



1.0 SCOPE: -

The fittings shall meet Indian Boiler Regulations (IBR), unless otherwise specified, and the following requirements in addition to the standards specified in the Purchase Order (PO).

2.0 RAW MATERIALS: -

- All fittings shall be of seamless construction unless otherwise specified in the purchase order. Pipes used for manufacturing of seamless fittings shall be seamless pipes or forgings only.
- All pipes used for fittings shall meet the respective specification. The test certificate shall be furnished with Traceability
- For Gr-91 Pipes:** Shall be procured from the Mills listed in document ref.QCP:19(latest revision). For pipe sources not listed in QCP:19, credentials shall be submitted by the vendor along with offer for BHEL review and approval. Indigenous vendors shall procure the raw material for Alloy Steel other than SA 335 P91 from IBR approved "creep resistance steel makers".
- Raw material Steel for IBR forging items to be inspected at Mill & test certificate countersigned by IBR approved Authority, if the mill is not approved under IBR as well-known steel maker.
- For Gr-91 Forgings:** The raw material shall be procured from the Mills listed in document ref.QCP:18(latest revision). For raw material sources not listed in QCP:18, credentials shall be submitted by the vendor along with offer for BHEL review and approval. Indigenous vendors shall procure the raw material for Alloy Steel other than SA182 F91 from IBR approved sources.

3.0 MANUFACTURING & TESTING REQUIREMENTS:

3.1 MANUFACTURING PROCESS :

(i) Seamless Fittings:-

A) Tees & Reducers : Upto 80mm thickness : Formed Type.

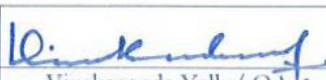
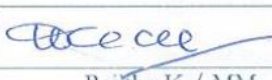
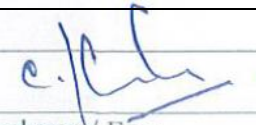
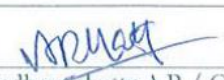
Above 80mm thickness Formed or Forged type.

B) Elbows : Formed type for all thickness

(ii) Welded Fittings:- Supplied only if indicated in P.O and shall be of **Two-Half construction**.

3.2 Machined Fittings (Max size permitted 4"- directly from bar) – Reducers, Couplings & End Caps : Fittings machined from Castings are **prohibited**.

Starting material	Heat treatment	CS – Normalised AS – Normalised & Tempered SS & Duplex SS (UNS32205) – Solution Annealed
Rolled or Forged Bars (Killed Steel)	NDE – UT	To be done after Heat treatment. For size above 40mm – to be done as per ASTM A 388 Acceptance to - ASME Sec.VIII Div.2 Cl.3.3.4. Actual measured notch depth to be specified in Test Certificate.
Finished fitting (after machining)	Heat treatment	Not required
	NDE (for all sizes)	- MT (100%) - Procedure - As per ASTM E709. No linear indications are acceptable (Linear Indication : Length $\geq$ 3XWidth) For WP91 Wet MPI shall be done - LPI – SS & Duplex SS (UNS32205): Shall be done as per ASTM E165. No linear indications are acceptable.
	Hardness	Base material Hardness for. WPB, WPC, WP11, WP12, WP22 – 197 HBW max. WP91 - 190-250 HBW – 100% to be checked Duplex SS (UNS32205) – 300BHN max
	Dimension	ASME B16.9 or as per Engineering Drawing indicated in Purchase Order.
	Bend Test (for IBR items)	Specimen: 19mm. Thickness (t) x 25.4mm width - cold bent 180 deg. over thin section without fracture, mandrel radius: CS : $\leq$ 6.35 mm. AS, SS : $\leq$ 1.5 times specimen thick.

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3.3 Seamless Formed Fittings – Ells, Tees, Reducers, Dished end (End cover / Cap)

