GUIDELINES
FOR
WELDING

IMPORTANT NOTE

THIS GUIDELINES FOR WELDING PROVIDES BROAD BASED GUIDELINES FOR CARRYING OUT WELDING WORK AT SITES. HOWEVER, SITES SHALL ENSURE ADHERENCE TO THE PRIMARY DOCUMENTS LIKE CONTRACT DRAWINGS, FIELD WELDING SCHEDULES, WELDING PROCEDURE SPECIFICATIONS, PLANT / CORPORATE STANDARDS, STATUTORY DOCUMENTS, CONTRACTUAL OBLIGATIONS,AS APPILCABLE ANDSPECIAL INSTRUCTIONS, IF ANY, ISSUED BY RESPECTIVE MANUFACTURING UNITS SPECIFIC TO THE PROJECTS.

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CHAPTER–A1
WELDING - GENERAL

A1: WELDING-GENERAL

1.0 SCOPE:

1.1 This manual deals with activities and information related to welding at site. Where specific documents are supplied by the Manufacturing Units (MUs)/Engineering Centers (ECs), the same shall be adopted.

2.0 DOCUMENTS REFERRED:

2.1 The following documents are referred in preparation of this manual.

1. AWS D1.1
2. AWS D1.6
3. ASME sections I, II (A&C), V & IX
4. ASME B31.1
5. IBR
6. BHEL Manufacturing Units/Engineering Centers Standards & practices

3.0 PROCEDURE:

3.1 The following documents shall be referred as primary documents

1. Contract drawings
2. Field Welding Schedule or equivalent
3. Plant / Corporate standards, wherever applicable
4. Statutory documents
5. Welding Procedure Specifications
6. Contractual obligations, if any.

4.0 WELDER QUALIFICATION:

4.1 Ensure, personnel qualified as per statutory requirements are engaged, where required.

4.2 For welding not under the purview of statutory requirements, qualification of welders shall be as in this manual.

4.3 Monitor performance of qualified butt welders as in this manual.

4.4 Ensure selection, procurement, storage, drying & issue of welding consumables, as detailed in this manual.

4.5 List of approved vendors of general purpose welding electrodes as provided by BHEL-Tiruchy Unit shall be used for selection of brands at sites. Alternatively specific contractual requirements, if any may be followed.

4.6 Where Tiruchy list does not cover site requirements, such specific cases may be referred toconcerned unit and Head (Quality) of the region.

4.7 Welding in-charge shall assign a unique identification for all the butt welds coming under the purview of statutory regulations. Such identification may be traceable through documents like drawings, sketches etc.

4.8 A welding "job card" incorporating the welding parameters and heat treatment requirements is recommended to be issued for all critical welds like pressure part welds, piping welds and

ceiling girder welds. The formats of the job card are enclosed for illustration in Annexure I, II, III and IV.

5.0 SELECTION OF ARGON GAS FOR GTAW:

5.1 USE OF ARGON GAS AT SITES:

In the welding process, Argon is used for **SHIELDING** and **PURGING (BACKING)** purpose. The welding process when exposed to air, most metals exhibit a strong tendency to combine with Oxygen, and to lesser extent with Nitrogen, especially when in the molten condition. The rate of oxide formation will vary with different metals, but even a thin film of oxide on the surface of metals to be welded can lead to difficulties. For the most part, the oxides are relatively weak, brittle materials that in no way resemble the metal from which they are formed. A layer of oxide can easily prevent the joining of two pieces by welding.

Argon is a shielding gas used in Gas Tungsten Arc Welding (GTAW). It is also used for purging (backing) during the root welding of Gr.91/Gr.92/Stainless steel materials. Argon protects welds against oxidation as well as reduces fume emissions during welding. The compressed argon is supplied in cylinders. The cylinder used for argon will have the body colour of BLUE without band, size of 25 cm dia. &1.5 m length, capacity of 6.2 m^3 and pressure of 137 Kg/Cm^2 when fully charged at 15°C (approximately).

5.2 PURITY LEVEL OF ARGON

As per IS 5760: 1998 there are 3 grades of argon, namely:

- **Grade 1:** Ultra high purity argon for use in electronics and allied industries and indirect reading vacuum spectrograph.
- **Grade 2:** High purity argon for use in lamp and allied industries.
- **Grade 3:** Commercial grade argon for use in welding industry and for other metallurgical operations.

Accordingly the argon shall comply with the requirements given below:

Sl. No.	CHARACTERISTIC	REQUIREMENT		
		Grade 1	Grade 2	Grade 3
i.	Oxygen, ppm, Max.	0.5	5.0	10.0
ii.	Nitrogen, ppm, Max.	2.0	10.0	300
iii.	Hydrogen, ppm, Max.	1.0	2.0	5.0
iv.	Water vapors, ppm. Max.	0.5	4.0	7.0
v.	Carbon dioxide, ppm, Max.	0.5	0.5	3.0
vi.	Carbon monoxide, ppm, Max.	0.5	0.5	2.0
vii.	Hydrocarbons, ppm, Max.	0.2	0.5	-

5.3 PURCHASE SPECIFICATION FOR ARGON:

Argon gas as per Grade 2 of IS-5760: 1998 with Argon purity level of min. 99.99%. The supply should accompany Test Certificate for the batch indicating compliance to the above requirements.

5.4 HEAT TREATMENT:

5.4.1 Preheat, inter pass, post heat and Post Weld Heat Treatment (PWHT) requirements shall be as per applicable documents; where these are not supplied, reference may be made to Welding / Heat Treatment Manual.

5.4.2 Prior to PWHT operation, a "job card" containing material specification, weld reference, size, rate of heating, soaking temperature, soaking time and rate of cooling shall be prepared referring to applicable documents, and issued.

5.4.3 The PWHT chart shall contain the chart number,Weld Joint No., Temperature recorder details (like Sl. No. make, range, chart speed), date of PWHT, start and end time of operation.

5.4.4 The chart shall be evaluated and results recorded on the PWHT job card. Refer Heat Treatment Manual (Document No. AA/CQ/GL/011/ Part II-HTM- Latest) for details.

6.0 EQUIPMENT & INSTRUMENTS:

6.1 Equipment/accessories used shall be assessed for fitness prior to use.

6.2 Use calibrated thermocouples, temperature measuring instruments and recorders.

6.3 Preheating shall be checked and ensured using temperature indicating crayons.

7.0 INSPECTION:

7.1 Inspection of welding shall be done as per Chapter A5 of this manual and records maintained as appropriate.

7.2 Weld log containing the following information shall be prepared for all completed systems.

Project / Unit reference
Drawing No.
Weld Joint No.
FWS/ Equivalent
Material specification
Consumable used
Welder code
Date of welding
NDE report No. and results (including repair details)
PWHT Chart No. and results
Remarks, if any.

8.0 SAFETY:

8.1 Safe access to weld area shall be provided.

8.2 Adequate protection shall be provided against wind and rain water entry during welding.

9.0 RECORDS:

9.1 All records, as required, shall be maintained by welding in-chargeand handed over to the appropriate authority at the end of the project closure.

Annexure – I: Welding Job Card

Welding Job Card

Project	:		
Unit No.	:	Area: Boiler/TG/PCP:	
Job Card No.	:	Date	:
FWS Number	:		
Joint No.	:		
Drawing No.	:		
System Description	:		
Size (Dia. x thick)	:		
Material Specification	:		
Consumable used	:		
Welder No.(s)	:		
Date of welding	:		
Filler wire Specification	:		
Electrode Specification	:		
Preheat temperature	:		
Inter pass temperature	:		
Post Heat temperature	:		
PWHT temperature	:		

Welding engineer

Filler wire/Electrode consumption

SMAW	ϕ 2.5 mm	:
	ϕ 3.15 mm	:
	ϕ 4.0 mm	:
Date of LPI for RG Plug		:
Remarks		:
Date of Return		:

Annexure – II: Welding Job Card for P91/P92 Welds

JOB CARD (WELDING, HEAT TREATMENT & ND EXAMINATION) FOR P91/P92 WELDS												
Card No.:								**Date:**				
Project:					**Unit No.**			**Contractor:**				
System:						Drawing No.						
PGMA:						DU No.:			Joint No.:			
Material Specification:			+			OD (mm):			Thick(mm)			
Filler metal:	GTAW					SMAW						
Joint fit-up:	Min. WT:		Root gap:			Root mismatch:			Log sheet filled:	Y / N		
No. of T/Cs:		Location:				Distance from EP edge:				mm		
Welders' ID:						M/c No.:						
Preheat Temp.:	°C Minimum					Rate of heating:			°C per hour			
Purging flow rate:		Litres / min.				Purging time:				Minutes		
Shielding flow rate:		Litres / min. for GTAW				Distance bet. dams:				Metres		
Interpass Temp.:	° C Maximum					Rate of cooling:			°C per hour			
Holding Temp. before PWHT:	° C for min. 1 hour											
PWHT:	° C					Rate of heating / cooling:			°C per hour			
Soaking time		Minutes (2.5 minutes per mm)				Cooling to:			300° C			
Preheating started at	Hrs. on					Preheating completed at			Hrs.			
Root welding started at	Hrs.					Root welding completed at			Hrs.			
Welding started at	Hrs.					Welding completed at			Hrs.			
Interpass temp. maintained between	°C and	°C										
Holding temp. reached at	Hrs.					Holding completed at			Hrs.			
No. of T/Cs:		Location										
PWHT started at	Hrs. on	.				Soaking started at			Hrs.			
Soaking completed at	Hrs.					300°C reached at			Hrs.			
UT Equipment used:						Calibration validity:						
UT carried out on						Result : OK / Not OK						
MPI Equipment used:						Calibration validity:						
MPI carried out on						Result: OK / Not OK						
Hardness test Equipment used:						Calibration validity:						
Hardness test carried out on						Value:						
History of interruption if any, with time:												
Contractor				**BHEL**					**Customer**			

Annexure – III: Welding Job Card for T91/T92 Welds

JOB CARD
(WELDING, HEAT TREATMENT & ND EXAMINATION)
FOR T91/T92 WELDS

Card No.:					**Date:**		
Project			**Unit No.**		**Contractor:**		
System:				Drawing No.			
PGMA:				DU No.:		Joint No.:	
Material Specification:		+		OD (mm):		Thick(mm)	
Filler metal:	GTAW			SMAW			
Joint fit-up:	Min. t:		Root gap:		Root mismatch:	Log sheet filled:	Y / N
No. of T/Cs:		Location :		Distance from EP edge:		mm	
Welders' ID:				M/c No.:			
Preheat Temp.:	°C Minimum			Rate of heating:	°C per hour		
Purging flow rate:		Litres / min.		Purging time:			Minutes
Shielding flow rate:		Litres / min. for GTAW		Distance bet. dams:			Metres
Interpass Temp.:	° C Maximum			Rate of cooling:	°C per hour		
PWHT:	° C			Rate of heating / cooling:	°C per hour		
Soaking time		Minutes (2.5 minutes per mm)		Cooling to:	300° C		
Preheating started at Hrs.	Hrs. on			Preheating completed at			
Root welding started at Hrs.	Hrs.			Root welding completed at			
Welding started at Hrs.	Hrs.			Welding completed at			
Interpass temp. maintained between	°C and	°C					
Holding temp. reached at	Hrs.			Holding completed at	Hrs.		
No. of T/Cs:		Location					
PWHT started at	Hrs. on			Soaking started at	Hrs.		
Soaking completed at	Hrs.			300°C reached at	Hrs.		
RT carried out on				Result : OK / Not OK			
Hardness test Equipment used				Calibration validity:			
Hardness test carried out on				Value:			
History of interruption if any, with time:							

Contractor	**BHEL**	**Customer**

Annexure – IV: Welding Job Card for T23 Welds

JOB CARD (WELDING, HEAT TREATMENT & ND EXAMINATION) FOR T23 WELDS												
Card No.:								**Date:**				
Project:				**Unit No.**				**Contractor:**				
System:							Drawing No.					
PGMA:							DU No.:			Joint No.:		
Material Specification:			+				OD (mm):			Thick(mm)		
Filler metal:	GTAW						SMAW					
Joint fit-up:	Min. t:		Root gap:				Root mismatch:			Log sheet filled:	Y / N	
No. of T/Cs:		Location:					Distance from EP edge:				mm	
Welders' ID:							M/c No.:					
Preheat Temp.:	°C Minimum						Rate of heating:			°C per hour		
Purging flow rate:			Litres / min.				Purging time:				Minutes	
Shielding flow rate:			Litres / min. for GTAW				Distance bet. dams:				Metres	
Interpass Temp.:	° C Maximum						Rate of cooling:			°C per hour		
Holding Temp.:	° C for min. 1 hour. for post heating											
PWHT:	° C						Rate of heating / cooling:			°C per hour		
Soaking time		Minutes (2.5 minutes per mm)					Cooling to:			300° C		
Preheating started at		Hrs. on					Preheating completed at				Hrs.	
Root welding started at		Hrs.					Root welding completed at				Hrs.	
Welding started at		Hrs.					Welding completed at				Hrs.	
Interpass temp. maintained between			°C and		°C							
Holding temp. reached at		Hrs.					Holding completed at			Hrs.		
No. of T/Cs		Location										
PWHT started at		Hrs. on					Soaking started at			Hrs.		
Soaking completed at		Hrs.					300°C reached at			Hrs.		
RT carried out on							Result : OK / Not OK					
Hardness test Equipment used							Calibration validity:					
Hardness test carried out on							Value:					
							Result:	OK / Not OK				
History of interruption if any, with time:												
Contractor				**BHEL**						**Customer**		

CHAPTER–A2
BASE MATERIALS

1.0 SCOPE:

1.1. This chapter contains tabulations of chemical compositions and mechanical properties of various materials generally used at BHEL sites.

