1
300	21.1	21.1
400	21.1	21.1
500	21.1	21.1
600	20.9	20.9
650	20.7	20.7
700	20.5	20.5
750	20.3	20.3
800	19.9	19.9
850	19.5	19.5
900	18.9	18.9
950	17.8	16.2
1000	14.3	13.3
1050	11.2	10.7
1100	8.4	8.3
1150	5.5	5.0
1200	1.4	1.4

NOTE:
(1) The allowable stress values are based on the revised criterion of tensile strength of 3.5, where applicable.

Rev Record: 01: 27.06.95: Modified based on feed back & amendment. Rev:02: text re-written. Rev 05: 27/02/04: Al.% relaxed to 0.05 from 0.03max. Bend test details indicated as supplementary test reference in the material Spec. is deleted .Rev: 06:14/02/08 SA 299 changed to SA 299 Gr A. Cl 1.0,3.0,4.0 and Cl 6.0 modified.

1.0 MATERIAL SPECIFICATION:

ASME: SA 299 Gr A (Latest as on PO date).,Additional Requirements as listed below (supplementary to Specification). Size, and Qty.: As per Purchase order (PO)

2.0 CHEMICAL COMPOSITION & PROCESS:

Killed steel, Final rolling: lengthwise. Vacuum treatment (S1 of SA 20). Plate thick(t)>80mm to be made only from ingots. Plate of t</=80mm. can be made from continuous cast slabs. Reduction ratio in thickness from slab to plate shall be 3:1. Sufficient 'Top of Ingot' to be discarded to ensure plate free of segregation. After top discard, the increase in carbon content at the top-mid width-mid thickness of the plate shall not exceed 20% of the reported ladle analysis value. This value shall be reported in TC. Ladle analysis: 1 sample per cast, Product analysis: minimum one sample per plate as rolled.

Max. Carbon: 0.28%, Max. Al: 0.05%. CE: C + Mn/6 + Si/24 + Ni/40 + Cr/5 + Mo/4 + V/14 <= 0.55% for t</=150mm.;0.58% for > 150mm.

3.0 HEAT TREATMENT (HT):

As rolled or Normalized as per mill practice. If Normalize Temperature:870-900deg.C

4.0 SIMULATION HEAT TREATMENT for test coupons in addition to Cl.:3.0:

Normalize: 870-900deg.C for 0.5hr/inch t, SR:615+/-10deg.C,3 hr./inch t, furnace cool to 400deg.C. ROH/ROC for SR: <220/t deg.C/hr.(t in inch), but need not be slower than 55 deg.C/hr.

5.0 MECHANICAL TESTS on simulation Heat Treated coupon:

Extent of test: For each rolled plate. Bend test: The longitudinal axis of the test specimen shall be transverse to the final rolling direction of the plate.The specimen thickness shall be 30 mm and width 45 mm, to be bent on a pin dia. of 3 times the thickness of the specimen . The as rolled surface of the specimen shall be on the outer surface.Two specimens shall be taken to cover the entire thickness of the plate. The angle of bend shall be 180^0

High temperature tensile test: S7 of SA 20. Min. yield strength at 350 deg.C: 21.2 Kg/sq.mm.

6.0 NON DESTRUCTIVE TEST:

Ultrasonic test: SA578. Acceptance criterion : Level B.

7.0 DIMENSIONAL TEST:

Tolerance on thickness of plates shall be positive only.

8.0 FINISH AND REPAIRS:

Plates to be free from loose mill scales & injurious defects. Repairs by fusion welding prohibited. Mechanical Removal of defects permited subject to min. thickness & smooth surface.

9.0 MARKING:

Specification, grade, Melt number, Plate number, Maker's emblem/code,Inspecting Authority's seal to be stamped with low stress stamp on each plate and bordered by white paint. Rolling direction shall be marked by paint. PO No., "BHEL - Tiruchirappalli" & weight to be painted on the product.

10.0 INSPECTION AND CERTIFICATION:

Products to be inspected at works & test certificates(in ENGLISH)countersigned by Inspecting Authority as below: Imported: Inspecting Authority approved by IBR for country of origin.(to be concurred by BHEL) Indigenously supplied IBR items: Boiler Inspectorate/directorate of Boilers of respective State. Test certificate in English for each product with following details shall ccompany the product.(in format approved by Boiler Inspectorate):

1. Purchase Order No.(BHEL),TDC No., Test certificate number & Quantity.
2. Specification and Grade with applicable year of code, Heat Number, Plate number.
3. Steel making process, Chemistry including incidental elements - Ladle and Product analysis.
4. HT details of material and test coupons like temperature, soaking time, cooling medium etc.
5. Mechanical, NDE & other test results with reference, acceptance standards.
6. Print of the stamp of Inspecting Officer, which is used on the plate.

Prepared by	Reviewed by		Approved by
V.Kalyanaraman	U. Revisankaran	K.Rengachari	C.R.Raju

Revision Record: Rev:04 : 18.07.08: Cl 1.0 to Cl: 6.0 modified.

1.0 MATERIAL SPECIFICATION:

ASME:(Latest as on PO Date) : Carbon steel (CS): SA 515 Gr. 70,
: Alloy Steel. (AS) :SA 387 Gr.12 Class 2, Gr.22 Class 2,

Additional Requirement : As listed below.(Supplementary to specification)

Size, and Qty .: As per Purchase order (PO)

2.0 CHEMICAL COMPOSITION & PROCESS:

All plates are of Fully Killed steel, Drum plates shall be of Vacuum Degassed.(S1 of SA20),
Final rolling: lengthwise. Ladle analysis:1 sample per cast, Product analysis: min.1 sample per plate as rolled.
Max Carbon: CS: 0.25% Max.Carbon Equivalent for Carbon steel : As per S20 of SA20.

3.0 HEAT TREATMENT (HT):

CS: Normalize at 880-920 deg.C, AS: Normalize and Temper.

4.0 SIMULATION HEAT TREATMENT for test coupons in addition to Cl.:3.0: (For CS only)

Normalize:880-920deg.C, SR:615+/-10deg.C, Soaking: 3 hr./ inch thick (t), furnace cool to 400deg.C.
ROH/ROC for SR:< 220/t deg.C/hr.(t in inch), but need not be slower than 55 deg.C/hr.

5.0 MECHANICAL TESTS:

On simulated Heat Treated condition for CS and in as delivered condition for AS.
Extent of test: For each plate. (1)Tensile test.(2).Bend test: Angle of bend:180 deg.
Diameter of the mandrel = 2 x Thickness of the plate as rolled.
High temperature tensile test for Drum Plates : S7 of SA 20. Min.yield strength at 350 deg.C: 19.7 Kg /sq.mm.

6.0 NON DESTRUCTIVE TEST:

Ultrasonic test: As per SA578. Acceptance: Level B.

7.0 DIMENSIONAL TEST:

Tolerance on thickness of plates shall be positive only.

8.0 FINISH AND REPAIRS:

Plates to be free of loose mill scales, edge crack & other injurious defects. Repairs by fusion welding prohibited. Mechanical removal of defects permitted subject to min. thickness & smooth surface.

9.0 MARKING:

Specification, grade, Melt number, Plate number, Maker's emblem/code, Inspecting Authority's seal to be stamped with low stress stamp on each plate & bordered by white paint. Rolling direction shall be marked by paint. PO No., "BHEL - Tiruchirappalli" & weight to be painted on the product.

10.0 INSPECTION AND CERTIFICATION:

Products to be inspected at works & test certificates countersigned by Inspecting Authority as below:
Imported: Inspecting Authority approved by IBR for country of origin.(to be concurred by BHEL)
Indigenously supplied IBR items: Boiler Inspectorate/Directorate of Boilers of respective State Supplier certified TC sufficient for IBR items from 'IBR approved well known Steel maker'. Test certificate in English for each product with following details shall accompany the product(in Form-IV)

1.Purchase Order No.(BHEL),TDC No., Test certificate number & Quantity.
2.Specification and Grade with applicable year of code, Heat Number, Plate number.
3.Steel making process, Chemistry including incidental elements - Ladle and Product analysis.
4.HT details of material and test coupons like temperature, soaking time, cooling medium etc.
5.Mechanical, NDE & other test results with reference, acceptance standards.
6.Print of the stamp of Inspecting Officer, which is used on the plate.

Prepared by	Reviewed by		Approved by
V.Kalyanaraman	U. Revisankaran	K.Rengachari	C.R.Raju

Records of Revision:
Rev 01 : In clause 5.0 for mechanical testing requirement for high temp tensile test deleted in line with IBR.

1.0 SCOPE

1.1 This Technical Delivery Condition specifies the additional requirements for the delivery of carbon steel forged nozzles conforming to the specification SA 105 to the latest edition.

1.2 This TDC is supplementary to the mandatory requirements covered in the specification.

1.3 The size and quantity shall be as specified in the purchase order.

2.0 CHEMICAL COMPOSITION AND PROCESS

2.1 The steel shall be manufactured by electric furnace or basic oxygen process and shall be fully killed.

2.2 The chemical composition of the steel shall be tested for each melt and shall conform to the specification requirements with the following restriction, in both ladle and product analysis:

2.2.1 The maximum carbon content shall be limited to 0.30%.

2.3 Forging_practice

2.3.1 Wherever possible, the forgings shall be ring forged or ring rolled. Nozzles of small diameters or nozzles of length more than the diameter may be forged as solid cylinders and subsequently bored.

2.3.2 The longitudinal axis of the finished cylinder shall be parallel to and shall coincide with the longitudinal axis of the starting billet. Billets shall not be sectioned to provide forging stock.

2.3.3 Centre punch outs and cores shall not be used.

2.3.4 All forgings shall be processed to provide adequate metal flow during the hot working operation in the direction most favourable for resisting stresses encountered in service.