Starting material:	Heat treatment shall be as per starting material specification	CS – Normalised AS – Normalised & Tempered SS & Duplex SS (UNS32205) – Solution Annealed				
1)Tube & Pipe	NDE – UT	UT shall be done as per - ASTM E 213 with longitudinal notch of 5% wall thickness with max.1.5mm and min. 0.3mm. Actual measured notch depth to be specified in Test Certificate.				
2) Forged blank (For End covers)	NDE – UT	For size above 40mm UT shall be done as per - ASTM A 388 In acceptance to - ASME Sec.VIII Div.2 Cl.3.3.4. Actual measured notch depth to be specified in Test Certificate.				
3) Plate	NDE – UT	For size above 10mm SA 578, Acceptance Level – B. Actual measured notch depth to be specified in Test Certificate.				
Finished fitting (cold/hot forming)	Heat treatment after forming	Shall be done as per SA234 and follow below table for heat treatment values.				
		Material	Heat Treatment Temp,°C		Soaking time, hr/in	
			Normalising	Tempering	Normalising	Tempering
		CS- WPB & WPC	870-900	-	1/2	-
		AS-WP11 & WP12	920-960	640-670	1/2	1
		AS-WP22	920-960	680-710	1/2	1
	AS- WP91	1040-1080	760-780	1/2	1	
	Stainless Steel - All grades & Duplex SS (UNS32205): - Solution Annealed: 1050-1100 Deg C Soaking time : ½ hr per inch with minimum 15 minutes Note: Normalising shall be done for a minimum time of 30 min while tempering to be done for a minimum time of 60min for all materials except SS & Duplex SS (UNS32205).					
NDE (for all sizes) – Except for Plate formed Dished end	• MT (100%) - Shall be as per - ASTM E709 No linear indications are acceptable. For WP91 Wet MPI shall be done. • LPI – SS & Duplex SS (UNS32205): Shall be done as per ASTM E165. No linear indications are acceptable.					
NDE–for Plate formed Dished end	For Plate Formed Dished end – 100% MT as per - ASTM E709 on both inner and outer surfaces of Knuckle radius and weld ends. No linear indications are acceptable. UT shall be as per A578 Level-B. Actual measured notch depth to be specified in Test Certificate.					
NDE – UT For OD >= 200mm or W.T >= 6mm	If made from Pipe & Tube – Shall be done as per - ASTM E 213 with longitudinal notch of 5% wall thickness with max.1.5mm and min. 0.3mm. Actual measured notch depth to be specified in Test Certificate. If made from Forging - Shall be as per - ASTM A 388 In acceptance to - ASME Sec.VIII Div.2 Cl.3.3.4. Actual measured notch depth to be specified in Test Certificate.					
Hardness	Base material Hardness for WPB, WPC, WP11, WP12, WP22 – 197 HBW max. WP91 - 191-250 HBW – 100% to be checked Duplex SS (UNS32205) – 300HBW max					
Dimension	ASME B16.9, As per Engineering drawing indicated in Purchase Order. The ends of reducers shall have a straight portion of Minimum 13mm.					
Bend Test (if starting material is forged blank) (for IBR items)	Specimen: 25.4 mm x 19 mm thick - cold bent 180 deg. over thin section without fracture, internal radius of bend: CS :<=6.35 mm. AS, SS: <=1.5 times specimen thick.					

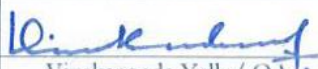
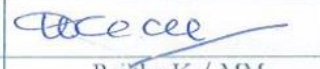
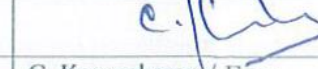
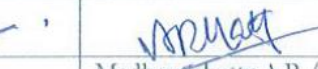
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3.4 Forged Fittings –Tees, Reducers, Couplings, Flanges & Dished End (End cover/Cap)

Shall be forged to the shape with a minimum forge reduction ratio of 1:4. Fitting shall not be machined from a forged block.