2.0 CONTENTS:

CHEMICAL COMPOSITION AND MECHANICAL PROPERTIES

Table A2.1 - Pipes (ASME)

Table A2.2 - Tubes (ASME)

Table A2.3 - Forgings (ASME)

Table A2.4 - Castings (ASME)

Table A2.5 - Plates / Sheets (ASTM, ASME& IS)

Table A2.6 - Pipes (Other specifications)

Table A2.7 - Tubes (Other specifications)

3.0 The data are for general information purposes. The corresponding P numbers are also indicated.

4.0 For materials not covered in this chapter,refer the relevant Material Specification Standard. In case it is not available at site, same shall be referred to Head quality of the region.

TABLE-A2.1: PIPES (ASME)

Sl. No.	P. No. /Group No.	MaterialSpecification	Chemical Composition (%)										Mechanical Properties (Min.)		
			C	Mn	P	S	Si	Ni	Cr	Mo	V	W	T.S MPa	Y.S MPa	% E Min.
1	P 1 / 1	SA 106 Gr. B (Remarks: Carbon restricted to 0.25% Max.)	0.30 Max.	0.29-1.06	0.035 Max.	0.035 Max.	0.10 Min.	0.40 Max.	0.40 Max.	0.15 Max.	0.08 Max	-	415	240	30
2	P 1 / 2	SA 106 Gr. C (Remarks: Carbon restricted to 0.25% Max.)	0.35 Max.	0.29-1.06	0.035 Max.	0.035 Max.	0.10 Min.	0.40 Max.	0.40	0.15 Max.	-	-	485	275	30
3	P4/1	SA 335 P 11	0.15 Max	0.30–0.60	0.025	0.025	0.50–1.00	-	1.00–1.50	0.44–0.65	-	-	380	205	30
4	P 4 / 1	SA 335 P 12	0.15 Max.	0.30-0.61	0.025 Max.	0.025 Max.	0.50 Max.	-	0.80-1.25	0.44-0.65	-	-	415	220	30
5	P 5A / 1	SA 335 P 22	0.15 Max.	0.30-0.60	0.025 Max.	0.025 Max.	0.50 Max.	-	1.90-2.60	0.87-1.13	-	-	415	205	30
6	P 15E /1	SA 335 P91	0.08-0.12	0.30-0.60	0.02 Max.	0.01 Max.	0.20-0.50	0.40 Max.	8.00-9.50	0.85-1.05	0.18-0.25	-	585	415	20
7	P15E/1	SA 335 P 92	0.13 Max	0.30-0.60	0.020	0.010	0.50 max	0.40 max	8.50-9.50	0.0-	0.15-0.25	1.5-2.0	620	400	20

TABLE-A2.2: TUBES(ASME)

Sl. No.	P. No. /Group No.	MaterialSpecification	Chemical Composition (%)										Mechanical Properties (Min.)		
			C	Mn	P	S	Si	Ni	Cr	Mo	V	W	T.S MPa	Y.S MPa	% E Min.
1	P 1 / 1	SA 192	0.06-0.18	0.27-0.63	0.035 Max.	0.035 Max.	0.25 Max.	-	-	-	-	-	325	180	35
2	P 1 / 1	SA 210 Gr A1 (Remarks: Carbon restricted to 0.25% Max.)	0.27 Max.	0.93 Max.	0.035 Max.	0.035 Max.	0.10 Max.	-	-	-	-	-	415	255	30
3	P 1 / 1	SA 179	0.06-0.18	0.27-0.63	0.035 Max.	0.035 Max.	-	-	-	-	-	-	325	180	35
4	P 1 / 2	SA 210 Gr C (Remarks: Carbon restricted to 0.30% Max.)	0.35 Max.	0.29-1.06	0.035 Max.	0.035 Max.	0.10 Max.	-	-	-	-	-	485	275	30
5	P 3 / 1	SA 209 T1	0.10-0.20	0.30-0.80	0.025 Max.	0.025 Max.	0.10-0.50	-	-	0.44-0.65	-	-	380	205	30
6	P 4 / 1	SA 213 T11	0.05-0.15	0.30-0.60	0.025 Max.	0.025 Max.	0.50-1.00	-	1.00-1.50	0.44-0.65	-	-	415	205	30
7	P 4 / 1	SA 213 T12	0.05-0.15	0.30-0.61	0.025 Max.	0.025 Max.	0.50 Max.	-	0.80-1.25	0.44-0.65	-	-	415	220	30
8	P 5 A / 1	SA 213 T22	0.05-0.15	0.30-0.60	0.025 Max.	0.025 Max.	0.50 Max.	-	1.90-2.60	0.87-1.13	-	-	415	205	30

TABLE-A2.2: TUBES(ASME) (Contd…)

Sl. No.	P. No. / Group No.	Material Specification	Chemical Composition (%)										Mechanical Properties (Min.)		
			C	Mn	P	S	Si	Ni	Cr	Mo	V	W	T.S MPa	Y.S MPa	% E Min.
9	P 5 B / 1	SA 213 T5	0.15 Max.	0.30-0.60	0.025 Max.	0.025 Max.	0.50 Max.	-	4.00-6.00	0.45-0.65	-	-	415	205	30
10	P 5 B / 1	SA 213 T9	0.15 Max.	0.30-0.60	0.025 Max.	0.025 Max.	0.25-1.00	-	8.00-10.00	0.90-1.10	-	-	415	205	30
11	P 1 5 E / 1	SA 213 T91	0.07-0.14	0.30-0.60	0.02 Max.	0.01 Max.	0.20-0.50	0.40 Max.	8.00-9.50	0.85-1.05	0.18-0.25	-	585	415	20
12	P 8 / 1	SA 213 TP 304 H	0.04-0.10	2.00 Max.	0.045 Max.	0.03 Max.	1.00 Max.	8.00-11.00	18.00-20.00	-	-	-	515	205	35
13	P8/1	SA 213 TP 321H	0.04-0.10	2.00 Max.	0.045 Max.	0.03 Max.	1.00 Max.	9.00-12.00	17.00-19.00	-	-	-	515	205	35
15	P 8 / 2	SA 213 TP 347 H	0.04-0.10	2.00 Max.	0.045 Max.	0.03 Max.	1.00 Max.	9.00-13.00	17.00-19.00	-	-	-	515	205	35
15	Code case 2199	SA213 T23	0.04-0.10	0.10-0.60	0.030	0.010	0.050	--	1.90-2.60	0.05-0.30	0.20-0.30	1.45-1.75	510	400	20
16	15E/1 (Code case 2169)	SA213 T92	0.07-0.13	0.30-0.60	0.020	0.010	0.50	0.40	8.5-9.5	0.30-0.60	0.15-0.25	1.5-2.0	620	440	20
17	P8/1 (Code case 2328 - S30432)	SA 213 UNS S30432 (Super 304H)	0.07-0.13	1.00	0.040	0.010	0.30	7.5-10.5	17.0-19.0	-	-	-	590	235	35

TABLE A2.3: FORGINGS (ASME)

Sl. No.	P. No. / Group No.	Material Specification	Chemical Composition (%)										Mechanical Properties (Min.)		
			C	Mn	P	S	Si	Ni	Cr	Mo	V	W, Cb	T.S MPa	Y.S MPa	% E Min.
1	P 1 / 2	SA 105 (Remarks: Carbon restricted to 0.25% Max.)	0.35 Max.	0.60-1.05	0.035 Max.	0.04 Max.	0.1 - 0.35	0.40 Max.	0.30 Max.	0.12 Max.	0.08 Max	-	485	250	30
2	P 4 / 1	SA 182 F11 Class 3	0.10-0.20	0.30-0.80	0.04 Max.	0.04 Max.	0.50 - 1.00	-	1.00-1.50	0.44-0.65	-	-	515	310	20
3	P 4 / 1	SA 182 F 12 Class 2	0.10-0.20	0.30-0.80	0.04 Max.	0.04 Max.	0.10 - 0.60	-	0.80-1.25	0.44-0.65	-	-	485	275	20
4	P 5 A / 1	SA 182 F 22 Class 3	0.15 Max.	0.30-0.60	0.04 Max.	0.04 Max.	0.50 Max.	-	2.00-2.50	0.87-1.13	-	-	515	310	20
5	P 1 5 E / 1	SA 182 F91	0.08-0.12	0.30-0.60	0.02 Max.	0.01 Max.	0.20 - 0.50	0.40 Max.	8.00-9.50	0.85-1.05	0.18-0.25	-	620	415	20
6	P 1 5 E / 1	SA 182 F92	0.7-0.13	0.30-0.60	0.02 Max.	0.01 Max.	0.50 Max.	0.40 Max.	8.50-9.50	0.30-0.60	0.15-0.25	W:1.50-2.00; Cb: 0.04-0.09	620	440	20

TABLE A2.4: CASTINGS (ASME)

Sl. o.	P. No. /Group No.	Material S e fi a on	Chemical Composition (%)								Mechanical Properties (Min.)		
			C	Mn	P	S	Si	Ni	Cr	Mo	MPa	MPa	% EMI n.
1	P 1 / 2	SA 216 WCB (Remarks: Carbon restricted to 0.25% Max.)	0.30 Max.	1.00 Max.	0.04 Max.	0.045 Max.	0.60 Max.	0.50 Max.	0.50 Max.	0.20 Max.	485	250	22
2	P 1 / 2	SA 216 WCC	0.25 Max.	1.20 Max.	0.04 Max.	0.045 Max.	0.60 Max.	0.50 Max.	0.50 Max.	0.20 Max.	485	275	22
3	P 4 / 1	SA 217 WC6	0.20 Max.	0.50-0.80	0.04 Max.	0.045 Max.	0.60 Max.	-	1.00-1.50	0.45-0.65	485	275	20
4	P 5 A / 1	SA 217 WC 9	0.18 Max.	0.40-0.70	0.04 Max.	0.045 Max.	0.60 Max.	-	2.00-2.75	0.90-1.20	485	275	20
5	P 8 / 1	SA 351 CF 8	0.08 Max.	1.50 Max.	0.04 Max.	0.04 Max.	2.00 Max.	8.00-11.00	18.00-21.00	0.50 Max.	485	205	35
6	P 8 / 1	SA 351 CF 8M	0.08 Max.	1.50 Max.	0.04 Max.	0.04 Max.	1.50 Max.	9.00-12.00	18.00-21.00	2.00-3.00	485	205	30
7	P 8 / 1	SA 351 CF 8C	0.08 Max.	1.50 Max.	0.04 Max.	0.04 Max.	2.00 Max.	9.00-12.00	18.00-21.00	0.50 Max.	485	205	30
8	P 8 / 2	SA 351 CH 20	0.04-0.20	1.50 Max.	0.04 Max.	0.04 Max.	2.00 Max.	12.00-15.00	22.00-26.00	0.50 Max.	485	205	30
9	P15E / 1	SA 217 C12A	0.08-0.12	0.30-0.60	0.030 Max.	0.010 Max.	0.20-0.50	0.40 Max.	8.00-10.00	0.85-1.05	585	415	18