2.3.4.1 Forgings made from continuous cast billets shall be hot forged to provide a 4:1 area reduction.

2.3.4.2 In the open die process, forgings made from hot rolled billets shall be forged to diameter at least 76 mm (3 inches) less than the starting size of the billet.

3.0 DIMENSIONAL TOLERANCES

3.1 The forgings shall conform to the dimensional tolerances as specified in the drawing. The following tolerances shall be used in proof machined condition, if it is not specified:

Outside diameter	: + 5 mm, - 0 mm
Wall thickness	: + 5 mm, - 0 mm
Length	: + 29 mm, - 0 mm
Eccentricity	: 3 mm max.

4.0 HEAT TREATMENT

4.1 The forgings shall be supplied in normalised condition as per specification.

5.0 MECHANICAL TESTING

5.1 The testing for mechanical properties shall be conducted from finished heat treated material or identical specimen which has undergone the same amount of working, as per ASTM A370 for each size/melt/Heat treatment batch and shall meet the requirements as given below:

5.1.1 Tensile test at room temperature, as per specification.

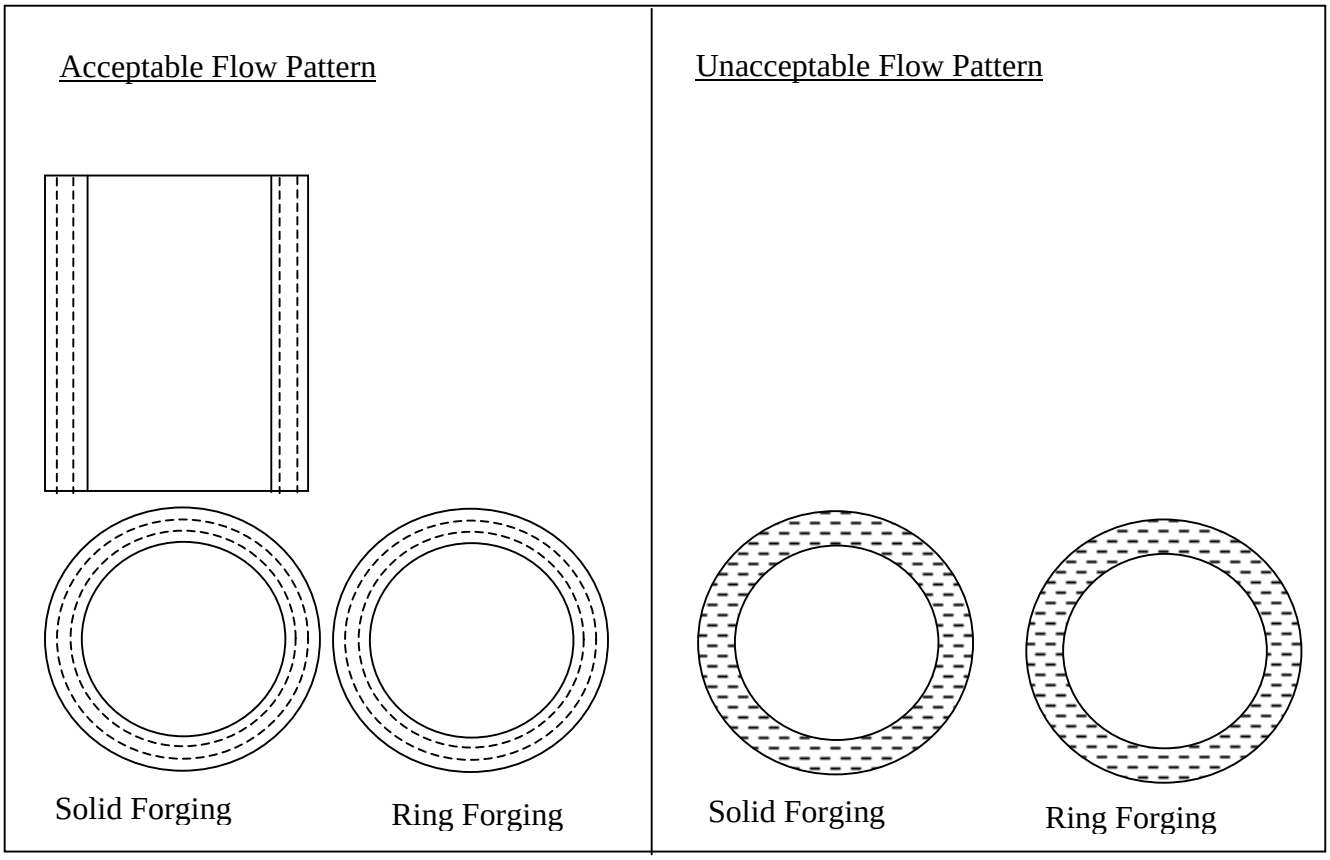
5.1.2 Bend test at room temperature

Bend test shall be done with specimen of rectangular cross section machined to a finished size of 25.4 mm wide by 19 mm thick. The test piece shall be bent cold over the thinner section through an angle of 180o without fracture, the internal diameter of the bend being not greater than the specimen thickness.

5.2 Macro_etching

5.2.1 A macro etch sample shall be taken from one end of the forging of each size and each forging practice. A cross section shall be polished and etched to develop flow lines. Forgings which display a pattern of flow lines that intersect both inside and outside are not acceptable (See figure - 1 below).

Figure-1



6.0 NON DESTRUCTIVE TESTING

6.1 100% ultrasonic test shall be conducted on all forgings according to SA 388 and the acceptance standard shall be as per AM 203.2 of ASME Section VIII Division 2.

7.0 WORKMANSHIP AND FINISH

7.1 The forgings shall be examined visually and shall be free from scales, laps, seams, folds, cracks or other injurious defects and shall have a workman like finish.

7.2 All the forgings shall be coated with a protective layer of transparent rust preventive before despatch.

8.0 REPAIR

8.1 Repairs involving fusion welding are prohibited.

8.2 Surface defects can be removed by mechanical means and the defective areas shall be smoothly dressed up with the adjacent surface. The minimum thickness after repair shall meet the drawing requirements.

9.0 MARKING AND PACKING

9.1 The following details shall be legibly marked on each forging by hard stamping with low stress stamps.

1. Specification and size
2. Melt number
3. Maker's emblem
4. Inspecting authority's seal

9.2 The forgings shall be properly packed and despatched to avoid any damage during transit.

10.0 INSPECTION AND CERTIFICATION

10.1 All the tests specified here shall be carried out at works and the test results shall be furnished in the test certificates, countersigned by an inspection agency recognised under IBR, if the Forger is not recognised as a "Well known Forger" under IBR. If the Forger is recognised as a "Well known Forger", then the Forger's TC is enough.

10.2 The test certificate shall contain the following details in English language only.

1. Purchase Order Number.
2. Test Certificate Number.
3. TDC Number.
4. Quantity and Size.
5. Steel making/Forging process.
6. Specification and Melt Number.
7. Chemistry - Meltwise (Ladle and product analysis).
8. Heat treatment details like Temperature, soaking time, cooling medium etc.
9. Mechanical test results - Tensile, Bend and Macro.
10. NDT results with reference and acceptance standards.

11.0 AUDIT CHECKS AT BHEL

11.1 BHEL reserves the right to carry out audit checks for chemistry, heat treated condition, mechanical testing and NDT on forgings at their discretion.

11.2 If any forging is found to be defective during check tests as per Cl. 11.1 or during subsequent processing at BHEL, such forgings are liable for rejection.

12.0 END USE

12.1 These forgings are intended for use in boiler drums as nozzles.

BHARAT HEAVY ELECTRICALS LIMITED
TIRUCHIRAPALLI 620 014

QUALITY ASSURANCE

SIP: PP: 04 / 06

HYDOROSTATIC TESTING OF PRESSURE PARTS
(BOILERS, PRESSURE VESSELS & HEAT EXCHANGERS)

REV	DATE	PREPARED	REVIEWED	APPROVED
06	19.05.2009	K.Mohan	S.Selvarajan	U.Revisankaran
05	17/03/2009	S.Selvarajan	U.Revisankaran	C.R.Raju
04	31/03/2006	S.Selvarajan	U.Revisankaran	C.R.Raju
03	01/03/2003	S.Selvarajan	U.Revisankaran	C.R.Raju

RECORD OF REVISIONS

Rev. No.	Clause No.	Details of Revision
00/15.07.96	---	This procedure has been made from the document PR:QE:015/03
01/ 03.04.00	1.2 2.0 to 2.6 3.2 to 3.6 Annexure	Clause revised. Hydro test pressure modified. Revised for clarity and re-numbered as 2.0 to 2.8. Clauses revised for clarity. “U2” stamp details modified.
02/ 24.04.00	2.6 & 2.10	Clauses revised for clarity.
03/ 01.03.03	1.2, 2.10, 3.3, 3.4 & Annexure 3.5.1	Modified Added
04/ 31.03.06	Clauses 2.1 to 2.10 Clauses 3.3, 3.4, 4.1 Annexure	Re-arranged, modified and re-numbered as 2.1 to 2.8. Modified for clarity. Deleted.
05/ 17.03.09	1.2	Revised. Basis of Hydro test pressure for ASME Sec.VIII.D2 vessels is changed based on the revision of ASME Sec.VIII.D2
06/ 19.05.09	1.2	Modified for clarity
	2.8	Split into 2.8 and 2.8.1
	3.2 & 3.3	Modified for clarity.

1.0 SCOPE

1.1 This procedure covers the requirements of hydrostatic testing of pressure parts in boilers, pressure vessels, heat exchangers, studded pipes etc. The specific requirements, if any, mentioned in the respective quality plans are also to be followed during the test.