Starting material: Rolled or Forged Bars, Blooms, Billets (Killed steel)	Heat treatment shall be as per starting material specification	CS – Normalised AS – Normalised & Tempered SS & Duplex SS (UNS32205) – Solution Annealed				
	NDE – UT	To be done for diameter or thickness above 40mm Procedure - As per ASTM A388 In acceptance to - ASME Sec.VIII Div.2 Cl.3.3.4. Actual measured notch depth to be specified in Test Certificate.				
Finished fitting	Heat treatment After forging (cold/hot forging)	Shall be done as per SA234 and follow below table for heat treatment values.				
		Material	Heat Treatment Temp,°C		Soaking time, hr/in	
			Normalizing	Tempering	Normalizing	Tempering
		CS- WPB & WPC	870-900	-	1/2	-
		AS–WP11 & WP12	920-960	640-670	1/2	1
		AS–WP22	920-960	680-710	1/2	1
		AS- WP91	1040-1080	760-780	1/2	1
	Stainless Steel - All grades & Duplex SS (UNS32205): - Solution Annealed: 1050-1100 Deg C Soaking time : ½ hr per inch with minimum 15 minutes Note: Normalising shall be done for a minimum time of 30 min while tempering to be done for a minimum time of 60min for all materials except SS & Duplex SS (UNS32205).					
	NDE – UT For OD >= 200mm or W.T >= 6mm	UT shall be done as per - ASTM A388 In Acceptance to - ASME Sec.VIII Div.2 Cl.3.3.4. Actual measured notch depth to be specified in Test Certificate.				
	NDE (for all sizes)	MT- (100%) Shall be done as per ASTM E709. No linear indications are acceptable. For WP91 Wet MPI shall be done. LPI – SS & Duplex SS (UNS32205): Shall be done as per ASTM E165. No linear indications are acceptable.				
Hardness	WPB, WPC, WP11, WP12, WP22 – 197 BHN max. WP91 - 191-250 BHN – 100% to be checked Duplex SS (UNS32205) – 300BHN max					
Dimension	ASME B16.9 or ASME B16.5 or as per Engineering drawing indicated in Purchase order.					
Bend Test (for IBR items)	Specimen: 19mm. Thickness (t) x 25.4mm width - cold bent 180 deg. over thin section without fracture, mandrel radius: CS :<=6.35 mm. AS, SS : <=1.5 times specimen thick.					

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3.5 Welded Fittings– Ells, Tees, Reducers (Two-Half construction):

Pipe made from plate and long seam welded shall not be used as a starting material.

Starting material: Plate	NDE – UT	For thickness above 10mm SA 578, Acceptance Level – B.				
Finished fitting	Heat Treatment After forming	Shall be done as per SA234 and follow below table for heat treatment values.				
		Material	Heat Treatment Temp,°C		Soaking time, hr/in	
			Normalizing	Tempering	Normalizing	Tempering
		CS- WPBW & WPCW	870-900	-	1/2	-
		AS–WP11W & WP12W	920-960	640-670	1/2	1
		AS–WP22W	920-960	680-710	1/2	1
		AS- WP91W	1040-1080	760-780	1/2	1
	Stainless Steel - All grades & Duplex SS (UNS32205) : - Solution Annealed: 1050-1100 Deg C Soaking time : ½ hr per inch with minimum 15 minutes					
	Post Weld Heat Treatment (PWHT)	PWHT shall be done as indicated below.				
		Material	Heat Treatment Temp,°C		Soaking time	
CS- WPB-W & WPC-W If weld thk>19mm			595-635	2.5min per mm of weld thk; Minimum 30minutes.		
AS–WP11-W&WP12-W		650-680	2.5min per mm of weld thk; Minimum 60minutes.			
AS–WP22-W		690-710				
AS- WP91-W		760-780				
NDE (for all sizes)	• MT (100%)- Procedure - As per ASTM E709. No linear indications are acceptable For WP91 Wet MPI shall be done • LPI – SS & Duplex SS (UNS32205) : Shall be done as per ASTM E165. No linear indications are acceptable.					
NDE – for Weld	• RT (100%)- Acceptance norm shall be UW 51 of ASME Sec VIII DIV-1.					
Hardness	Base material Hardness for WPB, WPC, WP11, WP12, WP22 – 197 BHN max. WP91 - 191-250 BHN – 100% to be checked Duplex SS (UNS32205) – 300BHN max Weld Hardness WP91 - 300 BHN max. – 100% to be checked					
Dimension	ASME B16.9 or as per Engineering drawing indicated in Purchase order.					
Bend Test (for IBR items)	Specimen: 19mm. Thickness (t) x 25.4mm width - cold bent 180 deg. over thin section without fracture, mandrel radius: CS :<=6.35 mm. AS, SS : <=1.5 times specimen thick.					

4.0 GENERAL REQUIREMENTS:

- Carbon < or = 0.25% for WPB (all thickness) and WPC (thickness < or = 20mm)
- Carbon < or = 0.30% for WPC (thickness > 20mm)
- If UT not done on the starting material, the same shall be done by the fitting manufactures before forming / fabrication.