TABLE A2.5: PLATES/SHEETS

Sl. No.	P. No./ Group No.	Material Specification	Thickness mm	C	Mn	P	S	Si	Ni	Cr	Mo	V	T.S (MPa)	Y.S (MPa)	%E Min.
1	P 1 / 1	ASTM A36	20 incl.	0.25	-	0.04	0.05	0.40	-	-	-	-	400	250	20
			20-40 incl.	0.25	0.80-1.20			0.40	-	-	-	-			
			40-65 incl.	0.26	0.80-1.20			0.40	-	-	-	-			
			65-100 incl.	0.27	0.85-1.20			0.15-0.40	-	-	-	-			
			over 100	0.29	0.85-1.20			0.15-0.40	-	-	-	-			
2	P 1 / 1	SA 516 Gr 60	12.5 incl	0.21	0.55-0.98	0.035	0.035	0.13-0.45	-	-	-	-	415	220	25
			12.5-50 incl	0.23	0.79-1.30				-	-	-	-			
			50-100 incl	0.25					-	-	-	-			
			100-200 incl	0.27					-	-	-	-			
			over 200	0.27					-	-	-	-			
3	P 1 / 2	SA516 Gr70	12.5 incl	0.27	0.79-1.30	0.035	0.035	0.13-0.45	-	-	-	-	485	260	21
			12.5-50 incl	0.28					-	-	-	-			
			50-100 incl	0.3					-	-	-	-			
			100-200 incl	0.31					-	-	-	-			
			over 200	0.31					-	-	-	-			
4	P 1 / 2	SA299 Gr.A	<25	0.26	0.84-1.52	0.035	0.035	0.13-0.45	-	-	-	-	515	275	19
			>25	0.28	0.84-1.62				-	-	-	-			
5	P 1 / 2	SA515 Gr70	<25	0.31	1.30	0.035	0.035	0.13-0.45	-	-	-	-	485	260	21
			25-50 incl	0.33					-	-	-	-			
			50-100 incl	0.35					-	-	-	-			
			100-200 incl	0.35					-	-	-	-			
			>200	0.35					-	-	-	-			
6	P311	SA204 Gr A	<25 incl	0.18	0.98	0.025	0.025	0.13-0.45	-	-	0.41-0.64	-	450	255	23
			>50 incl	0.21					-	-		-			
			>100 incl	0.23					-	-		-			
			>100	0.25					-	-		-			
7	P312	SA204 Gr B	<25 incl	0.20	0.98	0.025	0.025	0.13-0.45	-	-	0.41-0.64	-	485	275	21
			>50 incl	0.23					-	-		-			
			>100 incl	0.25					-	-		-			
			>100	0.27					-	-		-			
8	P411	SA 387 Gr 12 Class 2	<125 incl	0.04-0.17	0.35-0.73	0.025	0.025	0.13-0.45	-	0.74-1.21	0.40-0.65	-	450	275	22
			>125	0.17											
9	P5N1	SA387 Gr 22 Class 2	<125 incl	0.04-0.15.	0.25-0.66	0.025	0.025	0.50.	-	1.88-2.62	0.85-1.15	-	515	310	18
			>125	0.17											
10	P15El1	SA387 Gr 91	all thickness	0.06-0.15	0.25-0.66	0.025	0.012	0.18-0.56	0.43	7.90-9.60	0.80-1.10	0.16-0.27	585	415	18

TABLE A2.5: PLATES/SHEETS (Contd...)

Sl. No.	P.No./ Group No.	Material Specification	Thickness mm	C	Mn	P	S	Si	Ni	Cr	Mo	V	T.S (MPa)	Y.S (MPa)	%E Min.
11	P811	SA240 TYPE 304	all thickness	0.07	2	0.045	0.03	0.75	8.00-10.50	17.5.-19.5.0	-		515	205	40
12	P 1 / 1	ASTM A572 Gr50	<40 incl	0.23	1.35	0.04	0.05	0.4 0	-	-	-		450	345	17
			>40					0.15-0.40	-	-	-	0.01-0.1			
13	P 1 / 1	IS 2062 E250 Gr.A	all thickness	0.23	1.5	0.045	0.045	0.4	-	-	-	-	410	230	23
14	P 1 / 1	IS 2062 E250 Gr.BR BO	all thickness	0.22	1.5	0.045	0.045	0.4	-	-	-	-	410	230	23
15	P 1 / 1	IS 2062 E250 GrC	all thickness	0.2	1.5	0.04	0.04	0.4	-	-	-	-	410	230	23
16	P 1 / 1	IS 2062 E350 Gr A.BR,BO	all thickness	0.2	1.55	0.045	0.045	0.45	-	-	-	-	490	320	22
17	P 1 / 1	IS 2062 E350 GrC	all thickness	0.2	1.55	0.04	0.04	0.45	-	-	-	-	490	320	22
18	P 1 / 1	IS 2062 E450BR	all thickness	0.22	1.65	0.045	0.045	0.45	-	-	-	-	570	450	20
19	P 1 / 1	BSEN10025 Gr 420N	all thickness	0.2	1.0-1.7	0.03	0.025	0.6	0.8	0.3	0.1	0.2	500	320	18

TABLE A2.6: PIPES (OTHER SPECIFICATION)

Sl. No.	Equivalent P. No. /Group No.	Material Specification	Chemical Composition (%)									Mechanical Properties (Min.)		
			C	Mn	P	S	Si	Ni	Cr	Mo	V	T.S Kg / mm^2	Y.S Kg / mm^2	% EMin.
1	P1/1	DIN St. 35.8	0.17 Max.	0.40-0.80	0.04 Max.	0.04 Max.	0.10-0.35	-	-	-	-	36.70-48.96	24	25
2	P1/1	DIN St. 45.8	0.21 Max.	0.45-1.20	0.04 Max.	0.04 Max.	0.10-0.35	-	-	-	-	41.80-54.10	26	21
3	P1/1	BS 3602 / 410	0.21 Max.	0.40-1.20	0.045 Max.	0.045 Max.	0.35 Max.	-	-	-	-	41.82-56.10	25	22
4	P1/1	BS 3602 / 460	0.22 Max.	0.80-1.40	0.045 Max.	0.045 Max.	0.35 Max.	-	-	-	-	46.90-61.20	28.60	21
5	P4/1	BS 3604 620-460 HFS or CDS 620-440	0.10-0.15	0.40 Max.	0.04 Max.	0.04 Max.	0.10-0.35	-	0.70-1.10	0.45-0.65	-	46.90- 62.22	18.36	22
			0.10-0.18	0.40-0.70	0.04 Max.	0.04 Max.	0.10-0.35	-	0.70-1.10	0.45-0.65	-	44.90- 60.20	29.58	22
6	P5/1	BS 3604 622 HFS or CDS	0.08-0.15	0.40-0.70	0.04 Max.	0.04 Max.	0.50 Max.	-	2.00 2.50	0.90-1.20	-	48.80	26.80	17
7	-	BS 3604 HFS 660 Or CDS 660	0.15 Max.	0.40-0.70	0.04 Max.	0.04 Max.	0.10-0.35	-	0.25-0.50	0.50-0.70	0.22-0.30	47.30	30	17
8	P5B/2	X20CrMoV121D IN17175	0.17-0.23	≤ 1.00	0.030 Max.	0.030 Max.	≥ 0.50	0.30-0.80	10.00-12.50	0.80-1.20	0.25-0.35	70-86	50	17

TABLE A2.7: TUBES (OTHER SPECIFICATIONS)

Sl. No.	Equivalent P. No. /Group No.	Material Specification	Chemical Composition (%)									Mechanical Properties (Min.)		
			C	Mn	P	S	Si	Ni	Cr	Mo	V	T.S Kg / mm^2 (MPa)	Y.S Kg / mm^2 (MPa)	% E Min.
1	P1/1	DIN St. 35.8	0.17 Max.	0.40-0.80	0.04 Max.	0.04 Max.	0.10-0.35	-	-	-	-	36.70-48.96	24	25
2	P1/1	DIN St. 45.8	0.21 Max.	0.40-1.20	0.04 Max.	0.04 Max.	0.10-0.35	-	-	-	-	41.80-54.06	26	21
3	P1/1	BS 3059 / 360	0.17 Max.	0.40-0.80	0.045 Max.	0.045 Max.	0.35 Max.	-	-	-	-	36.70-51.00	22	24
4	P1/1	BS 3059 / 440	0.12-0.18	0.90-1.20	0.040 Max.	0.035 Max.	0.10-0.35	-	-	-	-	44.88-59.20	25	21
5	P3/1	15 Mo3 DIN17175	0.12-0.20	0.40-0.80	0.035 Max.	0.035 Max.	0.10-0.35	-	-	0.25-0.35	-	45.90-61.20	27.50	22
6	P4/1	13 Cr Mo 4-5DIN17175	0.10-0.18	0.40-0.70	0.035 Max.	0.035 Max.	0.10-0.35	-	0.70-1.10	0.45-0.65	-	44.88-60.18	29.60	22
7	P4 /1	BS 3059 / 620	0.10-0.15	0.40-0.70	0.040 Max.	0.040 Max.	0.10-0.35	-	0.70-1.10	0.45-0.65	-	46.90-62.20	18.40	22
8	P5/1	10 Cr Mo 9-10DIN17175	0.08-0.15	0.40-0.70	0.035 Max.	0.035 Max.	0.50 Max.	-	2.00-2.50	0.90-1.20	-	45.90-61.20	28.60	20
9	P5/1	BS 3059 (622) - 440	0.08-0.15	0.40-0.70	0.04 Max.	0.04 Max.	0.50 Max.	-	2.00-2.50	0.90-1.20	-	44.90-60.18	17.85	20
10	P5/1	BS 3059 (622) - 490	0.08-0.15	0.40-0.70	0.040 Max.	0.040 Max.	0.50 Max.	-	2.00-2.50	0.90-1.20	-	49.98-65.00	28.05	20
11	-	14 Mo V 63 DIN17175	0.10-0.18	0.40-0.70	0.035 Max.	0.035 Max.	0.10-0.35		0.30-0.60	0.50-0.70	0.22-0.32	46.90-62.22	32.60	20
12	P5B/2	X20CrMoV121 DIN17175	0.17-0.23	≤ 1.00	0.030 Max.	0.030 Max.	≥ 0.50	0.30-0.80	10.00-12.50	0.80-1.20	0.25-0.35	70-86	50	17

CHAPTER A3: WELDING MATERIAL SPECIFICATION AND CONTROL

SECTION A3.1-WELDING MATERIAL SPECIFICATION AND CONTROL

1.0 SCOPE:

1.1. This chapter details out the welding material specification and controls at sites.

2.0 CONTENTS:

1. Table- A3.1 - Weld Metal Chemical Composition.
2. Table - A3.2 - Mechanical property requirement for all-weld metal.
3. Receipt inspection of welding electrodes/filler wires.
4. Storage and identification of welding electrodes/filler wires.
5. Drying and holding of welding electrodes.
6. Selection and issue of welding electrodes/filler wires.
7. Table-A3.3 - Selection of GTAW filler wire, SMAW electrodes for butt welds in tubes, pipes, headers.
8. Table-A3.4 - Selection of electrodes for welding attachments to tubes.
9. Table-A3.5 - Selection of electrodes, preheat, PWHT for attachment to attachment welds.
10. Table-A3.6 -Selection of electrodes for welding nozzle attachments, hand hole plate, RG plug etc. to headers, pipes.
11. Table-A3.7 –Selection of filler wire and electrodes for non-pressure parts(including structures)
12. Table-A3.8 -A numbers
13. Table-A3.9 -F numbers
14. SFA Classification

3.0 For welding consumables not covered in this chapter, relevant details may be obtained from the concerned Manufacturing Units.

Table-A3.1
WELD METAL CHEMICAL COMPOSITION

Electrode/ Consumable	SFA No.	Weight, %										Other Elements %[a]
		C	Mn	Si	P	S	Ni	Cr	Mo	V	Cu	
E 6010	5.1	0.20	1.20	1.00	NS	NS	0.30	0.20	0.30	0.08	NS	Combined Limit for Mn+Ni+Cu+Mo+V=1.75
E 6013	5.1	0.20	1.20	1.00	NS	NS	0.30	0.20	0.30	0.08	NS	
E 7018	5.1	0.15	1.60	0.75	0.035	0.035	0.30	0.20	0.30	0.08	NS	
E 7018-1	5.1	0.15	1.60	0.75	0.035	0.035	0.30	0.20	0.30	0.08	NS	
E 7018-A1	5.5	0.12	0.90	0.80	0.03	0.03	NS	NS	0.40-0.65	NS	NS	
E 8018-B2	5.5	0.05-0.12	0.90	0.80	0.03	0.03	NS	1.00-1.50	0.40-0.65	NS	NS	
E 9018-B3	5.5	0.05-0.12	0.90	0.80	0.03	0.03	NS	2.00-2.50	0.90-1.20	NS	NS	
E 9015-B91	5.5	0.08-0.13	1.20	0.30	0.01	0.01	0.80	8.00-10.50	0.85-1.20	0.15-0.30	0.04 - 0.25	
E9015-B92	5.5	0.08-0.15	1.20	0.60	0.020	0.015	1.0	8.0-10.0	0.30-0.70	0.15-0.30	0.25	W: 1.50-2.00; Nb: 0.02-0.08 B:0.006; Al: 0.04; N: 0.03-0.08
E9018-B23/ E9015-B23	5.5	0.04-0.12	1.00	0.60	0.015	0.015	0.5	1.9-2.9	0.30	0.15-0.30	0.25	W: 1.50-2.00; Nb: 0.02-0.10 B:0.006; Al: 0.04; N: 0.05
E 308	5.4	0.08	0.50-2.50	1.00	0.04	0.03	9.00-11.00	18.00-21.00	0.75	NS	0.75	
E 308-L	5.4	0.04	0.50-2.50	1.00	0.04	0.03	9.00-11.00	18.00-21.00	0.75	NS	0.75	