1.2 Hydrostatic test shall be conducted at the minimum test pressure specified in the drawing. The basis for calculating test pressure is as follows:

a) For parts of IBR & ASME Sec. I : 1.5 times the MAWP

b) For parts of ASME Sec. VIII Div.1 : 1.3 times the MAWP x S_R

where MAWP = Maximum allowable working pressure and S_R is the lowest ratio (for the materials of which the vessel is constructed) of the stress value S for the test temperature on the vessel to the stress value S for the design temperature.

c) For parts of ASME Sec. VIII Div. 2 : Greater of 1.43 x MAWP (or) 1.25 x MAWP x (S_T/S)

where MAWP = Maximum allowable working pressure and S_T' is the allowable stress at Test temeperature and 'S' is the allowable stress at Design temperature and the ratio (S_T/S) is the lowest ratio for the pressure boundary materials, excluding bolting materials, of which the vessel is constructed

2.0 PREPARATION FOR HYDROSTATIC TEST

2.1 Before hydrostatic test, the components shall be complete with regard to welding, NDE, PWHT etc. as envisaged in the drawing and QP.

2.2 All the openings shall be closed with proper dummy welding or suitable mechanical fixtures.

2.3 The component shall be supported carefully avoiding point contacts.

2.4 An indicating guage shall be connected to the pressure part such that it is visible to the operator controlling the pressure applied. The pressure indicating gauges selected shall have dials graduated over a range of double the intended maximum test pressure; but in no case shall the range be less than 1.5 times the test pressure nor more than 4 times the intended test pressure. The spacing between graduations shall be such that the inspector and the operator controlling the test shall be able to determine when the required test pressure has been applied. The pressure guages shall have valid calibration.

2.5 For drums, headers and vessels, two pressure guages shall be used. One guage shall be kept on the top location of the part under test and the other one at any other convenient location. However, for tubular parts where pressure head is very low, the guage can be kept in the pressure line itself.

2.6 Vents shall be provided at all high points of the component / assembly in the position in which it is to be tested to purge possible air pockets while the components is being water filled.

2.7 The pressurising system shall have suitable valve connections such that the part under testing is isolated during the test.

2.8 Potable water shall be used for the test, unless specified otherwise. The temperature of water shall be not less than 20 deg. C and not more than 50 deg. C during the test.

2.8.1 For ASME Sec. VIII Div. 1 & 2 applications, it is recommended that the vessel metal temperature during testing is maintained at least 17 deg. C above the minimum design metal temperature (MDMT), but need not be more than 50 deg. C. In all cases, if the test temperature exceeds 50 deg. C, inspection of the vessel shall be delayed until the temperature is reduced to 50 deg. C or less.

3.0 HYDROSTATIC TEST

3.1 The hydrostaic test shall be conducted in the presence of Authourised inspector / inspecting officer, wherever applicable.

3.2 After complete venting, vents shall be closed. Careful examination shall be done for possible leakages especially in dummy blanks before pressurising. The pressure shall be raised gradually. In case of boiler parts, actual pressure may exceed the test pressure by note more than 6% provided no part of the boiler shall be subjected to a general membrane stress greater than 90% of its yield strength (0.2% offset) at test temperature.

3.3 The test pressure shall be maintained for 30 minutes (5 minutes for tubular products in boilers) minimum and then reduced to the pressure as follows.

a) For IBR and ASME Sec.I - MAWP

b) For ASME Sec.VIII Div.1 - Not less than the test pressure divided by 1.3

c) For ASME Sec.VIII Div.2 - Not less than the test pressure divided by 1.43

3.4 This pressure shall be maintained for a sufficient period to permit complete examination by the inspecting authority.

3.5 A close visual examination shall be carried out for leaks / sweats in welds at the pressure indicated as above. No leak / sweating is permitted. When there is an appreciable pressure drop without any gross leakages, the joints in the pump flanges, valve gasket and dummies shall be checked for leakages. After arresting them, the test shall continue.

3.6 Where leaks are noticed, it shall be recorded. After draining the water completely, the repair shall be done with the approval of the inspecting officer. Post weld Heat treatment, if required for repair, shall be done before retest.

3.7 When repairs are made, the part shall again be subjected to the hydrostatic test as in the regular way.

3.8 After successful hydrostatic test, the component shall be completely drained and dried where necessary.

4.0 STAMPING

4.1 After successful hydrostatic testing, the test parameters shall be stamped as detailed in the Quality Plan / Drawing for stamped parts / assemblies such as vessels, heat exchangers, drums, headers and pipings of dia. 127 mm & above. The details shall be stamped on a name plate / component.

5.0 DOCUMENTATION

5.1 A facsimile of the stamping details shall be taken on a tracing and filed.

5.2 A hydrostatic test report shall be prepared, duly signed by the inspection agency and filed.

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Revision Record: RECORD OF REVISIONS

Rev. No.	Clause No.	Details of Revision	Remarks
00		PR:QE:177/00 was revised and renamed as SIP:PP:05	

1 .0 SCOPE

This procedure details out the quality requirements for diameter, circularity and profile for shells and dished ends for boiler drums.

2.0 REFERENCE DOCUMENTS

IBR, ASME Section I.

3.0 QUALITY REQUIREMENTS

SHELLS

Diameter

Circumference measurements shall be performed at intervals of approximately 1 metre over the full length, on the outside of the vessel shell. From these measurements, the average outside diameter shall be calculated. The outer diameter shall not depart from the given theoretical outside diameter by more than + 1%.

Circularity

The difference between the maximum and minimum inside diameters measured at any cross section of the shell shall not exceed 1% of the nominal(average) internal diameter at the cross section under consideration.

The diameters may be measured on the outside or inside of the vessel. If measured on the outside, the diameters shall be corrected for the plate thickness at the cross section under consideration.

When the shell is made of plates of unequal thicknesses, the measurements shall be corrected for the plate thicknesses, as they may apply, to determine the diameters at the middle line of the plate thickness.

When the cross section passes through an opening or within 1 ID of the opening measured from the center of the opening, the permissible difference in inside diameters may be increased by 2% of the ID of the opening.

In order to meet the circularity requirements, the shell may be rerolled, reformed and heat treated subsequently, if necessary. If this occurs, it shall be followed by NDE (MPI & RT/UT) on the weld seams.

Profile

Any departure of profile measured on the outside of the shell with a profile gauge of the designed form of the exterior of the shell, having length equal to a quarter of the nominal internal diameter shall not exceed the percentage given below. Flats at the welded seams shall not be permitted and any local departure from circularity shall be gradual.

Nominal ID of drum	Profile departure in Percentage of nominal ID
Upto and including } 914 mm }	0.375

Over 914 upto and including 1143 mm	0.350
Over 1143 mm	0.300

DISHED ENDS

Diameter

The outer circumference of the dished end shall be measured at the skirt portion and the outer diameter shall be calculated. The outer diameter shall not depart from the given theoretical outside diameter by more than + 1%, however this deviation shall not affect the thickness requirement during machining.

Circularity

The skirts of dished ends shall be sufficiently true to round so that the difference between the maximum and minimum diameters shall not exceed 1% of the nominal (average) diameter. However, this out of circularity shall not affect the thickness requirements during machining.

Profile (For ASME Section I applications only)

The inner surface of the Ellipsoidal dished ends shall not deviate outside of the specified shape by more than 1.25% of the nominal inside diameter of the dished end (ID at the skirt portion). Departure inside of the specified shape shall not be permitted.

The deviation measurements shall be taken on the surface of the base metal and not on welds, using a profile gauge having length not less than a quarter of the nominal ID of the dished end.

4.0 DOCUMENTATION

The diameter, circularity and profile measurements shall be recorded in checklist, log or history card.

Bharat Heavy Electricals Ltd. Tiruchirappalli 620014 QUALITY ASSURANCE	

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PROCEDURE FOR SURFACE PREPARATION AND PAINTING

(Boilers and Valve Components)

REV	DATE	PREPARED	REVIEWED	APPROVED
03	10/05/03	(M. SOMU) Manager Plant Lab	(R. VEERARAGHAVAN) DGM/ Plant Lab	(A.V KRISHNAN) AGM / QA & Labs
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			SDGM/QC (J. KANNAN)	
			SDGM/QA (S. VISWANATHAN)	

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

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 + 0.85 + 0.60 + 0.50	0 % <0.10% 85.0% 97.0% (Cumulative)
Steel Grits to SAE G 40	+ 0.425 + 0.30 + 1.00	>70.0% >80.0% (Cumulative) 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 % Volume Solids = 40 (min), DFT= 50µm / Coat (min)
Pa 4	Chlorinated Rubber based Finish Paint % 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 % Volume Solids = 60 (min), DFT= 65µm / Coat (min)
Pa 7	Zinc chrome Primer (Alkyd base) by Dip Coat. (Shade : Yellow) BHEL specification PR:CHEM:09-03 (latest) *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. 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 % Volume Solids = 75 (min), DFT= 200µm / Coat (min)
Pa 14	High Build Aluminum Epoxy Mastic Primer to IS 13184 % Volume Solids = 80 (min), DFT= 100µm / Coat (min)
Pa 15	Aliphatic Acrylic Polyurethane Paint to IS 13213 % Volume Solids = 40 (min), DFT= 30µm / Coat (min)
Pa 16	Epoxy Polyamide cured Finish Paint to IS 14209 % 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 % 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 SSPC SP 3	3 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 SSPC SP 3	3 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, 36-811,813,814 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 Columns	34-850, 35-851 36-850,851,852,853 38-850, 39-850 36-1xx	SSPC SP 3 SSPC SP 6	1a 1a	Black Shade 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 SSPC SP 3	3 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/ Cold air Dampers Dampers Gates	48-0X2, 48-1X2 48-013, 033,113,143 48-XX3 (except 48-013,033,113,143) 48-XX0	SSPC SP 3 SSPC SP 3 SSPC SP 3 SSSP SP3	1a 1a 3 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 * Silencer/S.V. Escape Pipes Water Washing piping	24-X60,X73,X80 24-X20,X85 & X90 24-466	SSPC SP 3 SSPC SP 6 SSPC SP 3	3 9 1a	*Refer to Valves scheme
Manhole Doors	28-220	SSPC SP 3	10	
Fixing components (Boiler)	30-XXX	SSPC SP 3 SSPC SP 3	3 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 SSPC SP 3	3 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 SSPC SP 3	3 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 3	All Exterior surfaces All Interior surfaces
Gates	48-XX3, 48-XX0	SSPC SP 3	3	
Hot air/Flue Ducts/ Dampers/Gates	48-2XX ,48-3XX, 48-4XX ,48-7XX 44-432,48X 48-1xx	SSPC SP 3	1a 3	Exterior of HRSG casings. FBC (both sides), HRSG (Interior)
Coal Feeders	47-953	SSPC SP 3	1a	
Bunker	66-XXX (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, 5	3:headers 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
TIRUCHIRAPPALLI - 620 014
QUALITY ASSURANCE DEPARTMENT