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- d) **Mechanical Testing** –Test samples shall be tested in the Heat treatment of fitting delivered condition.
1. **Tensile Test**:- One sample of each specification, heat, heat treatment lot and size shall be subjected to Tension Test as per applicable standard.
 2. The following **supplementary tests** shall be carried out for specifications namely SA 234 WPC / WP11 / WP12 / WP22 / WP91 (No supplementary test applicable for SA 234 WPB)
 - i) Product analysis – one / heat / size.
 - ii) Tension test – one / heat / heat treatment lot / size
- e) **Photomicrograph test for WP91**:- Photomicrograph test shall be carried out on one per heat, per size. 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. Photomicrograph with 500x (Min) magnification along with Photomicrograph report to be provided. The actual magnification shall be indicated.
- f) In case of welded fittings, WPS, PQR & welder qualification shall be approved by BHEL, prior to start of welding.
- g) Unless otherwise specified in the P.O SA 234 WP 11/12/22 fittings shall be supplied as per class1.
- h) **Stainless Steel (SS) & Duplex SS (UNS32205)** : Finished fittings 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 hr or 1 micro Sievert per hr.

5.0 POSITIVE MATERIAL IDENTIFICATION (PMI) FOR ALLOY STEEL FITTINGS.

Each alloy steel fitting shall be checked for the correctness of the material during manufacturing and final inspection using X-ray fluorescence principle or spark emission spectrography.

6.0 WORKMANSHIP, FINISH AND REPAIR

All items shall have smooth, workman like finish, and to be free from scale & defects like laps, seams, folds, cracks, etc. Pickled & Passivated as per ASTM A380 for SS items & Duplex SS (UNS32205). Surface defects can be removed by mechanical means and defective areas smoothly dressed up with the adjacent surface. Minimum dimension after repair shall meet drawing / Specification. Repairs by fusion welding are prohibited.

Flatness on curved surfaces of fittings shall be limited to 6% of nominal OD.

Thickness: Outer Diameter & Transition: Variation shall be merged smooth to min 1:4 taper.

7.0 PAINTING, COLOUR CODING & MARKING

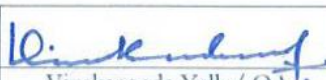
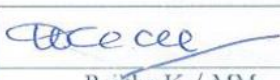
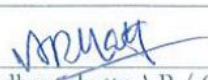
- 7.1 **PAINTING**: All fittings (except stainless steel and galvanized) shall be **painted** on the external surface as given below (unless otherwise specified): -
- a) **Surface preparation**: Blast cleaning
 - b) **Primer coat**: One coat of 60 microns of In-Organic Ethyl Zinc Silicate primer.
 - c) **Finish coat**: Two coats of 20 microns each of Heat Resistance Aluminium paint to IS13183 Gr-1.
 - d) **Total DFT**: 100 microns minimum.
 - e) **Shade**: Aluminium -- for all fittings.

The internal surface shall be protected with rust preventive coating or rust inhibitor.

Stainless steel and Duplex SS (UNS32205) fittings need not be painted.

- 7.2 **COLOUR CODING**: All fittings shall be colour coded circumferentially at all ends as given below:

Material Specification	Colour Code
WPB	Red
WPC	Blue
WP11	Green & White

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SA 234	WP12	Black & Red
	WP22	Blue & Red
	WP91	Brown & Red
SA 403	WP304	Blue & Yellow
	WP304H	Black, Blue & Yellow
	WP316	Black & Green
	WP316L	Blue, Brown & Yellow
	WP321	Blue & Brown
	WP347	Yellow & Black
SA815 (Duplex Stainless Steel)		Red, White & Green

7.3 MARKING (In English only):

7.3.1 The fittings dispatched to **BHEL Stores** shall be hard punched / etched with Material code, Heat number, material specification, maker's emblem, Inspectors seal, Running Serial number for the P.O. quantity and Statutory authorities seal as applicable.

In addition, the above details along with size shall be paint stencilled on the fittings. If the thickness of the fitting is less than 6 mm, punching is not permitted and the above details shall be paint stencilled. Fittings of size up to 2" (50mm) shall be tied together and the above details shall be punched / engraved in a separate tag and tied to it.

7.3.2 In case of fittings dispatched directly to project site as **DTS**, material code shall be replaced with DU code (14-digit work order du detail) as given by purchase during DTS advice. All other details shall be hard punched & stencilled as indicated in Para 7.3.1.

Sample format for Punching & Stencilling is given below.