Table-A3.1 (Contd...)
WELD METAL CHEMICAL COMPOSITION

Electrode/ Consumable	SFA No.	Weight, %										Other Elements %[a]
		C	Mn	Si	P	S	Ni	Cr	Mo	V	Cu	
E 309	5.4	0.15	0.50-2.50	1.00	0.04	0.03	12.00-14.00	22.00-25.00	0.75	NS	0.75	
E 309-L	5.4	0.04	0.50-2.50	1.00	0.04	0.03	12.00-14.00	22.00-25.00	0.75	NS	0.75	
E 347	5.4	0.08	0.50-2.50	1.00	0.04	0.03	9.00-11.00	18.00-21.00	0.75	NS	0.75	Cb+Ta 8XC Min. to 1.00 Max.
E316	5.4	0.08	0.5-2.5	1.00	0.04	0.03	11.0-14.0	17.0-20.0	2.0-3.0	NS	0.75	
E2209-16	5.4	0.04	0.5-2.0	1.00	0.04	0.03	7.5-9.5	21.5-23.5	2.5-3.5	NS	0.75	N:0.08-0.20
ENiCrFe-3	5.11	0.10	5.0-9.5	1.00	0.03	0.015	59.0 min	13.0-17.0	NS	NS	0.50	Fe: 12.0; Ta+ Cb: 1.0-2.5; Ti: 1.0; others: 0.5
ENiCrFe-7	5.11	0.05	5.0	0.75	0.03	0.015	Rem	28.0-31.5	0.5	NS	0.50	Fe: 7.0-12.0; Ta+ Cb: 1.0-2.5; others: 0.5
ENi-CI	5.15	2.00	2.50	4.00	NS	0.03	85[d] min	NS	NS	NS	2.5[e]	Fe 8.0 Al 1.0 others Total 1.0
ENiFe-CI	5.15	2.00	2.50	4.00	NS	0.03	45[d]-60	NS	NS	NS	2.5[e]	Fe Rem[f] Al 1.0 others Total 1.0
ER70S-2	5.18	0.07	0.90-1.40	0.40-0.70	0.025	0.035	0.15	0.15	0.15	0.03	0.50[b]	Ti 0.05-0.15 Zr 0.02-0.12 Al 0.05-0.15
ER70S-A1	5.28	0.12	1.30	0.30-0.70	0.025	0.025	0.20	NS	0.40-0.65	NS	0.35	Others : 0.50
E8018-G	5.5	0.08	1.0-1.8	0.5	0.025	0.025	0.5-1.20	NS	0.5	NS	NS	

Table-A3.1 (Contd…)
WELD METAL CHEMICAL COMPOSITION

Electrode/ Consumable	SFA No.	Weight, %										Other Elements %[a]
		C	Mn	Si	P	S	Ni	Cr	Mo	V	Cu	
ER80S-B2	5.28	0.07-0.12	0.40-0.70	0.40-0.70	0.025	0.025	0.20	1.20-1.50	0.40-0.65	NS	0.35[c]	Total other Elements 0.50
ER90S-B3	5.28	0.07-0.12	0.40-0.70	0.40-0.70	0.025	0.025	0.20	2.30-2.70	0.90-1.20	NS	0.35 [c]	Total other Elements 0.50
ER80S-D2	5.28	0.07-0.12	1.60-2.10	0.50-0.80	0.025	0.025	0.15	NS	0.40-0.60	NS	0.50 [c]	Total other Elements 0.50
ER90S-B9	5.28	0.07-0.13	1.20	0.15-0.30	0.01	0.01	0.80	8.00-10.50	0.80-1.20	0.15-0.23	0.20	Total other Elements 0.50
ER 308	5.9	0.08	1.00-2.50	0.30-0.65	0.03	0.03	9.00-11.00	19.50-22.00	0.75	NS	0.75	
ER 309	5.9	0.12	1.00-2.50	0.30-0.65	0.03	0.03	12.00-14.00	23.00-25.00	0.75	NS	0.75	
ER 309-L	5.9	0.03	1.00-2.50	0.30-0.65	0.03	0.03	12.00-14.00	23.00-25.00	0.75	NS	0.75	
ER316L	5.9	0.03	1.0-2.5	0.30-0.65	0.03	0.03	11.0-14.0	18.0-20.0	2.0-3.0	NS	0.75	---
ER 347	5.9	0.08	1.00-2.50	0.30-0.65	0.03	0.03	9.00-11.00	19.00-21.50	0.75	NS	0.75	Cb+Ta 10XC Min. to 1.0 Max.
ER2209	5.9	0.03	0.5-2.0	0.90	0.03	0.03	7.5-9.5	21.5-23.5	2.5-3.5	NS	0.75	N:0.08-0.20

Table-A3.1 (Contd…)
WELD METAL CHEMICAL COMPOSITION

Electrode/ Consumable	SFA No.	Weight, %										Other Elements %[a]
		C	Mn	Si	P	S	Ni	Cr	Mo	V	Cu	
ERNiCr-3	5.14	0.10	2.5-3.5	0.50	0.03	0.015	67.0 min	18.0-22.0	NS	NS	0.50	Fe: 3.0; Cb+Ta: 2.0-3.0; Ti: 0.75; Other: 0.5
ERNiCrFe-7A	5.14	0.04	1.0	0.50	0.02	0.015	Rem.	28.0-31.5	0.50		0.30	Fe: 7.0-11-0; Cb+Ta: 0.5-1.0; Ti: 1.0; Other: 0.5; Co: 0.12; Al: 1.10
YT 304H	--	Proprietary GTAW rod for Super 304H										
THERMANIT 304H Cu	--											
TGS2CW	--	Proprietary GTAW rod for T23										
YT-HCM2S												
2CrWV-TIG	--											
9CRWV TIG	--	Proprietary GTAW rod for Gr.92										
THERMANIT MTS 616	--											

TABLE – A3.1 (Contd...)
WELD METAL CHEMICAL COMPOSITION

Notes:

a) Other elements listed without specified values shall be reported, if intentionally added. The total of these latter unspecifiedelements and all other elements not intentionally added shall not exceed 0.50%.

b) The maximum weight percent of copper in the rod or electrode due to any coating plus the residual copper content in the steel shall be 0.50.

c) The maximum weight percent of copper in the rod or electrode due to any coating plus the residual copper content in the steel shall comply with the stated value.

d) Nickel plus incident Cobalt.

e) Copper plus incident Silver.

f) "Rem" stands for remainder.

g) Manufacturer's certification to have met the requirements of ASME Sec. II Part C is acceptable in cases where the chemical analysis are not reflected.

h) Single values are maximum.

i) NS – Not Specified

TABLE-A3.2
MECHANICAL PROPERTY REQUIREMENTFOR ALL-WELD METAL

Electrode	SFA No.	Tensile Strength Ksi / MPa	Yield Strength at 0.2% of Proof Stress, Ksi/ MPa	Elongation In 2 inch (50.8 mm) %
E6010	5.1	60 / 430	48 / 330	22
E6013	5.1	60 /430	48 / 330	17
E7018	5.1	70 / 490	58 / 400	22
E7018-1[a]	5.1	540	58 / 400	22
E7018-A1	5.5	70 / 490	57 / 390	22
E8018-G[b]	5.5	570	450	19
E8018-B2	5.5	80 /550	67 / 460	19
E9018-B3	5.5	90 /620	77 / 530	17
E9015-B91	5.5	90 /620	77 / 530	17
E9015-B92	5.5	90/620	77/530	17
E9018-B23	5.5	90/620	77/530	17
E308	5.4	80 / 550	-	35
E308L	5.4	75 / 520	-	35
E309	5.4	80 / 550	-	30
E309L	5.4	75 / 520	-	30
E347	5.4	75 / 520	-	30
E316	5.4	75/520	--	30
E2209	5.4	100/690	--	22
ENiCrFe-3	5.11	80/550	--	30
ENiCrFe-7	5.11	80/550	--	30
ENi-CI	5.15	40-65 / 276-448	38-60 / 268-414	3-6
ENiFe-CI	5.15	58-84 / 400 -579	43-63 / 294 -434	6-18

a. These electrodes shall meet the lower temperature impact requirement of average minimum. (27 Joules at −45° C) and other properties at 620±20°C for 300 minutes.

b. These electrodes shall meet the impact requirement of average minimum (20 Joules at + 25° C) and other properties at 550±10°C for 60 minutes.

Table- A3.2 (Contd...)

MECHANICAL PROPERTY REQUIREMENT FOR ALL-WELD METAL

Electrode	SFA No.	Tensile Strength Ksi / MPa	Yield Strength at 0.2% of Proof Stress, Ksi / MPa	Elongation In 2 inch (50.8 mm) %
ER70S-6	5.18	70/480	58/400	22
ER70S-A1	5.28	75/515	58/400	19
ER80S-B2	5.28	80 / 550	68 / 470	19
ER90S-B3	5.28	90 / 620	78 / 540	17
ER80S-D2	5.28	80 / 550	68 / 470	17
ER90S-B9	5.28	90 / 620	60 / 410	16
ER308	5.9	These values are not required in the test certificate		
ER308L	5.9			
ER309	5.9			
ER309L	5.9			
ER347	5.9			
ER316	5.9			
ER2209-16	5.9			
ERNiCr-3	5.14	80/550	--	
ERNiCrFe-7A	5.14	85/590	--	

NOTE:

a) Single values are minimum.

b) Manufacturer's certification to have met the requirements of ASME-Section II Part C is acceptable in cases where the mechanical properties are not reflected.

c) 1Ksi is approximately equal to 6.89 MPa.

Section A3.2- Receipt Inspection of Welding Electrodes / Filler Wires

1.0 All electrodes/filler wires received at site stores shall be segregated for type and size of electrode.

2.0 Ensure that electrode packets received are free from physical damage.

3.0 Where electrodes are damaged, the same shall be removed from use.

4.0 Only electrodes identified in the "list of approved vendors of welding electrodes" shall be accepted.

5.0 Where filler metals are supplied by manufacturing unit, inspect for damages, if any.

6.0 Ensure availability of relevant test certificates. Refer tables of chemical compositions and mechanical properties for acceptance.

7.0 Endorse acceptance/rejection on the test certificate.

Section A3.3- Storage & Identification of WeldingElectrodes/Filler Wires

1.0 SCOPE:

1.1 This procedure is applicable for storage of welding electrodes/filler wires used at sites.

2.0 PROCEDURE:

2.1 Only materials accepted (based on receipt inspection) shall be taken into account for storage.

2.2 STORAGE FACILITY:

2.2.1 The storage facility shall be identified.

2.2.2 Access shall be made available to authorized personnel.

2.2.3 The storage area shall be clean and dry.

2.2.4 Steel racks may be used for storage. Avoid usage of wooden racks for storing inside the storage room.

2.2.5 Maintain the temperature of the storage facility above the ambient temperature. This can be achieved by the use of appropriate heating arrangements.

2.3 The electrodes/filler wire shall be segregated and identified for

a. Type of electrode e.g. E7018.

b. Size of electrode e.g. Dia. 3.15 mm.

2.4 Identification of filler wires:

2.4.1 On receipt of GTAW filler wires, check AWS No. or brand name embossed and retain the same identification throughout.

Section A3.4-Drying and Holding of Welding Electrodes

1.0 SCOPE:

1.1 This section details activities regarding drying and holding of welding electrodes used at sites.

2.0 PROCEDURE:

2.1 While handling, avoid contact of oil, grease with electrodes. Do not use oily or wet gloves.

2.2 It is recommended that not more than two days' requirements electrodes are dried.

3.0 GTAW Filler Wires:

3.1 These wires do not require any drying.

4.0 Covered Electrodes:

4.1 Drying and holding :

4.1.1 Identify drying oven and holding oven.

4.1.2 They shall preferably have a temperature control facility upto 400°C for drying oven and 200°C for holding oven.

4.1.3 A calibrated thermometer shall be provided for monitoring temperature.

4.2 On opening a packet of electrodes, segregate and place them in the drying oven. Mix-up of electrodes shall be avoided.

4.2.1 After loading, raise the drying oven temperature to the desired range as per table in 4.2.5.

4.2.2 Note the time when the temperature reaches the desired range. Maintain this temperature for the duration required as per Table in 4.2.5.

4.2.3 On completion of drying, the electrodes shall be transferred to holding oven immediately and maintained at minimum temperature of 150°C till issue.

4.2.4 The electrode shall not be subjected to more than three cycles of drying.

4.2.5 Maintaina register containing following details:

Sl. No.	Date	AWS number/Specification	Batch No./Size	Dia.	Qty.	Drying temperature Start time	Drying Temperature end time	Remarks

Drying and Holding Parameters

AWS Classification	Drying (*)		Minimum Holding Temperature °C (@)
	Temperature °C	Time (Hours)	
E7018	250 - 300	2	150
E7018-1	250 - 300	2	150
E7018-A1	250 - 300	2	150
E8018-G	250 - 300	2	150
E8018-B2	250 - 300	2	150
E9018-B3	250 - 300	2	150
E9018-B23	250 - 300	2	150
E9015-B91	250 - 300	2	150
E9015-B92	250 - 300	2	150
E308, E309, E310 E316& E347	250 - 300	1	150
ENiCrFe-3	250 - 300	2	150
ENiCrFe-7	250 - 300	2	150

Note: (*) - Guideline has been given however, supplier's recommendations shall be followed.

