Record of Revision:

Rev 10: 27/01/04 Cl.8 Hydraulic test removed, further clauses renumbered. Annexures introduced for Cl.11. In Cl.2 limits for carbon in Gr C modified. In Cl. 4 normalizing made mandatory for all pipes of Gr C& Gr B meant for fitting. In Cl.5.0 test coupon for pipes meant for fittings removed.
Rev 11: 29/12/07 Cl 1, P92 included. P2, P5, P9, 304L, 321 Deleted.Cl.4, 10, 11, modified.
Rev 12: 29/07/10 Cl 1, P91, P92 Deleted and included in TDC 0123; Cl: 4, 5, 7, 8, 10, 11 modified.
Rev 13: 26/10/12 Cl 2, 6 & 11 modified for SS material
Rev 14: 29/12/12 Cl 4 – Heat treatment for CS modified. Cl 6 – corrected.
Rev 15: 28/11/13 TDC 123 Rev 00 and TDG 32 Rev 03 merged with TDC 101 Rev 15 & Product description modified. Cl 3 added. Cl 5, Cl 8, Cl12 modified. SA335 Gr 91, 92 included (Cl 1) and subsequent dimensional tolerance (Cl 3), heat treatment (Cl 5), mechanical testing (Cl 6), and photomicrograph (Cl 7 iii) added. SA335 Gr 23 removed from TDC 123 Rev 00
Rev 16: Cl 3– OD & ID tolerance revised, Cl 5– temperature for Gr 91, 92 modified, Cl 6 – mechanical test values changed in-line with ALSTOM purchase specification, Cl 7 – PMI magnification & frequency clarified, Cl 9&11 – modified, Cl 12-changed as per latest IBR.
Rev 17: Dt: 13/10/2017: Cl 1 modified; Cl 4 modified to include finishing process and polygonization requirements for pipes of OD ≤ 76.1; Cl 5 modified; Cl 6(c) added to include creep requirements; Cl 8 & 9 modified; Cl 12-changed as per latest IBR to include MAWP requirements and IBR Form IV.
Rev. 18: Dt: 11/11/2017: Cl. 6(c), Cl.12.3 (vii)-creep requirements removed.
Rev. 19: Dt: 03/05/2018: Cl 2 added to include Billet/Bloom Requirements, Cl. 13.3 (vii) added to include mill TC certification
Rev. 20: Dt: 26/09/2019: Cl 2 modified based on feedback from user departments, suppliers and internal discussions, Cl 14 added

---

1. MATERIAL:

Specification	:	ASME (Latest as on the date of Enquiry/PO, whichever is earlier):
Carbon Steel (CS)	:	SA106 Gr B & C
Alloy Steel (AS)	:	SA 335 Gr P11, P12, P22, P91 & P92 (Code Case: 2179)
Stainless Steel (SS)	:	SA 312 Gr TP 316, TP 316L
Additional requirement	:	As listed below (Supplementary to above material specifications).
Pipe Size and Qty	:	As per Purchase Order

2. BILLET/BLOOM REQUIREMENTS:

The billets/blooms shall be fully killed.

For carbon steel and alloy steel, billets/blooms shall be made by vacuum degassing. For Stainless steel, billets/blooms shall be made by vacuum degassing or argon oxygen decarburization (AOD).

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 P92 :	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. CHEMICAL COMPOSITION:

3.1 **Product analysis** on pipes is required for all steels. Chemistry shall be controlled as per applicable material specifications and the elements including Carbon (for SA 106 Gr B & C), Si, Ni & Cu (for SA335 GrP92) as indicated in Clause 2 shall also be reported in the product analysis.

3.2 All raw materials used in steel making including incoming scrap shall be checked by supplier to ensure freedom from radioactivity (Applicable for SS material only).

4. DIMENSIONAL TOLERANCES:

4.1 SA335 Gr P91, P92: For outside diameter (OD) controlled Pipes the tolerance on OD shall be: ±1% (Max: 4mm) of Nominal OD.

4.2 Other than SA335 Gr P91, P92: For outside diameter (OD) controlled Pipes the tolerance on OD shall be: ±1% (Max: 6 mm) of nominal OD.

4.3 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 metre: +10%, -5% on nominal weight **
** Nominal weight of ID pipe per metre shall be calculated as follows,
Weight $_{nom}$ = $(ID_{nom}+t_{nom}) * t_{nom}*0.02466$ kg/metre, where
ID $_{nom}$ = ID_{max}-1.6mm; $t_{nom}=t_{min}+3.2$mm

5. 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, the pipes shall be made by process 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:

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

Where, P is the degree of polygonization in %
D is the specified nominal OD of the pipe
$\sum$ SB is the sum of maximum pipe wall thicknesses measured at 6 locations 60 degrees apart and
$\sum$ SA 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.

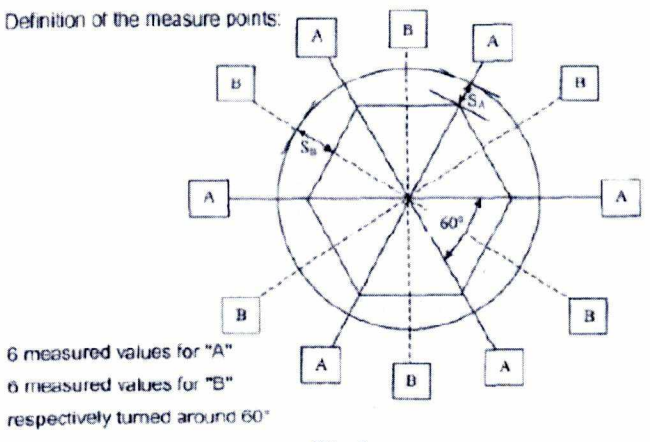

Fig. 1

6. HEAT TREATMENT:

The heat treatment temperatures and soaking time shall be reported in the test certificate.

