1.0 GENERAL

Materials: SA106GrB, Gr C; SA 335 P11, P12, P22, P91 & P92 (Code case: 2179).
This Technical Delivery Condition specifies the requirements in addition to ASME SA 106, SA 335.

2.0 BILLET / BLOOM REQUIREMENTS

The billets/blooms shall be fully killed and vacuum degassed. Ladle analysis is required for all steels. Chemistry shall be controlled as given below for below specified grades. For all other grades, it shall be as per applicable material specifications:

Ladle 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.
SA335 GrP92:	***Si: 0.10-0.50%; Ni: 0.30max and Cu: 0.25max***

The billet/bloom shall conform to the chemical and process requirements of respective pipe specifications. The billet/bloom shall be sourced from IBR well-known steel makers or with inspection and certification by IBR authorized Inspecting Authority in case the mill is not approved by IBR. Mill test certificate shall be submitted to BHEL.

3.0 CHEMICAL COMPOSITION

Product analysis on pipes is required for all steels. Chemistry shall be controlled as per applicable material specifications and the elements including Carbon (for SA106 Gr-B&C), Si, Ni, & Cu (for SA335 Gr-P92) as indicated in Clause 2.0 above shall also be reported in the product analysis.

4.0 TOLERANCES : Unless otherwise specified in the PO, tolerances shall be as below:

4.1 OD specified pipes:-
SA335 P91& P92: the tolerance on OD shall be: ±1% (Max: 4mm) of Nominal OD.

Other than SA335 P91& P92: the tolerance on OD shall be: ±1% (Max: 6mm) of Nominal OD.

4.2 ID specified pipes are specified by the maximum Internal Diameter and Minimum wall thickness. The tolerance if not specified in the PO shall be: ID: +0.0mm, -3.2mm & Thickness: +6.4mm, -0.0mm

- Weight per meter : +10% , -5% on nominal weight **

** Nominal weight of ID Pipe per meter shall be calculated as follows,
Wtnom =(IDnom + tnom)*tnom*0.02466 kg/meter , where
ID nom = IDmax-1.6 mm ; tnom = tmin+3.2 mm

Actual weight per meter shall be indicated in mill test certificate.

5.0 STRAIGHTNESS & POLYGONIZATION

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 for Pipes of OD > 76.1mm. A sharp bend at the end or kink and twist are not acceptable. These limitations are applicable for any given plane.
Also, for Pipes with OD ≤ 76.1mm, shall be made by processes specified below:

1. All pipes shall be cold formed in case of "t/D" ratios > 0.15, where "t" is the specified nominal wall thickness and "D" is the specified nominal OD of the pipe.
2. Pipes may be cold formed or hot formed in case of "t/D" ratios upto and including 0.15.
3. The degree of polygonization (P), measured as indicated in Fig.1 & calculated using the below formula, shall not exceed 15% in both the above cases:

$$P = \{[\sum S_B - \sum S_A] / [0.135*(3D - \sum S_A)]\} * 100$$

where, P is the degree of Polygonization in %
D is the specified nominal OD of the pipe
$\sum S_B$ is the sum of maximum pipe wall thicknesses measured at 6 locations 60 degrees apart and
$\sum S_A$ is the sum of minimum pipe wall thicknesses measured at 6 locations 60 degrees apart.

Wall thickness shall be measured using profile projector/shadowgraph/digital scanner/any other suitable instrument meant for this purpose.