Vendor code & Name	:	Makers Emblem Insp. Authority Stamp
Material code / DU details :	:	
Melt No.	:	
Material Specification	:	
Qty.	:	
Serial No	: (Example : 1,2,3,.....& 25)	
Weight.	:	

8.0 PACKING AND END PROTECTION:

Machined ends of the fittings shall be well Protected using end caps and fittings shall be suitably packed in box / crate as per the Packaging procedure PC: PKG: 01 to avoid transit & other damages.

9.0 INSPECTION & CERTIFICATION (In English only): -

9.1 All fittings are to be Inspected at the manufacturer's works by the Inspection agencies / authorities as per IBR and as indicated in the P.O. Inspection certificate in IBR Form III C & Form III-I for Dished Ends shall be submitted along with the Work Test Certificate countersigned by the above authorities and shall include the following (Three ink signed originals required).

1. Test Certificate Number & date.
2. BHEL P.O Number & Amendment Number
3. BHEL P.O. Serial Number
4. BHEL TDC Number
5. Size-wise Quantity
6. Specification, Grade & Year of code.

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7. Heat/Melt Number
8. Starting material details with traceability.
9. Steel making process
10. Ladle Analysis of Raw Material and product analysis of fitting.
- *11. Supplementary Test (Product analysis, Tension test.) results.
12. Tensile Test Report
- *13. Guarantee of HTP shall be given as follows:- "Fittings are capable of withstanding without failure, leakage or impairment of their serviceability a hydrostatic test pressure equal to that prescribed for the specified matching pipe of equivalent material".

*Details furnished in the Tests certificate in lieu of chart/report is acceptable.

9.2 The following reports shall be **furnished separately** along with the IBR Forms & MTC indicated in para 9.1 above.

- i. NDE reports for MT, RT, UT (UT Reports in soft copy + hard copy). Actual measured UT-notch depth to be specified in Test Certificate.
- ii. Positive Material identification (PMI) report for Alloy steel.
- iii. Heat Treatment Chart.
- iv. Hardness Test report.
- v. Photomicrograph test report along with photomicrograph with minimum 500x magnifications.
- vi. Dimensional report (as built drawing with dimensions)
- vii. Thickness Measurement Report for Elbows & Tees as per Doc No : TDG102:001 & TDG102:002

9.3 For CE marking items if indicated in P.O. the TCs with details specified above shall be submitted as per EN-10204 (Latest).

- i. For pressure parts test certificates of type 3.1 or 3.2 is acceptable.
Type 3.1 – Suppliers shall have ISO 9001-2008/2015 (with validity as applicable) certification certified by Notified Body recognized by European Community and test certificate certified by suppliers authorized inspection representative.
Type 3.2 – Components inspected and test certificates certified by both the supplier's authorized inspection representative and Notified Body recognized by European Community.
- ii. For non-pressure parts test certificates of type 2.2 is acceptable.
Type 2.2 – Suppliers test certificates certified by the supplier's authorized inspection representative with test results as required by this TDG.

10.0 AUDIT CHECKS AT BHEL

BHEL reserves the right to carry out audit checks for Chemistry, HT condition, Mechanical test and NDT on fittings.

Supplies found defective during check at BHEL are liable for rejection.

11.0 RECORDS OF REVISION:-

Rev 01 : a) Fully revised for better clarity.

b) Para 2.0 (e) added.

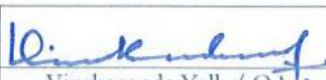
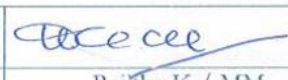
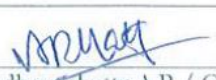
Rev 02 : a) Para 2.0 (c): UT acceptance norms revised from level A to B.

Rev 03 : a) Fully revised for better clarity.

b) Para 4.2, 6.0, 8.0 (11) added.

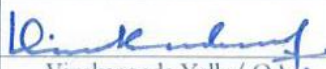
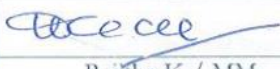
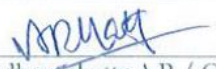
c) Para 2 (d), 4.1, 5 (d) are revised.

Rev 04 : a) Para 5.0 (g), 7.0 and 8.0 (17) are revised.