AMENDMENT TO QUALITY WORK INSTRUCTIONS (QWI)

QWI NO: QCP:001 REV: 05

AMENDMENT SL NO: A1 DATE: 19.05.2009

DESCRIPTION: FABRICATION OF PRESSURE PARTS (OTHER THAN TUBULAR PRODUCTS)

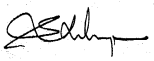
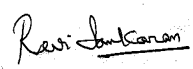
<table>
<tr><th>Clause No.</th><th>Amended as…</th><th>Remarks / Basis for Amendment</th></tr>
<tr><td>3.5.4

3.5.13</td><td>All components shall be loaded in raised platforms to avoid flame impingement during heat treatment in gas furnaces. The components shall be adequately supported to minimize distortion. Ensure test plate loading if applicable.

For interruptions during heat treatment, the following action has to be taken depending on the stage of occurrence:
<table>
<tr><th>Type of Heat treatment</th><th>Stage of interruption</th><th>Action</th></tr>
<tr><td rowspan="3">Stress Relieving</td><td>Heating</td><td>Heat treat subsequently as specified</td></tr>
<tr><td>Soaking</td><td>Heat treat subsequently for balance soaking with minimum 15 minutes</td></tr>
<tr><td>Cooling</td><td>If the ROC during interruption meets the specified rate, cool subsequently at the required rate. Otherwise, reheat to the soaking temperature, hold for 15 minutes and then cool at the specified rate</td></tr>
<tr><td rowspan="3">Tempering</td><td>Heating</td><td>Heat treat subsequently as specified</td></tr>
<tr><td>Soaking</td><td>Heat treat subsequently for balance Soaking with minimum 15 minutes</td></tr>
<tr><td>Cooling</td><td>Not applicable</td></tr>
<tr><td rowspan="3">Normalising & Solution annealing</td><td>Heating</td><td>Heat treat subsequently as specified</td></tr>
<tr><td>Soaking</td><td>Heat treat subsequently for full soaking</td></tr>
<tr><td>Cooling</td><td>Not applicable</td></tr>
</table>
3.5.14

If any thermocouple fails during furnace heat treatment, it shall be ensured that at least two thermo couples (covering the entire equipment / batch) reasonably are functioning within 4.5 metre distance. In case of local heat treatment, at least one thermocouple monitoring the temperature of the weld zone shall be functioning. One stand by thermocouple may be provided in the weld zone, which can be connected to the recorder in case the already connected thermocouple fails. Otherwise, PWHT is to be discontinued and restarted.

3.10.1 Unless otherwise specified, the tolerances for untoleranced dimensions shall be as per Drawing No. TP:023:0299 (latest)</td><td>For better clarity</td></tr>
<tr><td>NOTE</td><td colspan="2">The above-mentioned changes will be incorporated in the QWI during the next revision of the document.</td></tr>
</table>

Prepared by: S. Selvarajan	Approved by: U. Revisankaran
 Signature & Dt: 19.05.2009	 Signature & Dt: 19.05.2009

BHARAT HEAVY ELECTRICALS LIMITED
TIRUCHIRAPPALLI 620 014 INDIA

QUALITY CONTROL PROCEDURE FOR **QCP:001 / 05**

FABRICATION OF PRESSURE PARTS
(OTHER THAN TUBULAR PRODUCTS)

Prepared by Quality Assurance	U. Revisankaran	Ravi Sankaran

Reviewed by	Signature
Engineering (P.S. Guruchandran)	
Manufacturing Shops (R. Kothandapani)	
O P & C (G. Kumaraguru)	
Quality Control (J. Kannan)	
Quality Assurance (C.R. Raju)	

Revision No.	Date	Approved by	Signature
00	01/04/93	SM / QA	
01	01/01/95	SM / QA	
02	15/07/96	SM / QA	
03	13/11/97	DGM / QA	
04	01/04/03	SDGM / QA	
05	31/12/05	AGM / QA	

RECORD OF REVISIONS

Rev. No.	Date	Clause No.	Details of revision
00	01/04/93		This document consolidates all the general requirements and technical disciplines covered in the various QCPs.
01	01/01/95		This document has been modified to delete the scope of Tubular products. All amendments issued has been regularized and editorial corrections made for better clarity. Scope of machining also added in this document.
02	15/07/96		Totally revised and the clauses re-arranged.
03	13/11/97	3.2, 3.3.3.1. 3.3.9, 3.5.8, 3.6, 3.9.6 & Annexure I	Modified based on feedback
		3.5.9	Deleted
04	01/04/03	3.1.5, 3.1.6, 3.2.2.2, 3.2.2.4, 3.2.2.5, 3.2.6, 3.2.3.5, 3.2.4.3, 3.3.2.1, 3.3.3.1, 3.3.5.1, 3.3.9, 3.5.7.1, 3.4.2.2, 3.4.3.1, 3.5.5, 3.5.6, 3.5.8	Modified
		3.5.10, 3.5.11, 3.5.12, 3.5.15	Modified and re-numbered as 3.5.9, 3.5.10, 3.5.11 & 3.5.14 respectively
		3.5.13, 3.5.14	Re-numbered as 3.5.12 & 3.5.13 respectively
		3.2.4.3.1	Introduced from Amendment A1 dated 05/10/00 issued for Revision 03.
		3.2.4.3.2	Introduced from Amendment A2 dated 21/07/01 issued for Revision 03.
		3.3.3.2, 3.3.10	Added
		3.4.2.4	Introduced from Amendment A3 dated 15/11/01 issued for Revision 03.
		Annexure I	Modified
05	31/12/05	3.2.4.3	Soaking requirements modified for CS.
		3.5.8, 3.5.9	PWHT temperature for P4 material altered.
		3.5.13	Guidelines for interruptions during heat treatment altered based on Amendment A1 dated 13/03/04.

1.0 **SCOPE**

1.1 This procedure details out various disciplines to be followed during fabrication of pressure parts other than tubular products 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, preservation and dispatch

1.2 The specific product quality requirements are detailed in relevant Std. Quality Plan (SQP)/Inspn. & Test Procedure (SIP)

2.0 **MATERIAL IDENTIFICATION and TRACEABILITY**

2.1.1 During incoming inspection, the raw materials, welding consumables and sub deliveries are to be verified for correctness through test certificates (TC) as per relevant Technical delivery condition (TDC) / Material Specification/Purchase specification. This is applicable for Customer supplied materials also. Components received from subcontracting works are to be verified for correctness through Inspn./Dimension report.

2.1.2 Issue of materials shall be as per the MIV/MRS/CRS and freedom from visual damages like pitting, dents, laminations, scales, warpages etc. shall be ensured.

2.1.3 When in raw matls, defects are noticed, the same shall be confirmed by using appropriate NDE techniques and corrected, in consultation with QC.

2.1.4 The requirements of material traceability (ATTEST/CERTIFY) is as indicated in the respective drawings / material requisition slips (MRS) / Material issue vouchers (MIV).

2.1.5 ATTEST/PRODUCT ATTEST items, indicated as "A/P" in drawings, are traceable to the test certificates (TC) and identified as below. These items are issued with Attestation Form correlating the TCs and product through Work Order.

Product form	Identification	Method
Plates	Specn., Melt No, Plate No.	Stamping
Pipes ? >= 80mm, Forgings, Barstock	Specn., Melt No	Stamping
Pipes ? < 80mm & Tubes >= 31.8mm	Specn., Melt No	Stenciling / Engraving and Colour code
Tubes < 31.8mm	Specn., Melt No	Lot wise on a tag Colour code on individual tube
For Colour codes refer SIP:PP:21 (Latest)		

2.1.6 CERTIFIED items, indicated as "C" in drawings, are traceable to Specification / Grade only and identified by stamping/ engraving/ stenciling/ color coding/ marking.

2.1.7 Raw materials not covered by the above shall be identified by its W.O.No/ material code/ specification/ grade by painting or stenciling or engraving. All sub deliveries shall be identified by its material code by painting or through tags / name plates.

2.1.8 In case of marking, cutting or machining, the transfer of material identification shall be certified by QC. In case of tubes, the color code shall be transferred.

2.1.9 For stock raw materials, which are upgraded for special contract requirements, QC shall ensure that the respective TCs and laboratory reports satisfy specification/Contract, TDC/CQP as applicable and identified with W.O.No.

2.1.10 Unidentified materials if found in processing shall be verified for specification and H.T.condition through appropriate checks and shall be upgraded (wherever required) for relevant application.

3.0 **PROCESS CONTROL** [Refer Annexure I for P number grouping of materials & Annexure II for tolerance drawings].