(@) - Maintain the temperature in the oven till issue.

4.2.4 After issue, maintain the electrodes in a portable oven at a minimum temperature of 65°C till use. This is not applicable for E6013 (Rutile) electrodes, however the following instruction shall be followed for E6013 electrodes:

(1) Rutile electrodes require some moisture in the coating and they would not require drying. If they become damp, re-drying at around 120 to 150°C for 1 hour will be sufficient.

(2) These electrodes with potassium silicate binder can be used on both DCEP/DCEN polarities and on AC. E6013 electrodes generally have better arc striking and stability characteristics with an easily detachable slag.

4.3 Unused, returned electrodes shall be segregated and reused only after repeating drying and holding cycles.

Section A3.5- Selection and Issue of Welding Electrodes / Filler Wires

1.0 SCOPE:

1.1. This procedure details methods for selection and issue of welding electrodes/filler wires for site operations.

2.0 PROCEDURE:

2.1 Selection:

2.1.1 The type of filler wire/electrode for welding shall be based on the details given in the contract documents like Field Welding Schedule, drawings, Welding Procedure Specifications as supplied by the concernedmanufacturing units.

2.1.2 Where not specified by the manufacturing units, selection shall be based on the tables enclosed (Table A3.3 to Table A3.7. as applicable).

2.1.3 Where electrodes/ filler wires are not covered in the documents mentioned in 2.1.1 and 2.1.2, refer to the concernedmanufacturing units.

2.2 Issue:

2.2.1 Issue of welding electrodes / filler wires shall be based on authorised welding electrodes issue voucher.

2.2.2 It is recommended to restrict quantity issued to not more than 4 hours' requirements.

2.2.3 Re-dried low hydrogen electrodes shall be carried to the work spot in a portable oven.

2.2.4 Maintain the temperature in the portable oven at the work spot above 65°C.

2.2.5 Unused electrodes shall be segregated and reused only after repeating drying and holding cycles.

Table- A3.3
SELECTION OF GTAW FILLER WIRE, SMAW ELECTRODE FOR BUTT WELDS IN TUBES, PIPES AND HEADERS

Material	Welding Process	P1 Gr 1/ P1 Gr 2	P3 Gr 1	P4 Gr 1	P5A Gr 1	P15 E Gr 1	T23	T92/P92	P8	P8 SA 213 UNS S 30432	DIN14MoV6 3 or equivalent
P1 Gr 1	GTAW	ER 70S-A1									
P1 Gr 2	SMAW	E7018-1 Note 1									
P3 Gr 1	GTAW	ER 70S-A1	ER 70S-A1								
	SMAW	E7018-1	E7018-A1								
P4 Gr 1	GTAW	ER 70S-A1	ER 70S-A1	ER 80S-B2							
	SMAW	E7018-1	E7018-A1	E8018-B2							
P5A Gr 1	GTAW	ER 70S-A1	ER 70S-A1	ER 80S-B2	ER 90S-B3	ER 90S-B3	ER90S-B3				
	SMAW	E7018-1	E7018-A1	E8018-B2	E9018-B3	E9018-B3	E9018-B3				
P15 E Gr.1 Gr.91	GTAW					ER90S-B9	TGS2CW/ 2CrWVTIG/ YT-SCM2S	ER90S-B9			
	SMAW					E9015-91	E9018-B23	E9015-B91			
T23	GTAW						TGS2CW/ 2CrWVTIG/YT-SCM2S	TGS2CW/ 2CrWVTIG/ YT-SCM2S			
	SMAW						E9018-B23	E9018-B23			

Table- A3.3 (Contd...)

Material	Welding Process	P1 Gr 1 P1 Gr 2	P3 Gr 1	P4 Gr 1	P5A Gr 1	P15 E Gr 1	T23	T92/P92	P8	P8 SA 213 UNS S 30432	DIN14MoV63 or equivalent
P15 E Gr.1 Gr.92	GTAW							9CrWV-TIG/ Themanit-MTS616			
	SMAW							E9015-B92			
P8	GTAW			ERNi Cr3	ERNiCr3	ERNiCr3	ERNiCr3	ERNiCrFe7A	ER347		
	SMAW			ENiC rFe3	ENiCrFe3	ENiCrFe3	ENiCrFe3	ENiCrFe7	E347		
P8 SA 213 UNS S30432	GTAW									YT304H/ THERMANIT 304H Cu	
DIN14MoV63 or equivalent	GTAW				ER 90S-B3						ER90S-B3
	SMAW				E9018-B3						E9018-B3

Note-1: E7018-A1 for P1 Gr2 + P1 Gr2 when PWHT is involved.

Table- A3.4
SELECTION OF ELECTRODES FOR WELDING ATTACHMENTS TO TUBES

Tube Material	Attachment Material			
	P1 Group 1	**P4 Group 1**	**P5A Group 1**	**P8**
P1 Group 1 P1 Group 2	E 7018	E 7018	E 7018	E 309
P3	E 7018-A1	E 7018-A1	E 7018-A1	E 309
P4 Group 1	E 8018-B2	E 8018-B2	E 8018-B2	E 309
P5A Group 1	E 9018-B3	E 9018-B3	E 9018-B3	E 309
P8 including SA 213 UNS S30432		E 309	E 309	E 347
P15E Gr.1 (Gr. 91/92)			E9018-B3	ENiCrFe-3
SA213T23			E9018-B3	ENiCrFe-3

Table- A3.5
SELECTION OF ELECTRODES, PREHEAT, PWHT
FOR ATTACHMENT TO ATTACHMENT WELDS
(Seal Bands, High Crown Bars, End Bars, End Bar Lifting Lugs and Collector Plates etc.)

Material (Note 2)	Welding Requirements	P1	P3	P4	P5 A	P8 Group 1	P8 Group 2	P15E/1
P1	Electrode Preheat PWHT	E7018 Nil Nil	-	E 7018 150°C 650 – 670°C	-	-	-	-
P3	Electrode Preheat PWHT	E7018 150°C (Note 1) For Thickness>16mm: 620-650°C	E7018-A1 150°C For Thickness>16mm: 620-650°C	-	-	-	-	-
P4	Electrode Preheat PWHT	E7018 150°C (Note 1) For Thickness>13mm: 650-670°C	E7018-A1 150°C For Thickness>13mm: 650-670°	E8018-B2 150°C (Note 1) For Thickness>13mm: 650-670°C	-	-	-	-
P5 A	Electrode Preheat PWHT	-	-	E8018-B2 150°C (Note 1) For Thickness>13: 680-710°C	E9018-B3 150°C (Note 1) For Thickness>13:680-710°C	-	-	-
P8	Electrode Preheat PWHT	E309 Nil Nil	-	E309 Nil Nil	E309 Nil Nil	E347 Nil Nil	E309 Nil Nil	-
P 15E/ 1	Electrode Preheat PWHT	-	-	-	E9018-B3 220°C 730-760 °C	ENi Cr Fe3 220°C (only on P15E side) 730-760 °C	ENi Cr Fe3 220°C (only on P15E side) 730-760 °C	E9015-B91 220°C 740-770 °C

Note – 1 : Preheat is not required for P3/P4up to 16 mm& for P5 A up to 13 mm, if PWHT is carried out.
Note - 2: For load carrying members, PWHT is required irrespective of thickness.

Table- A3.6
SELECTION OF ELECTRODES FOR WELDING NOZZLE ATTACHMENTS, HAND HOLE PLATE, RG PLUG ETC. TO HEADERS, PIPES

Header, Pipe Material	Attachment Material					
	P1	**P3**	**P4**	**P5 A**	**P15 E/1**	**P8**
P1	E7018-1	E7018-1	E7018-1	-	-	ENiCrFe3
P4	E7018-1	E7018-A1	E8018-B2	E8018-B2	-	-
P5 A	-	-	E8018-B2	E9018-B3	E9018-B3	ENiCrFe3
P15 E/1	-	-	-	E9018-B3	E9015-B91	ENiCrFe3
DIN 14MoV63 or equivalent	-	-	-	E9018-B3	-	ENiCrFe3

Table – A3.7
SELECTION OF ELECTRODES FOR NON-PRESSURE PARTS (INCLUDING STRUCTURES) (NOTE 1)

Material	SMAW Electrodes	SAW Wires	CO_2 Wires
P1 + P1 (IS2062 E250)	For butt welds ≤ 6 mm: E 6013 (only for Ducts) > 6 mm: E 7018 For fillets ≤8 mm : E 6013 >8 mm: E 7018	EL 8 EM 12 K EL 8 EM 12 K	E 71 T - 1
Corten Steel + P1	E 6013 or E 7018	EM 12 K	
Corten Steel + Corten Steel	E 8018 – B2	EB 2	E 81 T 1 – B2
IS2062 E350+E350/ E250	E7018-1	EM 12 K	NA
IS2062 E450+E450	E8018-G	EG	NA
SA 204 Gr.A	E7018-A1	NA	NA

Note 1: E 6013 Electrodes can be used for all non-load carrying welds of all thickness of IS 2062 plates up to 20 mm thickness and 8 mm fillets

TABLE- A3.8
A NUMBERS
CLASSIFICATION OF FERROUS WELD METAL ANALYSIS FOR PROCEDURE QUALIFICATION

A. No.	Types of Weld Deposit	Analysis, % (Note 1)					
		C	Cr	Mo	Ni	Mn	Si
1	Mild steel	0.20	–	–	–	1.60	1.00
2	Carbon-Molybdenum	0.15	0.50	0.40-0.65	–	1.60	1.00
3	Chrome (0.4% to 2%)-Molybdenum	0.15	0.40-2.00	0.40-0.65	–	1.60	1.00
4	Chrome (2% to 6%)-Molybdenum	0.15	2.00-6.00	0.40-1.50	–	1.60	2.00
5	Chrome (6% to 10.5%)-Molybdenum	0.15	6.00-10.50	0.40-1.50	–	1.20	2.00
6	Chrome-Martensitic	0.15	11.00-15.00	0.70	–	2.00	1.00
7	Chrome-Ferritic	0.15	11.00-30.00	1.00	–	1.00	3.00
8	Chromium-Nickel	0.15	14.50-30.00	4.00	7.50-15.00	2.50	1.00
9	Chromium-Nickel	0.30	19.00-30.00	6.00	15.00-37.00	2.50	1.00
10	Nickel to 4%	0.15	–	0.55	0.80-4.00	1.70	1.00
11	Manganese-Molybdenum	0.17	–	0.25-0.75	0.85	1.25-2.25	1.00
12	Nickel-Chrome-Molybdenum	0.15	1.50	0.25-0.80	1.25-2.80	0.75-2.25	1.00

Note 1: Single values shown above are maximum.