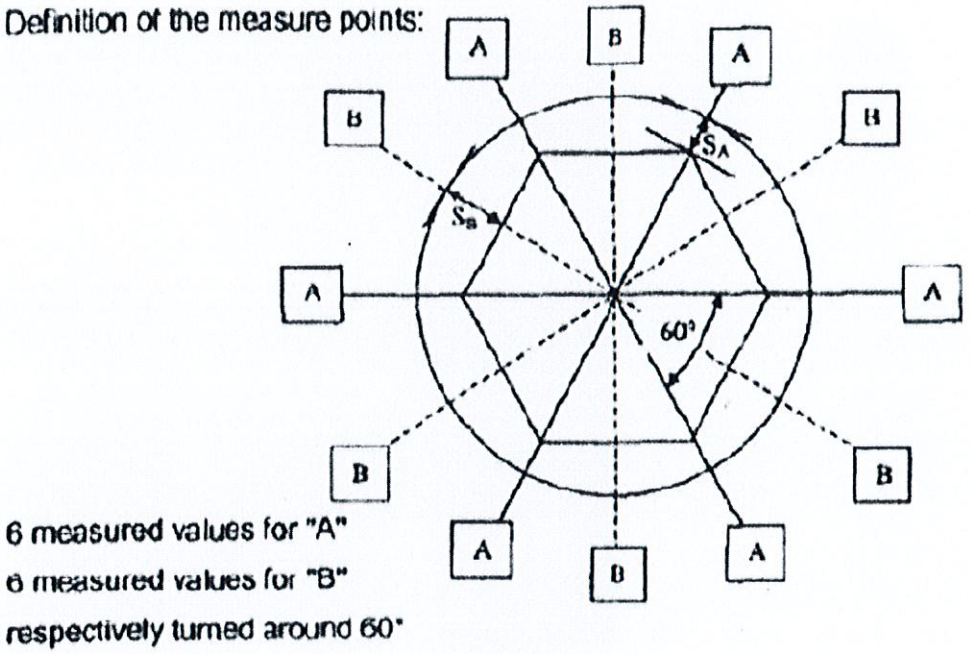

Fig. 1

6.0 HEAT TREATMENT & MECHANICAL TESTS

6.1 HEAT TREATMENT

CS: Hot Finished : OD <= 76.1mm no heat treatment required. OD > 76.1mm shall be in Normalised condition.
CS: Cold Finished : All Sizes – In Sub-critical annealed, fully annealed or in Normalised condition.
AS: All sizes – SA335 P11, P12 & P22 – Either in Normalised and tempered or Isothermal Annealed condition.
AS: All sizes – SA335 P91 & P92: Shall be Normalised as per specification & Tempered between 750°C-780°C.

6.2 MECHANICAL TESTS:

As per specification. Quantum of test: As per specification – For each nominal size per heat per heat treatment batch. (Minimum 2 pipes for first 100 pipes and 1 per 100 or part thereof for pipes over 100 numbers, as per IBR). For alloy steel pipes meant for fitting (As indicated in the Purchase order), test coupon shall be in normalised and tempered condition.

For P91 Pipes, Ys (0.2% offset) - 450 MPa Min ; Ts – Min 630 MPa, Max 850 MPa.
For P92 pipes Ts- Min 630 Mpa, Max 850 Mpa.
For other grades, Ys and Ts shall be as per specifications.

6.3 HARDNESS FOR SA 335 P91 & P92 PIPES :

Hardness test shall be carried out on each pipe. The hardness value for P91 shall be 195-250 BHN and that for P92 shall be 190-250 BHN. The hardness test values shall be indicated in the Test certificate

7.0 SUPPLEMENTARY TESTS

These are applicable to SA 106 Cr C, SA335 P11, P12, P22 and P91. The supplementary test results shall be indicated in the Test Certificate along with the mandatory test results.

7.1. **Product Analysis (S1):-** Product Analysis for all steels shall be carried out on 5% of pipes per heat per heat treatment batch (minimum 2 Nos) for size NB 200 mm and above.

7.2. **Transverse tension test (S2):-** Transverse tension test shall be carried out (for size NB 200 mm and above) on one end of 5% of pipes per heat per heat treatment batch (minimum 1 No).

7.3. **Photomicrograph test for P91 & P92 (S5):-** Photomicrograph test shall be carried out from a specimen of pipe in the as finished condition for each individual size (OD and wall thickness) per heat per heat treatment batch. Acceptance norms - The Material shall be free from any micro fissures. Microstructure shall show tempered martensite and also to be examined for any grain growth and delta ferrite (to be maintained within 3% for Gr92 and within 2% for Gr91 when measured as per VD TUV 1272). Photomicrograph with 400x (Min) magnification along with Photomicrograph report to be provided. The actual magnification shall be indicated.

7.4. **Supplementary and Additional requirements for P92:-** Supplementary tests S1 Product Analysis, S2 Transverse Tension test, S3 Flattening test and S4 Metal Structure& Etching test as per ASTM A 335 shall be done. Quantum of tests shall be at least 5% of the pipes per heat or Minimum 2 pipes per heat from one end / both end of the pipe as specified in ASTM A335. S5 Photomicrograph test requirement shall be as per Clause 7.3.