3.1 **FABRICATION**

3.1.1 Ensure correctness of raw material identification and attestation to drawing requirements, as required. Traceability to the contract shall be ensured by stamping or marking / painting applicable WO No. and DU / Part no .

3.1.2 Whenever marking operation is carried during shell plate layout, openings on shells, dished ends or pipes, hole locations on baffles/ girth flanges/ tube sheets, attachments locations etc. the marking correctness shall be ensured as per relevant drawing. The marking shall be identified with punch marks. Wherever required the allowance for cutting/ machining shall be provided.

3.1.3 Before removal of any identification marks during cutting / machining they shall be transferred on adjacent area and certified by QC. All marking inspection shall be performed by QC prior to further operation. The material Specn./Grade/Melt No./Attestation No., as applicable, are to be transferred on balance raw materials for future use.

3.1.4 Reference line mark shall be ensured at a distance of about 100mm from the free ends. For pipes meant for bending and attachment welding, center line marking shall be done.

3.1.5 Cutting may be done by shearing, saw cutting or gas cutting. Stainless steel shall be plasma cut or sheared. Where shearing is for thickness > 25 mm., the cut edges shall be ground. Only saw cutting shall be used for X20 and P91 materials.

3.1.6 During gas cutting and thermal gouging, proper preheating shall be ensured. The requirements of preheating for gas cutting / gouging is as follows.

Carbon steel up to and including 25 mm	::	Nil
Carbon steel above 25 mm	::	100 deg.C.min.
Alloy steel (all t) & SA299	::	150 deg.C.min.
Stainless steel, X20 & P91	::	Not applicable

3.1.7 The thermal cut edges shall be ground to be free from surface irregularities, scales and burrs,chips etc. The ends prepared for welding shall conform to the relevant drawing. Unless and other wise specified in SQP/CQP all bevels / edges, which are gas cut and are to be welded to pressure parts, shall be ground to 1 to 2 mm for removal of HAZ and checked by LPI/MPI.

3.2 **FORMING**

3.2.1 General.

3.2.1.1 Forming shall be done using proper toolings free from high spots and damages. The process/tooling shall have been qualified by a first off trial and the records shall be verified for compliance before production, as applicable.

3.2.1.2 The method of forming (Cold or Hot) shall be as specified in OPS/Traveler.

3.2.1.3 The prebend profile shall be ensured for correctness before forming shells to final radius.

3.2.1.4 The profile shall be checked using a template of forming radius and chord length at least equal to 1/4 ID. Surface waviness shall be suitably sized. Variations of the profile shall not be abrupt but shall merge gradually in the specified shape.

3.2.1.5 Surface depression in formed areas shall be merged gradually into the base material surface to 1:4 taper. Minimum thickness after forming shall be verified & ensured.

3.2.1.6 Carbon Steel Plates shall be normalized before cold forming if the plates are received in "as rolled condition".

3.2.2 Cold Forming:

3.2.2.1 Fiber Elongation (FE)in % = 50t/R for single radius and 75t/R for multiple radius, Where t = thickness, R = Mean radius

3.2.2.2 Cold Forming/Sizing can be done for Material Groups P1 to P5 without inter stage Heat Treatment under the following conditions.

I. For thickness 50 mm and below, if outer fiber elongation does not exceed 5 %.
II. For thickness above 50 mm and up to 100 mm, if outer fiber elongation does not exceed 3.5 %.
III. For thickness above 100 mm and up to 150 mm if outer fiber elongation does not exceed 3 %.
IV. For thickness above 150 mm cold forming is not recommended.

3.2.2.3 When the above conditions are not met, forming in 2 stages is required. Initial forming shall be done to a radius which satisfies above conditions. Then an inter stage heat treatment is to be carried out as per Clause 3.5.8 before forming to finishing radius.

3.2.2.4 When cold rerolling of shells is to be done after welding, the following shall be ensured.

a. Flush grinding of weld reinforcement on both surfaces prior to rerolling.

b. Interstage Heat Treatment of Shells after welding and before rerolling is required as below.

- P1 upto P4 Group Matls. : if thickness exceeds 50 mm
- P5 Group of materials : For all thickness
- Inter stage heat treatment shall be as per Cl: 3.5.8 except that a soaking for minimum period of 1/2 hour is sufficient for any thickness in case of Carbon steel and 1 hour in case of Alloy steel.

c. LPI/MPI shall be done on weld seams after re-rolling.

3.2.2.5 During cold forming of stainless steel plates suitable nonmetallic pads shall be used to avoid direct contact with ferritic materials. Cold forming of austenitic stainless steel material (P8) can be done without further heat treatment if the outer fibre elongation does not exceed 10%.

3.2.2.6 Heat treatment after cold forming of P8 steels shall be as per relevant SQP/CQP.

3.2.3 Hot Forming:

3.2.3.1 During hot forming the material shall be heated all round uniformly to the specified temperature.

3.2.3.2 After hot forming and prior to cold sizing / weld fit up of material groups P3,P4,P5, a tempering operation shall be carried out . The temperatures shall be as per Cl:3.5.8 unless otherwise stated.

3.2.3.3 Post form heat treatment can be combined with PWHT of the product/component as per Clause 3.5.8 except for P5 Formed fittings, P5 Plate formed pipes.

3.2.3.4 After hot forming, Heat Treatment shall be carried when required as per relevant SQP/CQP . The temperature shall be as per relevant SQP/CQP.

3.2.3.5 P8 materials when Hot Formed require Solution Annealing (SA) as detailed out in the relevant SQP/CQP.

3.2.4 Heat Treatment Parameters:

3.2.4.1 The temperatures shall be as per relevant SQP/CQP.

3.2.4.2 Rate of Heating :

Hot working	For t <= 100mm, 200 °C/hour max.
Normalizing	For t > 100mm, 150 °C/hour max.
Sol. Annealing	
SR/Tempering	As per Clause 3.5.8

3.2.4.3 Soaking during heating / Post forming heat treatment shall be as per below guide lines.

Hot working/Normalizing	1/2 hour per inch of "t" (15 minutes minimum)
SR/Tempering	CS - 1 hour per inch of "t" for “t” upto 2 inches with an additional 15 minutes for every inch above 2 inches (15 minutes minimum). AS - 1 hour per inch of "t" (P3 & P4) - 30 minutes min. (P5A) - 60 minutes min. except for P5A pipes of OD <= 127mm and t <= 13mm, which require only 30 minutes) (P5B) - 120 minutes min.
Solution Annealing	1 hour per inch of "t" (15 minutes minimum)

where " t " is nominal thickness for plates, pipes and diameter for bar stock.

3.2.4.3.1 In case of mixed loads of materials not covered under simulation HT, the maximum soaking time for Hot working/ Normalising of any item shall not exceed twice the minimum calculated as above. For Tempering/SR, this shall be as per Cl. 3.5.10.

3.2.4.3.2 In case of pipe bends / fittings, thickness " T " for determining soaking time shall be calculated as

T = t * (2R - r) / (2R – 2r) where " R " is the radius of the bend and " r " is the mean radius of the pipe.

3.2.4.4 Rate of Cooling

Normalizing,tempering : Air Cooling
Stress Relieving : As per Clause 3.5.8
Sol. Annealing : Air Blast / Water Cooling

3.2.5 The temperatures are only indicative. The actual temperature shall be as per material Mill TC wherever Simulation Heat Treatment is a requirement.

3.2.6 All heat treatment shall be applied only after the component temperature falls below 200 deg. C (below 100 deg. C for P91). Temperature of the furnace during loading shall be below 300 deg. C.

3.2.7 Any scales due to hot forming shall be removed by suitable blasting in case of ferritic steel and pickling/passivation in case stainless steel.

3.3 **WELDING**

3.3.1 Fit-up of the weld joints including Tube to tube sheet joints shall be ensured as per drawing. All run out pieces, bridge on pieces and temporary attachments shall be identified and welded with necessary preheat and matching electrodes.

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

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

3.3.2.1 Tack welds shall be done to a sufficient length (25 mm minimum) and width using qualified procedure and personnel . Tack welds found defective during visual examination shall be removed.

3.3.3 For 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

3.3.3.1 Tolerance for alignment (surface mismatch) of butt welds shall be as per table below unless requirements are otherwise specified in respective Standard/Contract Quality Plans.

Section Thickness	**Long seam**	**Cir seam**
Up to 13mm	1/4t	1/4t
Over 13mm to 19mm	3 mm	1/4t
Over 19mm to 38mm	3 mm	4.8 mm
Over 38mm to 51mm	3 mm	1/8t
Over 51 mm	Lesser of 1/16t or 9mm	Lesser of 1/8t or 19mm

3.3.3.2 If plate edges of unequal thickness are abutted and the surface offset exceeds the limits mentioned above on either side, the thicker plate shall be thinned down to a smooth taper of 1:4 minimum over the width of the weld.

3.3.4 Weld and adjacent base material surface approximately 15 mm on either side of weld shall be thoroughly cleaned and ensured free from oil, grease, rust, scales etc. For tube to tube sheet joints cleanliness of tube and tube sheet holes shall be ensured before fit up.

3.3.5 Preheat/Inter pass requirements for welding shall be as per the WPS and controls shall be exercised as detailed below:

3.3.5.1 Preheating must be applied using gas burner or induction / resistance heating method before starting each cycle of welding as specified in WPS. Preheat temperature, subsequent extended preheat/inter pass temp. shall be maintained and verified throughout welding using thermal chalks (temperature indicating crayons)/ thermocouples. The preheat shall be applied for a width of 75 mm or 1.5 times the base metal thickness, whichever is more, around the point of welding (not less than 25 mm in case of tack welding) in all directions.