6.1 CS: Hot Finished: OD ≤ 76.1mm no heat treatment required. OD > 76.1mm shall be in Normalized condition.
CS: Cold Finished: All sizes – In sub critical annealed, fully annealed or in Normalised condition.

6.2 AS: All sizes – SA335 Gr P11, P12 & P22 – Either in Normalised and tempered or Isothermal Annealed condition.

6.3 AS: All sizes – SA335 Gr P91 & P92: All pipes Normalised as per material specification and Tempered at 750-780 °C.

6.4 SS: All sizes – Solution Annealed condition as per material specification.

7. MECHANICAL TESTS:

a) 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).

b) For alloy steel pipes meant for fitting (As indicated in the Purchase order), test coupon shall be in normalised and tempered condition.
P91- TS: Min: 630MPa, Max: 850MPa; YS: (0.2% offset):450MPa Min; Hardness (HB): Min: 195 Max: 250
P92- TS: Min: 630MPa, Max: 850MPa; Hardness (HB): Min: 190 Max: 250
P91, P92 hardness shall be checked on each pipe and values reported in MTC.

8. NON DESTRUCTIVE TEST:

8.1 ULTRASONIC TEST : ASTM E213
Calibration: Axial 50 mm long V or Square notch, one in OD and the other in ID. Notch Depth: 5% of Max.Thickness.(Min. 0.3 mm, Max. 1.5mm).
For ID<16mm one notch in OD is enough. Scanning:Clockwise and Anti clockwise.

8.2 SS: Finished pipes shall be checked for radioactive contamination and reported. Survey meter shall be used to measure at 5cm near the surface.
Acceptance limits: Shall be less than 0.1 milli Rontgen (mR) per hour or 1 micro Sievert per hour.

8.3 Photomicrograph test for P91 & P92 pipes - Photomicrograph test shall be carried out from a specimen of pipe in the as finished condition for 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 and structure shall be indicated in the report.

9. FINISH AND REPAIR:

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.

10. MARKING: (In English only): All mandatory marking shall be done as per material specification (latest).

10.1 **Details to be identified:** On Each Pipe (1) PO Number (2) Maker's emblem/code (3) Specification & grade (4) Code case, if applicable (5) Heat number (6) Size (OD x Thickness x Length, in mm), (7) No. of pipes (8) Inspector's seal

- Upto OD 31.8 (Excl.) – Sl.No: 1 to 8 to be stamped on metal or plastic tag attached to bundle.
- OD 31.8 to OD 76.1 (Incl.) – Sl.No:1 to 6, 8 to be paint stenciled on each pipe, 1 to 8 to be stamped on metal or plastic tag attached to bundle.
- OD > 76.1- Sl.No: 2 to 6 & 8 to be hard stamped with round edged stamp at 100mm from an end of each pipe and 1 to 6 to be paint stenciled on each pipe.

10.2 **Colour Coding:** Continuous longitudinal colour coding shall be done on the entire length of all pipes, without masking stencilling. Colour coding scheme shall be as per Procedure SIP: PP: 21 (latest).

11. PRESERVATION:

All pipes except SS shall be applied with resin type rust preventive coating with visibility to stencilled details on outside and either with rust preventive coating or rust inhibitor inside. Thick black coating which camouflages the surface of the pipes is not permitted. SS pipes to be surface treated as per ASTM A380 both inside and outside. Ends to be closed with end caps for secured storage.

12. 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 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.

13. INSPECTION AND CERTIFICATION (In English Only):

13.1 Products shall be inspected at works and the applicable IBR Form 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: Director of Boilers/Chief Inspector of Boilers/Inspecting Authority approved by IBR, for the respective state.

13.2 Certification in IBR Form III-A for finished pipes from "IBR-Well Known Pipe Maker" or "Inspecting Authority", as applicable, shall be submitted to BHEL.

Also, certification in IBR Form IV for the raw material signed by "IBR-Well Known Steel Maker" or "Inspecting Authority", as applicable, shall be submitted to BHEL.

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

13.3 Additionally, Manufacturer's Test certificate (MTC) (ORIGINAL in ENGLISH) with following details shall be submitted:

i) Purchase Order No. (BHEL), TDC No. and its Rev No, Test certificate No. & TC Date, Size and Quantity-Melt wise.
ii) Specification and Grade with year of code, Code case number (if applicable), Heat Number, Steel & Pipe making process, chemistry including incidental Elements-Ladle and product Analysis.
iii) Heat Treatment details with actual temperature and soaking time
iv) Mechanical test Results.
v) For P91, P92 supplies – the Photomicrograph test report along with photomicrograph with 400X (min) magnification shall be furnished.
vi) Detailed N.D.E. report with reference norms, Acceptance standards and test results.
vii) Mill test certificate of the raw material (billets/blooms) as per Cl. 2.

13.4 For SS: Measured Radioactivity levels shall be reported in the Mill Test Certificate and shall be submitted to BHEL (Not to be recorded in IBR Form).

14 *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.*

26/09/2019	26/09/2019	26/09/2019	26/09/19	26/09/2019
Abdur Rahman Sultan	K. Sridharan	M. Nadanakumar	R. Dharmar	JVV Aruna Kumar
Sr. Engr/QA	DGM/PE/FB	AGM/MM	AGM/QC	SDGM/QA
Prepared By	**Reviewed by**			**Approved By**