Table A3.9
F NUMBERS GROUPING OF ELECTRODES AND WELDING RODS FOR QUALIFICATION

	ASME Specification No.	AWS Classification No.
1	SFA-5.1	EXX20
1	SFA-5.1	EXX22
1	SFA-5.1	EXX24
1	SFA-5.1	EXX27
1	SFA-5.1	EXX28
1	SFA-5.4	EXXX(X)-26
1	SFA-5.5	EXX20-X
1	SFA-5.5	EXX27-X
2	SFA-5.1	EXX12
2	SFA-5.1	EXX13
2	SFA-5.1	EXX14
2	SFA-5.1	EXX19
2	SFA-5.5	E(X)XX13-X
3	SFA-5.1	EXX10
3	SFA-5.1	EXX11
3	SFA-5.5	E(X)XX10-X
3	SFA-5.5	E(X)XX11-X
4	SFA-5.1	EXX15
4	SFA-5.1	EXX16
4	SFA-5.1	EXX18
4	SFA-5.1	EXX18M
4	SFA-5.1	EXX48
4	SFA-5.4 other than austenitic and duplex	EXXX(X)-15
4	SFA-5.4 other than austenitic and duplex	EXXX(X)-16
4	SFA-5.4 other than austenitic and duplex	EXXX(X)-17
4	SFA-5.5	E(X)XX15-X
4	SFA-5.5	E(X)XX16-X
4	SFA-5.5	E(X)XX18-X
4	SFA-5.5	E(X)XX18M
4	SFA-5.5	E(X)XX18M1

Table- A3.9 (Contd...)
F NUMBERS GROUPING OF ELECTRODES AND WELDING RODS FOR QUALIFICATION

F.No.	ASME Specification No.	AWS Classification No.
5	SFA-5.4 austenitic and duplex	EXXX(X)-15
5	SFA-5.4 austenitic and duplex	EXXX(X)-16
5	SFA-5.4 austenitic and duplex	EXXX(X)-17
6	SFA-5.2	All classifications
6	SFA-5.9	All classifications
6	SFA-5.17	All classifications
6	SFA-5.18	All classifications
6	SFA-5.20	All classifications
6	SFA-5.22	All classifications
6	SFA-5.23	All classifications
6	SFA-5.25	All classifications
6	SFA-5.26	All classifications
6	SFA-5.28	All classifications
6	SFA-5.29	All classifications
6	SFA-5.30	INMs-X
6	SFA-5.30	IN5XX
6	SFA-5.30	IN3XX(X)
Aluminium and Aluminium-Base Alloys		
21	SFA-5.3	E1100
21	SFA-5.3	E3003
21	SFA-5.10	ER1100
21	SFA-5.10	R1100
21	SFA-5.10	ER1188
21	SFA-5.10	R1188
22	SFA-5.10	ER5183
22	SFA-5.10	R5183
22	SFA-5.10	ER5356
22	SFA-5.10	R5356
22	SFA-5.10	ER5554
22	SFA-5.10	R5554
22	SFA-5.10	ER5556

TABLE- A3.9 (Contd...)
F NUMBERS GROUPING OF ELECTRODES AND WELDING RODS FOR QUALIFICATION

F.No.	ASME Specification No.	AWS Classification No.
22	SFA-5.10	R5556
22	SFA-5.10	ER5654
22	SFA-5.10	R5654
23	SFA-5.3	E4043
23	SFA-5.10	ER4009
23	SFA-5.10	R4009
23	SFA-5.10	ER4010
23	SFA-5.10	R4010
23	SFA-5.10	R4011
23	SFA-5.10	ER4043
23	SFA-5.10	R4043
23	SFA-5.10	ER4047
23	SFA-5.10	R4047
23	SFA-5.10	ER4145
23	SFA-5.10	R4145
23	SFA-5.10	ER4643
23	SFA-5.10	R4643
24	SFA-5.10	R206.0
24	SFA-5.10	R-C355.0
24	SFA-5.10	R-A356.0
24	SFA-5.10	R357.0
24	SFA-5.10	R-A357.0
25	SFA-5.10	ER2319
25	SFA-5.10	R2319
Copper And Copper Alloys		
31	SFA-5.6	ECu
31	SFA-5.7	ERCu
32	SFA-5.6	ECuSi
32	SFA-5.7	ERCuSi-A

TABLE- A3.9 (Contd...)
F NUMBERS
GROUPING OF ELECTRODES AND WELDING RODS FOR QUALIFICATION

F.No.	ASME Specification No.	AWS Classification No.
33	SFA-5.6	ECuSn-A
33	SFA-5.6	ECuSn-C
33	SFA-5.7	ERCuSn-A
34	SFA-5.6	ECuNi
34	SFA-5.7	ERCuNi
34	SFA-5.30	IN67
35	SFA-5.8	RBCuZn-A
35	SFA-5.8	RBCuZn-B
35	SFA-5.8	RBCuZn-C
35	SFA-5.8	RBCuZn-D
36	SFA-5.6	ECuAl-A2
36	SFA-5.6	ECuAl-B
36	SFA-5.7	ERCuAl-A1
36	SFA-5.7	ERCuAl-A2
36	SFA-5.7	ERCuAl-A3
37	SFA-5.6	ECuNiAl
37	SFA-5.6	ECuMnNiAl
37	SFA-5.7	ERCuNiAl
37	SFA-5.7	ERCuMnNiAl
Nickel And Nickel Alloys		
41	SFA-5.11	ENi-1
41	SFA -5.11	ENiCrFe-3 & ENiCrFe-7A
41	SFA-5.14	ERNi-1
41	SFA-5.14	ERNiCr-3 & ENiCrFe-7A
41	SFA-5.30	IN61
42	SFA-5.11	ENiCu-7
42	SFA-5.14	ERNiCu-7
42	SFA-5.14	ERNiCu-8
42	SFA-5.30-7	IN60

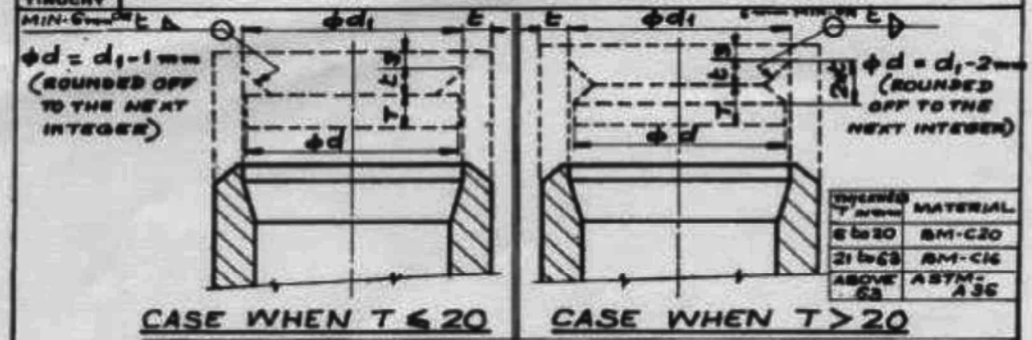
TABLE- A3.9 (Contd...)
F NUMBERSGROUPING OF ELECTRODES AND WELDING RODS FOR QUALIFICATION

F.No.	ASME Specification No.	AWS Classification No.
45	SFA5.11	ENiCrMo-11
45	SFA5.14	ERNiCrMo-1
45	SFA5.14	ERNiCrMo-8
45	SFA5.14	ERNiCrMo-9
45	SFA5.14	ERNiCrMo-11
45	SFA5.14	ERNiFeCr-1
Hard-Facing Weld Metal Overlay		
71	SFA-5.13	E Co Cr – A & All classifications
72	SFA-5.21	ER Co Cr – A & All classifications

SELECTION CHART FOR DUMMY END COVERS FOR HYDRAULIC TEST

TIRUCHY

THICKNESS 'T' = 0·5 $d_1 \sqrt{P/f}$ (ISO - SEC. II 831/1968) f = 1900 kg/cm²
ROUNDED OFF TO THE NEXT NEAREST RATIONALISED PLATE SIZE.



THICKNESS 'T' mm	MATERIAL
6 to 20	BM-C20
21 to 63	BM-C16
ABOVE 63	ASTM-A36

THICKNESS OF DUMMY END COVERS FOR HYDRAULIC TEST (T)

'P' TEST PRESSURE [illegible]	30	45	60	75	90	105	120	135	150	165	180	210	240	270	300	350
15	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
25	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	8
30	5	5	5	5	5	5	5	5	5	6	6	6	8	8	8	8
35	5	5	5	5	5	5	6	6	6	6	8	8	8	8	8	10
40	5	5	5	5	6	6	6	8	8	8	8	8	8	10	10	10
45	5	5	5	6	6	6	8	8	8	8	8	10	10	10	10	12
50	5	5	6	6	8	8	8	8	8	10	10	10	10	12	12	12
55	5	6	6	8	8	8	8	10	10	10	10	10	12	12	12	14
60	5	6	8	8	8	8	10	10	10	10	10	12	12	14	14	14
65	5	6	8	8	8	10	10	10	10	12	12	12	14	14	14	16
70	6	8	8	8	10	10	10	12	12	12	12	14	14	14	16	16
75	6	8	8	10	10	10	12	12	12	12	14	14	16	16	16	20
80	6	8	8	10	10	12	12	12	12	14	14	14	16	16	20	20
85	8	8	10	10	10	12	12	14	14	14	14	16	16	20	20	20
90	8	8	10	10	12	12	14	14	14	14	16	16	20	20	20	20
95	8	10	10	12	12	12	14	14	16	16	16	20	20	20	20	25
100	8	10	10	12	12	14	14	16	16	16	20	20	20	20	25	25
125	10	12	12	14	16	16	20	20	20	20	20	25	25	25	32	32
150	12	14	16	16	20	20	20	25	25	25	25	32	32	32	32	36
175	12	16	20	20	20	25	25	25	32	32	32	32	32	36	36	40
200	14	20	20	25	25	25	32	32	32	32	32	36	40	40	56	56
250	20	20	25	32	32	32	36	36	36	40	40	56	56	76	56	56
300	20	25	32	32	36	36	40	56	56	56	56	56	56	63	63	65
350	25	32	32	36	40	56	56	56	56	56	56	63	63	70	75	80
400	32	32	40	56	56	56	56	56	63	63	63	70	75	80	85	90
450	32	36	56	56	56	56	63	63	65	70	70	80	85	90	95	100
500	36	40	56	56	56	63	65	70	75	75	80	85	90	95	100	110

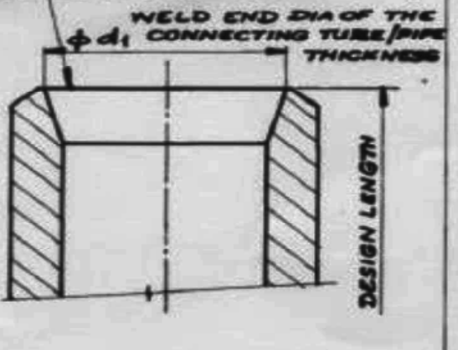
PREPARED BY	CHECKED BY	
[signature]	[signature]	40-B-006-2887

TIRUCHY

NIPPLES - FREE END DETAILS.

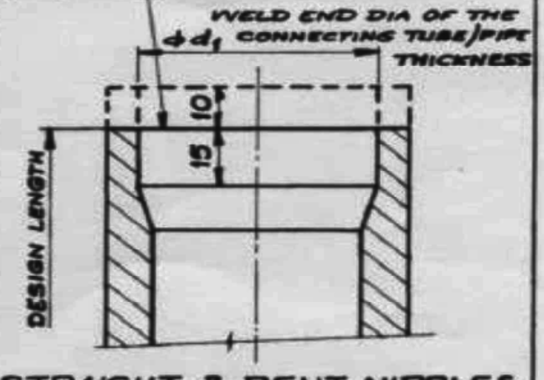
(FOR HEADERS ONLY.)

INDICATE STYLE NO 'D' - d_1
TO BPS NO 710004-74 (LAT. REV.)



STRAIGHT NIPPLES WHICH DO NOT REQUIRE ANY ALLO-WANCE. (NO SHOP HYD. TEST.)

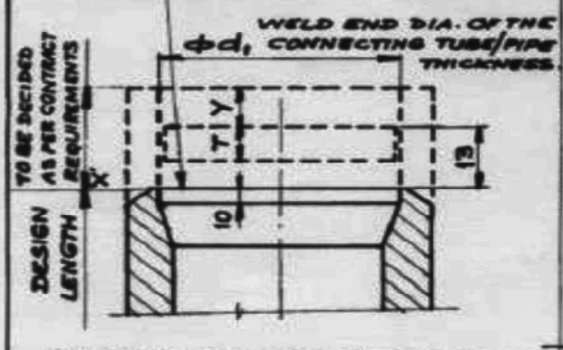
INDICATE STYLE NO 'C' - d_1
TO BPS NO 710004-74 (LAT. REV.)



STRAIGHT & BENT NIPPLES WHICH REQUIRE 10 mm ALLO-WANCE. (NO SHOP HYD. TEST.)

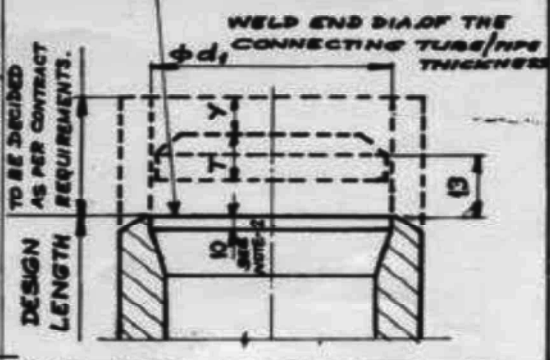
CASE WHEN T ≤ 20

INDICATE STYLE NO 'C' - d_1
TO BPS NO 710004-74 (LAT. REV.)



CASE WHEN T > 20

INDICATE STYLE NO 'C' - d_1
TO BPS NO 710006-74 (LAT. REV.)



STRAIGHT & BENT NIPPLES THAT ARE HYD: TESTED AT SHOPS. (WHETHER THEY REQUIRE ANY ALLOWANCE OR NOT)

NOTE: 1. FOR VALUES OF T & Y FOR DIFFERENT SIZES OF NIPPLES AT VARIOUS TEST PRESSURES REFER DRG: NO 40-B-006-2897.

2. IN CASE THE THICKNESS REQUIRED FOR THE DUMMY END COVER IS MORE THAN 25mm THE INSIDE HEIGHT OF MACHINING (WHICH IS NOW 10mm) WILL BE INCREASED ACCORDINGLY.