3.3.6 Welding shall be performed with qualified procedures and qualified personnel. Welding procedures are qualified to ASME Sec. IX and personnel to IBR/ASME Sec.IX, unless specified otherwise.

3.3.7 Ensure correctness of welding consumables before use including baking and drying. Where specified, the batch traceability shall be maintained through records.

3.3.8 Wherever post heating is specified in WPS, the preheat temperature shall continue after welding till attaining the post heat temperature and maintained for the required time and cooled slowly.

3.3.9 In Headers and Piping products, the distance between any two pipe butt joints shall be greater than one diameter and shall not be less than 500 mm. For tubes, the minimum distance between butt joints shall be 150 mm except for inserts which shall be as per drawing.

3.3.10 In case of interruptions in welding, the minimum preheat temperature shall be maintained until any required PWHT is performed on P3, P4, P5A, P5B and P6 materials except when all of the following conditions are satisfied.

i. A minimum of at least 10 mm thickness of the weld is deposited or 25% of the weld groove is filled, whichever is less.
ii. For P3, P4 and P5A materials, the weld is allowed to cool slowly to room temperature.
iii. For P5B and P6 materials, the weld is subjected to an adequate intermediate stress relieving.
iv. After cooling and before welding is resumed, visual examination of the weld shall be performed to assure that no cracks have formed.
v. Required preheat shall be applied before welding is resumed.

3.4 WELD INSPECTION (Visual, NDE) AND REPAIRS

3.4.1 Visual Inspection

3.4.1.1 After completion of welding, visual inspection shall be done as per SIP:PP:02 (latest), unless specified otherwise in the relevant SQP/CQP.

3.4.1.2 Where parts of different thickness are welded, the change in thickness shall be made gradual, either by grinding or machining to a 1:4 taper.

3.4.1.3 Stray arcs shall be avoided. Arc spots, if any, shall be ground and checked by LPI/MPI. Ensure thickness requirements in such cases.

3.4.2 **Nondestructive Examination (NDE)**

3.4.2.1 The extent and type of NDE are specified in the respective SQP/CQP.

3.4.2.2 NDE shall be performed using qualified procedures and personnel only. NDE techniques are based on ASME Sec. V unless specified otherwise. The acceptance norms shall be based on the relevant code of construction, built into the respective NDE procedures and approved by the statutory authorities, as required.

3.4.2.3 The Welder No., radiography No. and reference axis marks shall be punched in case of radiography joints of size above 108 mm. In case of other welds suitable records can be maintained correlating the weld joint.

3.4.2.4 In drums and alloy steel headers, when tube holes are envisaged on weld seams (longitudinal and circumferential), such welds shall be radiographed and stress relieved prior to tube hole drilling.

3.4.3 **Repairs**

3.4.3.1 Defects noticed shall be removed by air arc gouging, drilling, machining or grinding with suitable bevel for welding. When defects are air arc gouged preheat shall be applied as required for gas cutting of material and the cavity shall be ground to remove black spots. The area shall be free of any irregularities that might trap slag during welding. Gouging is not permitted for P91 and X20 materials.

3.4.3.2 MPI/LPI shall be conducted on the cavity to ensure complete removal of defects, such as cracks, ICP and lack of fusion. For other defects such as slag, pores etc., a thorough visual inspection is necessary before repair welding.

3.4.3.3 All repair welding shall be using qualified WPS and qualified welders.

3.4.3.4 Defects in the completed test plates shall not be repaired. Defect free portion can be used for testing.

3.4.3.5 The repair welds shall be subjected to the same NDE as per the original weld.

3.4.3.6 After all welding, NDE and successful weld repairs, the welds shall be visually inspected for completeness and cleared for heat treatment wherever applicable.

3.5 **POST WELD HEAT TREATMENT (PWHT)**

3.5.1 The parts/assemblies shall be cleaned prior to PWHT.

3.5.2 PWHT shall be by furnace or local heat treatment.

3.5.3 The thermocouples and recording instruments shall be calibrated and records maintained. The furnace shall have been qualified for temperature distribution.

3.5.4 All materials shall be loaded in raised platforms to avoid flame impingement during heat treatment in gas furnace. Ensure test plate loading if applicable.

3.5.5 Thermocouples shall be attached to the component as per the following guidelines:

a. Thermocouples shall be placed such that the entire component (including the anticipated hottest and coldest zones) is covered.

b. The maximum distance between any two thermocouples shall not exceed 4.5 metres.

c. The temperature variation between any 4.5 metre distance shall be 100 deg. C maximum for temperature above 400 deg. C during heating.

3.5.6 Local heat treatment can be done either by Resistance heating or by Induction heating. P91 and X20 components shall be locally heat treated using induction heating only.

3.5.6.1 When heat treating butt joints, width of the circumferential heating band on either side of the weld must be at least 3 times the width of the widest part of the weld groove; but not less than twice the thickness of the thicker part welded.

3.5.6.2 When heat treating nozzles and attachment welds, the width of the heating band on either side of weld shall be 6 times the base material thickness beyond the welding to be heat treated. The heating band shall extend axially around the entire vessel.

3.5.6.3 Width of the insulation band beyond the heating band shall be at least twice the total width of the heating band.

3.5.6.4 A minimum of three thermocouples shall be placed such that at least one is on the weldment / HAZ and the other two on the base material on either side of the weldment within the heating band. Two Thermocouples are sufficient for Piping & Header items.

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

3.5.7 Unless otherwise specified in SQP/CQP, the following rules shall apply to establish the governing thickness (T) for determining the **soaking time for PWHT.** Soaking time is accounted as the time between the temperature crossing and leaving the minimum recommended temperature.

3.5.7.1 For Butt welds, "T" shall be thickness of the weld. For bar stock "T" shall be the diameter. For fillet welds, "T" shall be the throat thickness. If a fillet weld is used in conjunction with a groove weld, "T" shall be the total of the depth of the groove plus the fillet throat thickness.

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

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

3.5.7.4 For combination of different welds in a component, the higher governing thickness "T" shall govern.

3.5.7.5 For IBR items having welded joint connecting parts of different thickness, the governing thickness (T) for determining the **soaking time for PWHT** shall be the maximum thickness of the part welded.

3.5.8 Guidelines for selecting soaking temperature for PWHT unless specified otherwise in relevant WPS/SQP.

a)

MATERIAL	TEMPERATURE deg. C
P1, P9 B	595-625
P3	620-660
P4	630-670 (Minimum 650 Deg. C for ASME jobs)
P5A	680-720
P5B	750-770
P8	PWHT Nil

b) Rate of heating / cooling for SR and rate of heating for tempering shall be as below unless otherwise specified. Incase of SR, cooling shall be in furnace up to 400 deg. C (350 deg. C for X20 and P91) and further in Air.

Thickness of Material	Maximum Rate of Heating & Cooling above 400 deg. C
Up to 25mm	220°C/Hr
Over 25 - 50mm	110°C/Hr
Over 50 - 75mm	75°C/Hr
Over 75mm	55°C/Hr

c) Soaking shall be as per Clause 3.2.4.3

3.5.9 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 3.5.10.

i) Where a component has a butt joint between P1 & P4, or P3 & P4, the cycle shall be 630 - 670 deg. C (Minimum 650 Deg. C for ASME jobs).
ii) Where a component has a butt joint between P4 & P5A, the cycle shall be 680 - 720 deg. C.
iii) Where a component has a butt joint between P1 & P3, the cycle shall be 620-660 deg. C.
iv) Where a component has a butt joint between P5A & P5B, the cycle shall be 730-760 deg. C.
v) For P1+P5A material combination, follow the WPS requirements.

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

i) Separate jobs of P1 and P4
ii) Separate jobs of P4 and P5
iii) Separate jobs of P5A and P5B

3.5.10 For PWHT of materials not covered under simulation heat treatment, in case of 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, 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

3.5.11 After PWHT, the charts shall be correlated with the job and cleared by QC. The charts shall contain the cycle No., date, recorder number, and WO & material details. The cycle temperature, ROH,ROC & soaking time shall be calculated from the chart and entered in the chart signed off by QC and statutory authorities as required.

3.5.12 Wherever specified, the test plate shall be tested and reports obtained to complete the clearance of heat treatment operation.

3.5.13 For interruptions during heat treatment, the following action has to be taken depending on the stage of occurrence:

Type of Heat treatment	Stage of interruption	Action
Stress Relieving	Heating	Heat treat subsequently as specified
	Soaking	Heat treat subsequently for balance soaking
	Cooling	If the ROC during interruption meets the specified rate, cool subsequently at the required rate. Otherwise, reheat to the soaking temperature, hold for 15 minutes and then cool at the specified rate
Tempering	Heating	Heat treat subsequently as specified
	Soaking	Heat treat subsequently for balance soaking
	Cooling	Not applicable
Normalising & Solution annealing	Heating	Heat treat subsequently as specified
	Soaking	Heat treat subsequently for full soaking
	Cooling	Not applicable

3.5.14 If any thermocouple fails during furnace heat treatment, it shall be ensured that at least two thermo couples (covering the entire equipment / batch) reasonably are functioning. In case of local heat treatment, at least one thermocouple monitoring the temperature of the weld zone shall be functioning. One stand by thermocouple may be provided in the weld zone, which can be connected to the recorder in case the already connected thermocouple fails. Otherwise, PWHT is to be discontinued and restarted.

3.6 HOT CORRECTION AFTER PWHT

3.6.1 When hot correction for bow, distortion, alignment etc. is required, flame heating may be adopted, limiting the maximum temperature as below.

P1 (CS) :950 deg.C.(if weld joints are not getting heated)
:650 deg C (if weld joints are getting heated)
P3/P4 :720 deg.C.
P5A/12X1MF:760 deg.C.
P5B (T91) :760 deg.C (followed by Tempering).