8.0 NON DESTRUCTIVE TEST

Each pipe shall be ultrasonically tested as per ASTM E 213 in both clockwise & anticlockwise directions; calibration to be done on two axial notches of 50 mm length (inside & outside) and a depth of 5% of wall thickness (minimum 0.3 mm; maximum 1.5mm). The results shall be indicated in the Test Certificate.

9.0 REPAIR

Repair by welding is prohibited. The pipe shall meet the dimensional tolerance (clause 3.0 above) after any mechanical repair as permitted in the standard.

10.0 WORKMANSHIP

The Inside & outside surfaces of the pipes shall be free from any imperfections & defects like laps,seams,folds, cracks, pitting etc,. Localised imperfections, if any,may be removed by grinding or skin machining only, ensuring the wall thickness, inside and outside diameter to provide workmanship like finish. Local depressions or ground spots are not acceptable. Loose scales shall be removed by blast cleaning in both inside and outside surface. Repair by welding is prohibited.

11.0 MARKING & COLOUR CODING

The following details are to be marked on the consignment for identification

1) PO Number 2) Supplier's emblem/code 3) Specification & grade (Code Case if applicable) 4) Heat number
5) Size (OD/ID X Thickness X Length, in mm) 6) No. of pipes 7) Inspector's seal

OD up to 31.8 mm (excluding)	Details 1 to 7 shall be stamped on metal / plastic tag attached to bundle
OD 31.8 mm to OD 76.1mm (including)	Details 1 to 5 shall be paint stencilled on each pipe. Details1 to 7 to be stamped on Metal / Plastic tag attached to bundle.
OD above 76.1 mm	Details 2,3,4,5 & 7 shall be hard stamped with round edged stamp at 100mm from an end of each pipe. Details 1 to 5 shall be paint stencilled on each pipe.

Longitudinal colour bands on the entire length of all pipes. The colours shall be as per BHEL procedure SIP: PP: 21(Latest).

12.0 PRESERVATION

- Outside: - Resin type rust preventive coating with visibility to stencilled details. Thick Black coating which camouflages the Surface of the pipes is not permitted.
- Inside: - Rust inhibitor or resin type rust preventive coating.
- Ends of the pipes shall be secured with caps.

13.0 PACKING

a) Thickness</=2.5mm in boxes. b) OD </= 159 mm in bundles. Others in loose condition.
Pipe bundles to be < 4 tons of equal no.of pipes, fastened with galvanised strap/ anti-rust coated (1x25mm.min.) for Carbon Steel & Alloy Steel and by Nylon strap for Stainless Steel at 2 ends & at 1m interval. Wooden pallets to cover pipes are not permitted.

14.0 INSPECTION AND CERTIFICATION (In English Only)

14.1. Products shall be inspected at works and the applicable IBR Forms must be Countersigned by the Inspecting Authority as indicated below:
a) Imported Items: Inspecting Authority approved by IBR for the Country of origin (To be concurred by BHEL before placing PO).
b) Indigenously Supplied items: Director/Chief Inspector of Boilers of respective State.

14.2. Certification in IBR Form-IIIA for Pipes & IBR Form-IV for the raw material steel from "IBR-Well Known Pipe Maker" or "Inspecting Authority" as applicable, to be submitted.

14.3. Test Certificate shall include PO no.(BHEL), TDC no., Pipe size and quantity- melt wise, specification and grade with year of code, Heat no., Steel &Pipe making process, chemistry including incidental elements on Ladle and Product analysis, Heat treatment details with actual temperature and soaking time, Mechanical results.

14.4. Detailed NDT reports with reference norms, acceptance standards and test results shall be furnished along with Test certificates.

14.5. For P91 & P92 pipes the Photomicrograph test report along with photomicrograph with 400x (min) magnification shall be furnished.

14.6. Refer to BHEL Engineering Drawing: 4-03-000-00062 (Latest Rev) for MAWP values for various material grades & sizes at various temperatures.

*14.7. **Mill test certificate of the raw material (billet/bloom) as per Cl.2.0***

15.0 End Use : These pipes are meant for use in subcritical and supercritical Boilers. These pipes shall be capable of undergoing forming, bending and welding operations necessary for the application without developing defects.

RECORDS OF REVISIONS

i) Rev 01 – Para 2.0 modified based on feedback from user departments, suppliers and internal discussions, Para 15.0 added

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