MICROFILMED ON
ROLL 20037 FRAME 53

PREPARED BY	CHECKED BY.	
[signature]	[signature]	40-B-006-2899

CHAPTER A4 - PROCEDURE FOR WELDER QUALIFICATION

SECTION A4.1-PROCEDURE FOR WELDER QUALIFICATION FOR NON-IBR APPLICATIONS

1.0 SCOPE:

1.1 This chapter details the procedure for qualification of welder and performance monitoring.

2.0 CONTENTS:

1. Qualification of Welder.
2. Table- A6.1 - Welder Qualification Requirements for non-IBR applications.
3. Figure-A6.1 - Structural Tack Weld Specimen.

   Figure- A6.2 - Break test.

   Figure- A6.3 - Weld Positions.

   Figure- A6.4 - 6G position

   Figure- A6.5 - Flat position

   Figure- A6.6 - Vertical position

   Figure- A6.7 - Horizontal position

   Figure- A6.8 - Overhead position

   Figure- A6.9- Plate Butt Weld Specimen.

   Figure- A6.10- Pipe Butt Weld Specimen.
4. Record of Welder Performance Qualification Tests.
5. Welder performance monitoring.

SECTION A4.2-QUALIFICATION OF WELDER

1.0 BASE METAL:

1.1 For selection refer Tables provided in Chapter II (Base Materials) of this manual.

2.0 TEST COUPON:

2.1 Depending on the range to be qualified, choose the appropriate test coupon from Table – A6.1

2.2 For plate butt welds, details of edge preparation shall be as per Figure-A6.9.

2.3 For pipe butt welds, details of edge preparation shall be as per Figure-A6.10.

2.4 For structural tack welds, refer Figure-A6.1.

3.0 REQUIREMENT OF TESTS:

3.1 For Structural Tack Welders:

3.1.1 Break Test as per Figure-A6.2.

3.2 For Plate and Pipe Butt welders:

3.2.1 100 % Radiographic examination of test welds shall be carried out. Procedure and acceptance criteria shall be as per NDE Manual (BHEL:PS:NDEM – Latest)

4.0 ESSENTIAL VARIABLES :

4.1 Changes to the following variables require requalification.

4.1.1 **Process:** Example: Change from GTAW to SMAW or vice versa.

4.1.2 **Joint:** A change from one type of bevel to another. Example: 'V' bevel to 'U' bevel.

4.1.3 **Base Metal :**A change in thickness or pipe diameter beyond the limits as prescribed in Table- A6.1

4.1.4 **Filler Metal:**A change from one F number to another F-number, except as specified in Table-A6.1.

4.1.5 **Positions:**This procedure envisages qualification of welders to perform in all positions. Deviation to this is not recommended.

4.1.6 **Gas:**This procedure envisages test to pre-prescribed gas as for production welds. Deviation to this is not recommended.

4.1.7 **Electrical Characteristics:**

a) AC to DC and vice versa.

b) In DC, DCEN (Electrode Negative) to DCEP (Electrode Positive) and vice versa.

4.1.8 **Technique:** This procedure envisages only use of uphill progression technique.

Acceptance Criteria:

Structural Tack Welding:

- No cracks.
- No lack of fusion.
- Undercut not exceeding 1 mm.
- Not more than 1 porosity (max. diameter of porosity 2 mm).

Plate/Pipe Welding:

Visual Inspection:

a) No cracks.

b) No lack of fusion or incomplete penetration.

c) Not more than 1 porosity in a length of 100 mm of length of weld (max. porosity diameter 2mm).

5.0 VALIDITY:

5.1 When a welder meets the requirements of this procedure, the validity will be for a maximum of 2 years from the date of test, limited to validity specified by statutory authority, as applicable.The validity may be extended by one year each time, based on satisfactory performance, with sufficient back up records.

6.0 REQUALIFICATION :

6.1 Requalification is required for the following :

a) Where there is a specific reason to doubt the skill of the welder.

b) Due to non-engagement of the welder for a continuous period of 6 months.

7.0 RECORDS:

The welding in charge at site shall maintain the following records:

a) Record of Welder Performance qualification Test (as per Annexure V).

b) Register of qualified welders (employer-wise) containing the following details:

1) Name of welder.
2) Age.
3) Tested for pipe / tube / plate / tack.
4) Performance Test No.
5) Validity.
6) Welder Code.
7) Remarks.

The above register shall be updated for deletions also.Copies of welder identity card (including details as in 7 b and relevant variables qualified) and pertinent radiography reports.

8.0 ENCLOSURES :

1. Table –A6.1: Welder Qualification Requirements.
2. Record of Welder Performance Qualification Test.
3. Figure-A6.1: Structural Tack Weld Specimen.
4. Figure-A6.2: Break Test.
5. Figure-A6.3:Weld Positions.
6. Figure- A6.4 - 6G position
7. Figure- A6.5 - Flat position
8. Figure- A6.6 - Vertical position
9. Figure- A6.7 - Horizontal position
10. Figure- A6.8 - Overhead position
11. Figure-A6.9: Plate Butt Weld Specimen.
12. Figure-A6.10: Pipe Butt Weld Specimen

ANNEXURE - V: RECORD OF WELDER PERFORMANCE QUALIFICATION TEST

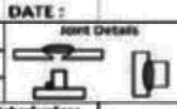
WELDER/TACK WELDER QUALIFICATION TEST RECORD -NON IBR					
Site :			Test Record No. :		Affix welder photo
Contractor Name :			DATE :		
NAME Sri.			Joint Details 		
ID NO :					
WPS No. :		Rev :			
Variables			**Recorded Actual values used in Qualification**		**Qualification Range**
Process / Type					
Electrode (Single or Multiple)					
Current / Polarity					
Position					
Weld Progression					
Backing					
Material / Specification			to		
Thickness : (Plate)					
Groove					
Fillet					
Thickness : (Pipe / Tube)					
Groove					
Fillet					
Diameter : (Pipe)					
Groove					
Fillet					
Filler Rod / Electrode					
SFA No					
AWS Class					
F.No					
Gas / Flux Type :					
Pre-heat temp :		Inter-pass Temp :		Post-heat Temp :	
VISUAL INSPECTION					
ACCEPTABLE :	YES	or	NO	DATE :	
Guided Bend Test Results					
Type	Result	Type	Result		
Fillet Test Results					
Apperance				Fillet Size	
Fracture Test Root Penetration				Macroetch	
Inspected by			Test Number		
Organization			Date		
RADIOGRAPHIC TEST RESULTS					
Report No/Date	Result	Report No/Date	Result		
Reviewed by			Reviewer Level :		
NDT Company Name :			Date		
We certify that the statement in this record is correct and that the test weld were prepared, welded and tested in accordance with requirements.					
This is valid upto					
Contractor :		Signature :		Date :	
BHEL :		Signature :		Date :	
Customer :		Signature :		Date :	

TABLE – A6.1
WELDER QUALIFICATION REQUIREMENTS (FOR NON-IBR APPLICATIONS)

Sl. No.	Test For	Base[6] Metal Note 1	Test Coupon Dimension OD, t	Electrode[6] to be used Note 2, 4	Weld Positions	Reference Figure	Range Qualified Dia. & T	Position Qualified	Electrode Qualified Note 2, 4
1	Structural tack	P1 Gr 1	t=10mm or 12mm	(E6013) F2	3F&4F	Fig. A6.1 A6.2 & A6.3	T-Unlimited	All	F2, F1
				(E7018) F4	3F&4F		T-Unlimited	All	F4 & Below
2	Plate Welder (Structural)	- do -	t≥25mm	F4	3G & 4G	Fig.A6.7 & A6.8	T≥3.0 mm*	All	F4 & Below
			t<25mm	F4	3G & 4G		T>3.0 mm*≤2t	All	F4 & Below
3	Plate Welder (Other than structural)	- do -	t≥13mm	F4	2G, 3G & 4G	Fig.A6.6 , A6.7 & A6.8	T-Unlimited OD≥600mm	All	F4 & Below
			t<13mm	F4	2G, 3G & 4G		T≤2t OD≥600mm	All	F4 & Below
4	Pipe/Tube Welder	- do -	OD<25mm	F4	6G	Fig.A6.4	Test piece Dia.& above	All	F4 & Below
			OD≥25mm &≤73mm	F4	6G		25mm & above	All	F4 & Below
			OD>73mm	F4	6G		73mm & above	All	F4 & Below
			t<13mm	F4	6G		T≤2t	All	F4 & Below
			t≥13mm	F4	6G		T-Unlimited	All	F4 & Below

* Also qualifies for welding fillet welds on material of unlimited thickness.

TABLE – A6.1 (contd...)

NOTES:

1. For P grouping refer Chapter II.
2. For F grouping refer Chapter III.
3. Base material limitation:
   a. Where test coupons belong to P1 thro' P15E, welder is qualified for base materials P1 thro' P15E.(ASME Sec IX QW 423, Alternate base material for welder qualification)

      It means, if a welder is qualified with carbon steel material, he is also qualified for alloy steel and vice versa.
   b. Use appropriate F group electrodes.
4. Qualification in one F number, qualifies for that F-number only, except as stated below in A, B, C & D.
   A. Qualification in F4 qualifies for F4 and below.
   B. Qualification in F5 qualifies for F5 only.
   C. Qualification in any of F41 thro' F45 qualifies for F41 thro' F45.
   D. For non-ferrous materials, the base materials shall be typical of production material and appropriate filler materials shall be selected. Qualification is limited to the base material, process and filler F group. Diameter and thickness limitations apply as per Table –A6.1

   OD = outer diameter, t = thickness of test coupon; T = thickness qualified.
5. Where qualification is for GTAW followed by SMAW, the welder is also qualified up-to 6 mm thickness by GTAW process.
6. Base material indicated is carbon steel; for other base materials, corresponding electrodes are to be chosen. Also for GTAW process, the corresponding filler wire should be chosen.

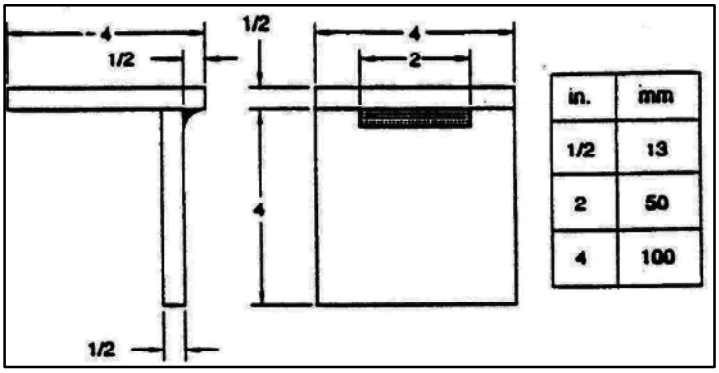


Figure A6.1 – Structural Tack Weld Specimen

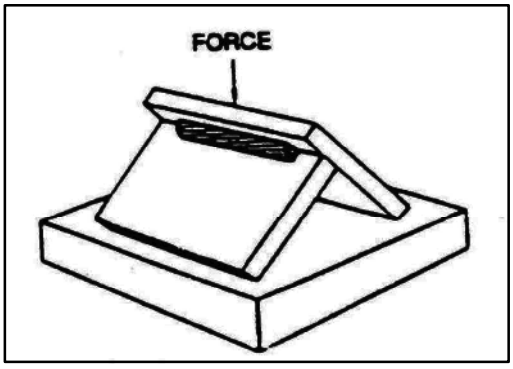


Figure A6.2 – Break Test

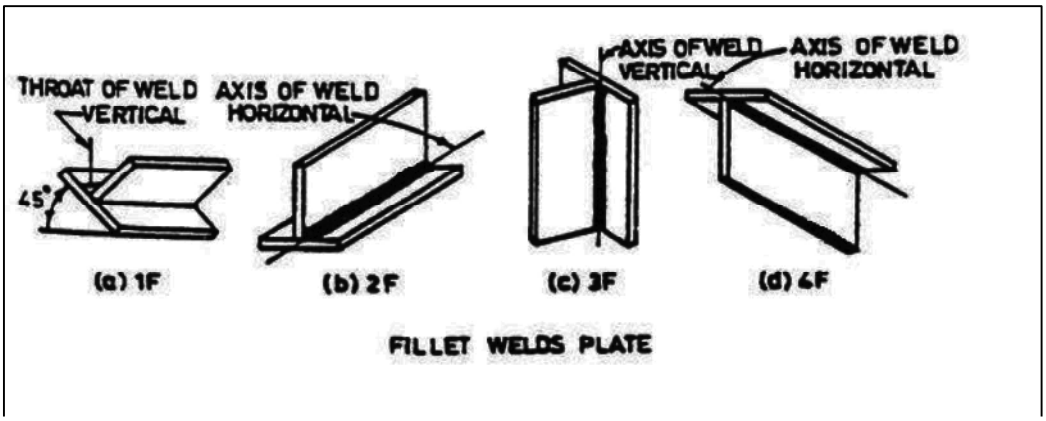


Figure A6.3 - WeldPositions

SECTION A4.3-PROCEDURE FOR WELDER QUALIFICATION FOR IBR APPLICATIONS

1.0 SCOPE

1.1 These requirements shall apply to testing of welders/welding operators engaged in the manufacture and welding connected with sitefabrication, erection and repair of boilers and piping of ferrous material under the purview of IBR.