For C.S & T91, the temperatures shall not exceed the above values. For others, if the temperature exceeds the above limits, the items shall be subsequently stress relieved. The metal temperature shall be checked using thermal chalks or other suitable means. Flame heating shall be avoided on headers, but correction can be done by mechanical means/induction heating limited to the temperatures specified above.

3.6.2 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.

3.7 TUBE EXPANSION

3.7.1 Before expansion of Tube to tube sheet joints, ensure thorough cleanliness of the tube ends for a distance equal to tube sheet thickness plus 30 mm.

3.7.2 Suitable lubricants shall be used for expansion. The expansion toolings like mandrel, rollers etc. shall be examined periodically to be free from damage.

3.7.3 Expansion shall be done using the qualified torque for the required length.

3.7.4 QC/Shop shall ensure correctness of expansion in each shift periodically. In the case of expansion to full thickness of Tube sheet it shall be ensured that the expansion shall terminate 3 mm from the back face of the Tube sheet.

3.7.5 The expanded area and the tube sheet face shall be cleaned thoroughly.

3.8 **AIR LEAK TEST, HYDROSTATIC TEST**

3.8.1 The surface shall be thoroughly cleaned before pressurizing.

3.8.2 Wherever air leak test is called for, the test medium shall be air or Nitrogen. The test pressure shall be raised gradually . Test parameters shall be as per SQP/Drawing.

3.8.3 Wherever hydrostatic test is specified, the same shall be performed in accordance with SIP:PP:04 (latest) or relevant SQP/Drawing.

3.9 **MACHINING**

3.9.1 The work center for finish machining shall be identified on the OPS based on the process capability of the machine or Machine accuracy established to suit the tolerances. All cutting tools shall have been ensured for correctness before use.

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

3.9.3 Ensure verticality and parallelity of the jobs on the machine by using the reference markings or dialing the surfaces after clamping the job and periodically during machining.

3.9.4 After machining the surfaces shall be suitably deburred and cleaned. After removing from the machine it shall be properly stored.

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

3.9.6 Ensure proper reaming allowances for finish operations.

3.9.7 During boring operations, control on feed for finish cut shall be ensured to achieve required size and finish.

3.10 **UNTOLERANCED DIMENSIONS**

3.10.1 Unless otherwise specified ,the following tolerances can be used for untoleranced dimensions.

Linear	Upto 50	51 to 500	501 to 2000	Above 2000
Machining	+/- 0.2	+/- 0.5	+/- 1.0	+/- 2.0
Fabrication	+/- 1.0	+/- 2.0	+/- 4.0	+/- 6.0
Angular	Assembly : +/- 0.5 deg.		Others : +/- 1 deg.	

3.11 **SURFACE CLEANING & PAINTING**

3.11.1 Unless otherwise specified, all completed parts/assemblies shall be cleaned thoroughly using wire brush or power tools to remove scales, dirts and any other foreign material before painting.

3.11.2 Where blast cleaning is mentioned before application of special paint, sand or shot blasting shall be done at area with moisture protected environment. Blasting shall be done with suitable nozzle with constant velocity and pressure. Compressed air used for blasting shall be free from moisture. The finished blasted surface shall have metal finish without any black spots and other foreign matters.

3.11.3 Painting shall be applied within shortest period after blasting is completed.

3.11.4 Any marking about dispatch details shall be as per relevant drawing/SQP. This shall be painted in bold white paint stenciled letters on the part/assembly.

4.0 CALIBRATION/VERIFICATION OF EQUIPMENT AND INSTRUMENTS

4.1 Ensure the following.

-Usage of calibrated measuring instruments, and test gauges.
-Usage of validated test hardware like jigs, fixtures and copying templates etc.
-Checking of shop made templates before use.
-Validation of software and programs used on NC machines.

5.0 HANDLING, STORAGE, PRESERVATION & DISPATCH

5.1 All materials shall be handled with properly maintained equipment, tools and tackles to ensure handling damages. This is applicable at stores , various shops and shipping .

5.2 Ensure capacity of the handling equipment based on the part to be handled.

5.3 Materials/components shall be stored at identified location properly for easy retrieval.

5.4 The stored components/ materials shall be preserved/protected to prevent damages/ rusting/ warpages.

5.5 Storing and preservation of Welding consumables till issue shall be ensured as per recommendation of WTC. The issue of welding consumables shall be authorized by WTC. At manufacturing shops the welding consumable are ensured for adequate baking and drying before use . The issue of welding consumables shall be authorized by shop.

5.6 Components/Products shall be packed in such a manner to avoid damage/transit loss. All packages shall be identified with packing slips duly certified.

5.7 The assembly shall be securely anchored for dispatch to prevent any damage during transit. Protrusions from main components shall be suitably protected. All openings shall be suitably blanked.

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Annexure I

ASME MATERIALS & P - NUMBER GROUPING

P-No.	PLATES	PIPES	TUBES	FORGINGS / FITTINGS
P1/Gr 1 (Carbon Steel)	SA 515 Gr 60 SA 516 Gr 60 SA 283 Gr A-D SA 285 Gr C SA 334 Gr 1,6	SA 106 GrA,B SA 333 Gr 1,6	SA 178 Gr A,C SA 179 SA 192 SA 210 Gr A1	SA 350 LF1 SA 266 Cl1
P1/Gr 2 (Carbon Steel)	SA 515 Gr 70 SA 516 Gr 70 SA 299 SA 537 Cl 1	SA 106 Gr C	SA 178 Gr D SA 210 Gr C	SA 105 SA 266 Cl2, Cl3 SA 350 LF2
P3/Gr 1 (L A S)	SA 204 Gr A SA 387 Gr2/Cl1	SA 335 P1,P2	SA 209 T1,T1A SA 213 T2	
P3/Gr 2 (L A S)	SA 204 Gr B,C			SA 182 F1,F2
P4/Gr 1 (L A S)	SA 387 Gr11 Cl 1 & Cl 2 SA 387 Gr12 Cl 1 & Cl 2	SA 335 P11 SA 335 P12	SA 213 T11 SA 213 T12 SA 199 T11	SA 182 F11 Cl 1,2,3 SA 182 F12 Cl 1,2 SA 234 WP11 Cl 1 SA 234 WP12 Cl 1 SA 336 F11 Cl 1,2,3 SA 336 F12 Cl 1,2
P5A/Gr 1 (L A S)	SA 387 Gr22 Cl 1 & Cl 2	SA 335 P22	SA 213 T22 SA 199 T22	SA 182 F22 Cl 1,3 SA 234 WP22 Cl 1
P5B/Gr 1 (A S)	SA387 Gr5/Cl1 SA387 Gr9/Cl2	SA 335 P5 SA 335 P9	SA 199 T5 SA 199 T9	SA 182 F5, F9 SA 234 WP5, WP9 SA 336 F5, F9
P5B/Gr 2 (A S)	SA 387 Gr 91	SA 335 P91	SA 213 T91	SA 182 F91 SA 234 WP91 SA 336 F91
P6/Gr 1 (SS 410)	SA 240 TP 410		SA 268 TP 410	SA 182 F6aCl1
P6/Gr 2 (SS 429)	SA 240 TP 429		SA 268 TP 429	
P6/Gr 3 (S S)				SA 182 F6aCl2 SA 336 F6
P7/Gr 1 (SS 410S)	SA 240 TP 410S, TP 405, TP 409		SA 268 TP 405, TP 409	
P7/Gr 2			SA 268 TP 430	
P8/Gr 1 (S S)	SA 240 TP 304, 304L 304H, 316, 316L, 321, 347, 347L, 347H	SA 312 TP 304, 304L, 316, 316L, 321, 347	SA 213 TP 304H, 316, 316H, 321H, 347H, 316 Ti	SA 182 F304H SA 182 F347H
P9B/Gr1 (L A S)	SA 203 Gr D,E,F	SA 333 Gr 3	SA 334 Gr 3	SA 350 LF3

For Clad plates & Non ASME Materials, refer to the respective Standard / Contract QPs.

ANNEXURE - II

TOLERANCE DRAWINGS

Sl.No.	Drawing No.	Description	Product
01	0-03-000-00001	Allowable Drum Tolerance	Drum
02	1-03-000-00011	Socket seat weld plain ends	Headers
03	1-03-000-00014	Socket seat weld tapered ends	Headers
04	1-03-000-00034	Header Tolerance	Headers
05	2-03-000-00001	Socket seat weld plain ends for schedule pipes	Headers
06	2-03-000-00028	Fabrication Tolerance for Feeder headers and down comers (Waste heat boilers)	HRSG Header & Down comers
07	2-03-000-00029	Fabrication tolerance for Module box assembly (for Waste heat boiler)	HRSG
08	2-03-000-00030	Fabrication tolerance for Shop assembled piping	HRSG
09	2-03-000-00031	Fabrication tolerance for Module (Waste heat boiler)	HRSG modules
10	3-PV-000-00075	Vessel Tolerance	Pressure Vessels
11	TEMA Table RCB 7.41	Tube sheet Hole Diameter Tolerance	Heat Exchangers
12	TEMA Table RCB 7.42	Tube sheet Holes Ligament and Drill drift	Heat Exchangers
13	TEMA Fig.F1	External dimensions, Nozzle and Support locations	Heat Exchangers
14	TEMA Fig.F2	Recommended Fabrication Tolerances	Heat Exchangers
15	TEMA Fig.F3	Tube sheets, Partitions, Covers & Flanges - Machining Tolerances	Heat Exchangers

Note: Revision status of these drawings/standards shall be ensured before use.

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Revision Record: RECORD OF REVISIONS

Rev. No.	Clause No.	Details of Revision	Remarks
00		This procedure has been made from the document PR:QE:017/03 with total modification.	