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- Rev 05 :** a) New material specification SA 815 Duplex Stainless Steel included.
b) Para 4.1, 4.2, 5.0 (d), 7.1 & 7.2 are revised.
c) 5.0 (a), (b), (c), (e), (f), (g), 7.3.1 & 7.3.2 are modified for better clarity.
- Rev 06 :** a) Para 8.2 added.
b) Para 5.0(d), 5.0(g), 7.1, & 8.1 are revised.
c) Para 1.0 & 7.2 are modified.
- Rev 07 :** Para 8.2 - vii added.
- Rev 08 :** a) Title revised for better clarity
b) Para 1.0,2.0(a),5.0(c),8.4,9.1(8) & 9.2(vi) are revised.
c) From Para 3.0(f),4.2,5.0(d),(f),(g),7.2 forging spec removed
d) Para 2.0(c),(f),3.0(a),7.0 & 10.0 added
e) Para 3.0(e) deleted
f) Document no.TDG102:002 Rev.00 added.
- Rev 09 :** Fully revised for better clarity

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THICKNESS MEASUREMENT REPORT FOR ELBOW

Doc No: TDG102:001 Rev.00

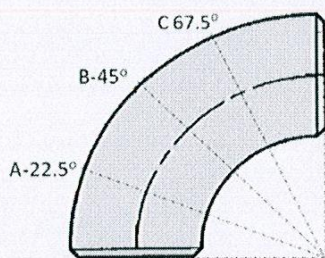
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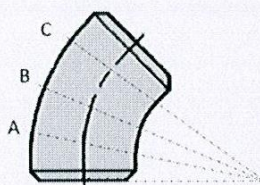
Work order/Du:

Heat no:

Size:



90° Elbow



Less than 90°

Measurement (Extrados) points

Angle	A	B	C
90	22.50°	45.00°	67.50°
60	15.00°	30.00°	45.00°
45	11.25°	22.50°	33.75°
30	NA	15.00°	NA

Description of item :
Material Spec :
Material Code :

No	Wall thickness at ends		Wall Thickness at angle			Remarks
	End 1	End 2	A	B	C	
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						

Vivekananda Yellu/ QA
Prepared by

Rajitha K / MM
Reviewed by

C. Karunakaran / Engg
Reviewed by

Madhavankutty.A.P / Quality
Approved by



THICKNESS MEASUREMENT REPORT FOR TEE's

Doc No: TDG102:002 Rev.00

Date: 20.06.2015

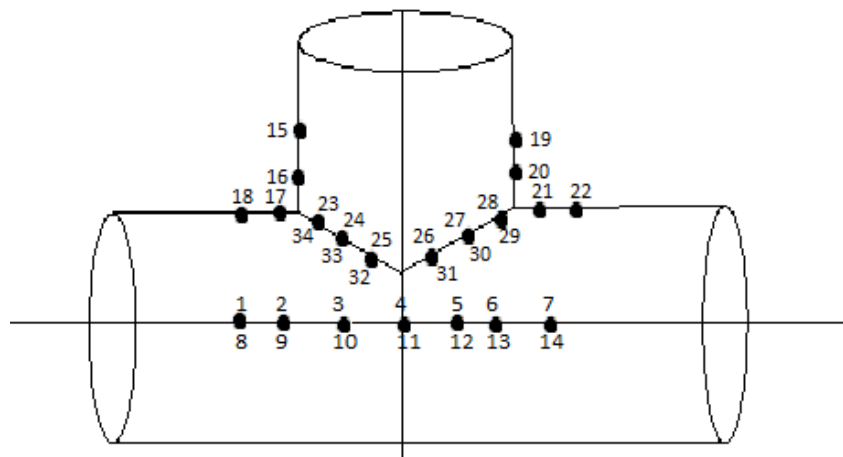
PO Number:

Description of Material:

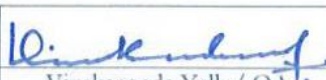
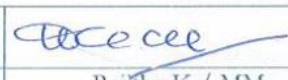
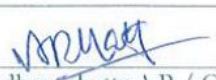
Size:

Material Spec.

Work order/Du:



Location	Thickness (mm)	Location	Thickness (mm)	Location	Thickness (mm)
1		13		24	
2		14		25	
3		15		26	
4		16		27	
5		17		28	
6		18		29	
7		19		30	
8		20		31	
9		21		32	
10		22		33	
11		23		34	
12		24			

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Prepared by	Reviewed by		Approved by