1.0 SCOPE

This procedure is applicable for visual inspection and blending of base metal surfaces at welds on drums, headers, piping and fittings.
This is also applicable for repair of deficient surface areas on the base materials as well as on welds.

2.0 MATERIALS

All materials of P1, P2, P3, P4 and P5 as per ASME Section IX and Steel 20 & 12X1MO of GOST specification will be covered by this procedure.

3.0 SURFACE EXAMINATION BEFORE POST WELD HEAT TREATMENT

Prior to post weld heat treatment, the base metal surfaces and surfaces at welds in drums, headers, nozzles, nipples, pipes and fittings shall be visually examined for surface quality.
The following criteria shall be met:
Base metal surfaces
Minor local surface imperfections noted by visual examination may be accepted without grinding or weld repair, provided they are less than 4 mm in depth (2 mm for fittings). However, the sides shall not be closer than 2 mm.
In case they don't comply, the depression should be ground so that the contours comply with the requirements of 1:4 taper with the adjoining surfaces.
The surface imperfections shall in all cases be free of tears or cracks. The thickness at the depression shall not encroach on the minimum design thickness.
Surface at welds
Undercuts shall not exceed 0.8 mm in depth as measured from the adjacent unaffected surfaces. Areas on pipes or tubes of diameter 108 mm or less which are used as nipples shall not contain undercuts that exceed the lesser of 0.8 mm or 10% of the wall thickness.
Reinforcement requirements
The maximum permitted reinforcement on the butt welds shall be as follows:

Nominal thickness in mm	Maximum reinforcement in mm
	circum. jt.| other welds in pipes & |

	tubes
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.	* 4.0
over 76.2 to 101.6 incl.	* 5.5
over 101.6 to 127 incl.	* 6.35
over 127	* 8.0

* The greater of 6.35 or 1/8 times the weld width.

4.0 SURFACE EXAMINATION AFTER POST WELD HEAT TREATMENT

When the surface becomes marred after the final postweld heat treatment, the affected area shall be reconditioned by grinding and blending to remove all tears and upset metal. The contour of the ground and blended depression shall be flared to have a 1:4 taper and to have a minimum bottom radius of three times the depth.

Such reconditioned areas may be left without weld repair when they meet the following dimensional limits:

If the depression does not encroach on the required minimum wall thickness at that region, the length and width is limited by the requirements on slope of the flared out area.

If the depression encroaches on minimum wall by not more than the lesser of 10% of the required minimum wall or 6.4 mm [lesser of 5% or 3.2 mm for fittings] and the width and the length of the depression do not exceed 50 mm. No two reconditioned areas of this type shall be closer than 150 mm edge to edge.

When the marred area cannot be reconditioned within the dimensional requirements given above, the area shall be repaired by welding in accordance with the following.

5.0 REPAIR TO WELDS

Parts not meeting the requirements shall be weld repaired and non-destructively tested as per the original requirement. It is the intent that necessary weld repairs be accomplished prior to heat treatment. It is mandatory however to meet the requirements listed in the Cl. 6.0.

When unacceptable indications are detected in weld joints by visual or by Non destructive examination, the unacceptable indication shall be removed by mechanical means or by thermal grooving. When thermal grooving is used, the excavated area shall be ground as necessary to assure removal of surface carbides. The excavated areas shall be free of any irregularities that might trap slag. These areas shall be magnetic particle examined to assure complete removal of the defect in case of crack, lack of fusion or ICP and visually inspected in case of other defects, and shall then be rewelded.

6.0 REPAIR TO BASE MATERIALS

The welding electrodes, preheat and postweld heat treatment requirements to base materials shall be in accordance with the relevant WPS.

The holding time when postweld heat treatment is required shall be based on the depth of the groove after preparation for welding.

Weld repairs may be made to "nipple to header/pipe" or "nipple to drum" weld joints after post weld heat treatment without subsequent postweld heat treatment [except for P5 Group 2 & 12X1MO materials], provided the following conditions are met:

The depth of any rework area ground out shall not exceed the smaller of 10% of the thickness of the drum/pipe/ header or 50% of the wall thickness of the tube. The rework shall be limited to P1 (Except SA 106 Gr. C, SA 299 & SA 515 Gr. 70) and P4 materials only if it is on the drum/header/pipe surface adjacent to the fillet.

The nipples shall not exceed 108 mm in OD except for P1 material which shall not exceed 150 mm.

The number of rework welds allowed on the base header material shall not exceed the lesser of 10% of the nipples on the header or eight (8) rework welds on any P1 or P4 header. Rework of this type shall be kept to an absolute minimum by careful examination prior to post-weld heat treatment.

The number of rework welds on the nipple side for any single header is not limited.

P4 material need not be postweld heat treated provided all of the following apply:

1) The outside diameter is 108 mm or less.
2) The wall thickness is 16 mm or less.
3) The specified carbon content is 0.15% or less.
4) A preheat of 125 deg. C or higher is applied.

P5 material need not be postweld heat treated provided all of the following apply:

1) The outside diameter is 108 mm or less.
2) The wall thickness is 16 mm or less.
3) The specified carbon content is 0.15% or less.
4) A preheat of 150 deg. C or higher is applied.
5) Chromium content does not exceed 3.0%.

Preheat shall be maintained at 150 deg. C minimum from the time welding is started until the component is given an extended preheat or an Interstage heat treatment. This requirement applies to all P5 materials not exempted by Cl. 6.5 and to SA 106 Gr. C materials used to fabricate headers.

Extended preheat - Raise preheat in entire weld zone to 300 + 15 deg. C, hold for 4 hours minimum and then cool to ambient.

Interstage - Heat in furnace to 600 deg. C minimum, but not to exceed 750 deg. C for half an hour minimum soaking, and then air or furnace cool to ambient.

Apply a final postweld heat treatment to P5 & SA 106 Gr. C materials prior to shipment.

Girth Butt welds or repairs to girth butt welds in P1

material (except SA 106 Gr. C), 19 mm or under in thickness need not be post weld heat treated.

7.0 ATTACHMENTS TO PRESSURE PARTS

The welding electrodes, preheat and postweld heat treatment requirements shall be in accordance with the relevant WPS.

Wherever required, extended preheat shall be maintained as per Cl. 6.6.

Post weld heat treatment is not required, if the fillet weld throat thickness does not exceed 13 mm. For attachments to P4 and P5 materials, this requirement can only be applied after all the requirements of clauses 6.4 & 6.5 are met.

Post weld heat treatment is not required after welding attachments to P1 pressure parts, in situations where welding after PWHT is unavoidable, provided all of the following apply:

1) Maximum specified carbon content of the pressure part does not exceed 0.3%.
2) A minimum preheat of 125 deg. C is applied prior to the start of welding and is maintained throughout welding.
3) Fillet weld throat thickness does not exceed 13 mm.
4) Pressure part thickness does not exceed 100 mm.
5) An extended preheat of 300 + 15 deg. C is maintained for 4 hours after welding in the case of SA 106 Gr. C material.

8.0

DOCUMENTATION

8.1

The details of weld repair carried out, if any, shall be recorded.

Revision Record: RECORD OF REVISIONS

Rev. No.	Clause No.	Details of Revision	Remarks
00		This procedure has been made from the document PR:QE:170/00.	
	2.3 & 5.2	Deleted.	
	4.3, 5.1 & 6.1	Modified.	
	5.3 to 5.10	Renumbered as 5.2 to 5.9.	

1.0 SCOPE

This details out the procedure for welding of lifting lugs to boiler drums by shielded metal arc welding.

2.0 REFERENCE DOCUMENTS

Engineering Drawings
WPS issued by WTC

3.0 MATERIALS INVOLVED

SA 515 Gr. 70 & SA 299

4.0 PREPARATION PRIOR TO WELDING

Welding of lifting lugs shall be done before final post weld heat treatment of the drum.

The lug area on the drum surface shall be checked by straight beam ultrasonic examination for laminations. The area to be examined shall extend 50 mm beyond the finished weld for a depth of 50 mm from the surface. Any defects found exceeding any of the following shall be repaired.

50% loss of back reflection that extends for more than 25 mm.

Complete loss of back reflection.

Any defects that exceed 600 square cm in any 2400 square cm area.

The area to be welded shall be chipped, ground or air arc gouged to a depth of 12 mm in the area of the lug and 6 mm wider than the lug on each side and at both ends. Proper preheating shall be carried for air arc gouging, in case gouging is used for excavating the area. The gouged area shall be ground to sound metal and all carbon deposits shall be removed. The ground area shall be tested by MPI and any defect found shall be repaired before welding is started (Refer Figure 3).

5.0 FIT-UP AND WELDING

All welding shall be carried out according to the WPS. The excavated areas shall be first welded and filled up approximately 1.5 to 3 mm above the surface (Refer

Figure 4). MPI and UT shall be conducted on the weld after flush grinding.

After welding the excavated areas, the drum may be allowed to cool before fitting the lugs.

The lugs shall be fitted in position and braced to prevent an angular distortion of more than 6 mm as the final alignment tolerance.

After fitting and bracing the lugs, the area to be welded shall be preheated as per WPS.

Type "A" lugs shall be turned down on the sides for better welding access (Refer Figure 1).

Type "B" lugs shall be welded wih the lugs turned straight upon the drum (Refer Figure 2).

After welding from one side, backgouging shall be done from the other side with necessary preheat. The gouged area shall be ground and tested by MPI. Then, welding shall be completed.

After completion of welding, the weld shall be dressed up and tested by MPI and UT.

6.0 HEAT TREATMENT

The completed drum shall be stress relieved as per the SQP requirements.

7.0 NDE AFTER HEAT TREATMENT

After HT, the weld shall be tested by MPI and UT.

8.0 DOCUMENTATION

The details of work carried out shall be documented.