2.0 DEFINITION

Welder: one who performs manual or semiautomatic welding.

3.0 ENGAGING OF CERTIFIED WELDERS

All welders engaged on welding of boilers or piping under fabrication, erection and repair at site shall possess a valid certificate as required byIBR, as per Form XIII issued by the Competent Authority under IBR.

4.0 QUALIFICATION TEST AND ISSUE OF CERTIFICATE

Every welder shall be duly tested and qualified at site to the satisfaction of BHEL/Customer.Every welded test piece for the examination of welders/welding operator shall be stamped by BHEL with an identification mark on either side of the weld. After satisfactory completion of the tests, BHEL shall issue a Certificate/ID Card to each Qualified Welder as per the Format given in Figure no.A6.9.

4.1 Each welder shall havebasic knowledge on the following:

i. Weld edge preparation
ii. Working of welding equipment.
iii. Properties of material to be welded – cold and hot working, thermal conductivity, fusion point, oxidation (for welders engaged in alloy steel welding).
iv. Electro-technical principles viz. kinds of current, striking arc voltage, welding arc voltage, etc.
v. Weld defects, their causes and prevention.
vi. Electrodes for different types of materials, welds and joints in different positions.

4.2 **MATERIAL FOR TESTS** – The material of plates, tubes, pipes and electrodes used for these tests shall conform to the requirements given below:

4.2.1 TEST WELDS FOR QUALIFICATION

(a) PLATE WELDING –

i. One weld joint of two pieces of boiler quality plates with double 'V' ordouble 'U' grooves over a minimum length of 300 mm shall be made in the following positions (size of plates to be welded being not less than 229 mm x 381 mm x 16 mm each):

(1) Flat position (figure A6.5) - Plate in a horizontal plane with the weld metal deposited from above.

(2) Horizontal Position (figure A6.6) – Plate in a vertical plane with the axis of the weld horizontal.

(3) Vertical Position (figure A6.7)- Plate in a vertical plane with the axis of the weld vertical

(4) Overhead Position (figure A6.8) – Plate in a horizontal plane with the weld metal deposited from underneath.

Qualification in Horizontal position shall automatically qualify Flat position. Qualification in Vertical position shall automatically qualify Flat and Horizontal positions. Also, qualification in Overhead position shall automatically qualify Flat, Horizontal and Vertical positions.

(b) For Pipe Welding –6G-Position:

Tube/Pipe with its axis inclined at 45 Deg. to horizontal. Welding shall be done without rotating the Tube/ pipe. Refer FigureA6.4.

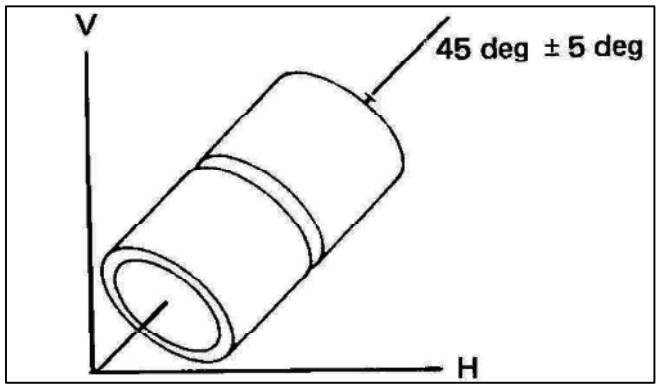


Figure A6.46G-Position

5.0 VALIDITY OF CERTIFICATE

a) Certificate issued to a welder shall remain valid for a period of twenty-four months from the date of issue, provided that the welder has, subsequent to the test, been continuously (gap not more than six months) employed on the class and type of work for which he is qualified.

b) The certificate may be extended, after the validity period, for another twenty-four months after conducting the re-qualification tests in-line with the initial Qualification tests.

c) In case of unsatisfactory performance of the Certified Welder as observed by the site engineer, the welder shall be re-qualified as per the requirements prior to engaging in subsequent welding works.

d) A welder qualified for a type and process of higher grade of steel can be allowed to weld the lower grade of steel.

e) A welder qualified on groove weld shall automatically qualify for fillet and socket welds.

6.0 EXAMINATION OF TEST SPECIMENS FOR QUALIFICATION TESTS

(a) The test specimens shall be visually examined as per Cl 6.0 of Chapter A7 of this Manual.

(b) After visual examination, the test specimen shall be subjected to radiographic examination as per the requirements specified in NDE Manual (BHEL:PS:NDEM-Latest).

7.0 MAINTENANCE OF RECORDS

Records of Qualified welders shall be maintained by the site engineer till the closure of the project. At the time of project closure, these records shall be handed over to the customer, if required by the Contract.

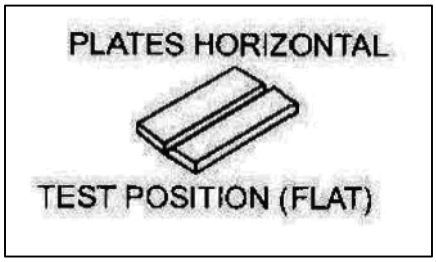


Figure A6.5Flat position

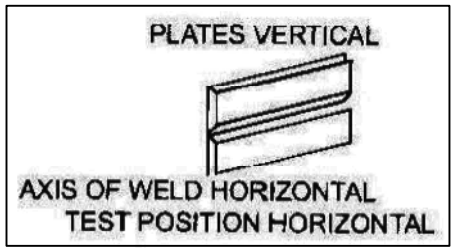


Figure A6.6Horizontal Position

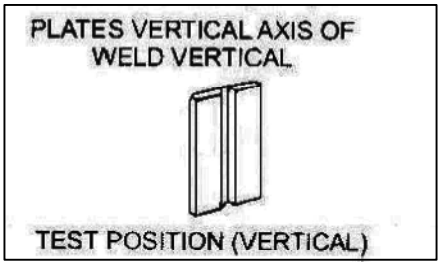


Figure A6.7Vertical Position

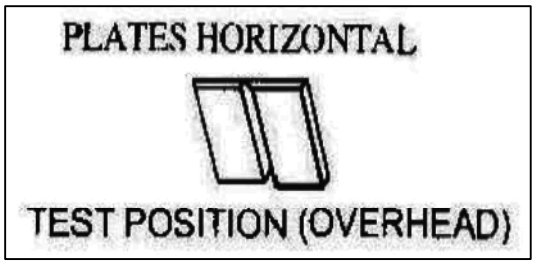


Figure A6.8Overhead Position

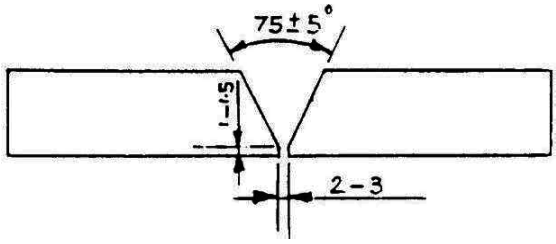
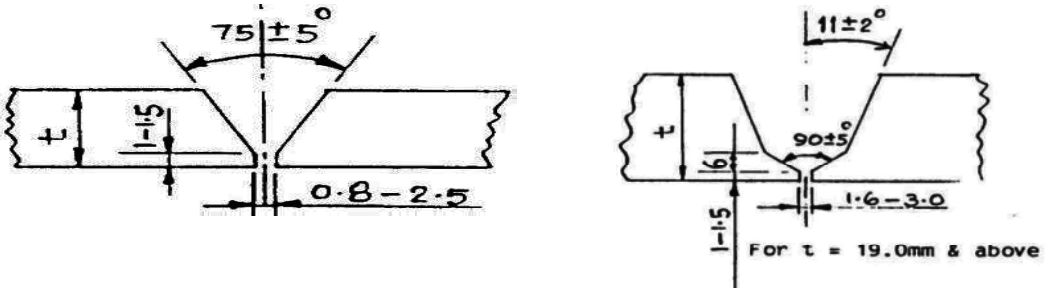
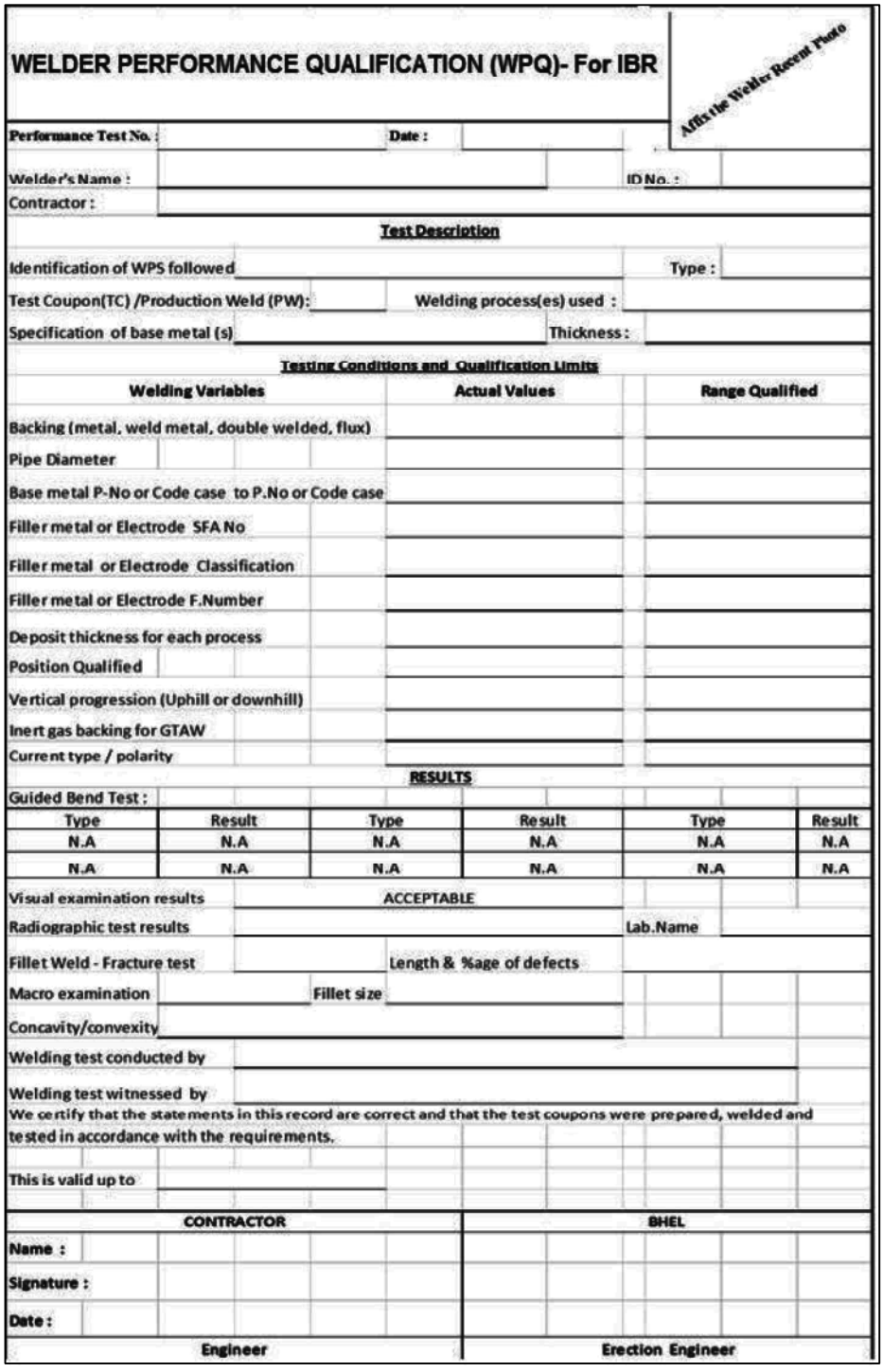


Figure A6.9- Plate butt weld specimen



(A) for T upto 19 mm (B) For T = 19.0mm &Above

Figure – A6.10 – Pipe Butt Weld Specimen



WELDER PERFORMANCE QUALIFICATION (WPQ)- For IBR

Affix the Welder Recent Photo

Performance Test No. : Date :

Welder's Name : ID No. :

Contractor :

Test Description

Identification of WPS followed Type :

Test Coupon(TC) /Production Weld (PW): Welding process(es) used :

Specification of base metal (s) Thickness :

Testing Conditions and Qualification Limits

Welding Variables	Actual Values	Range Qualified
Backing (metal, weld metal, double welded, flux)		
Pipe Diameter		
Base metal P-No or Code case to P.No or Code case		
Filler metal or Electrode SFA No		
Filler metal or Electrode Classification		
Filler metal or Electrode F.Number		
Deposit thickness for each process		
Position Qualified		
Vertical progression (Uphill or downhill)		
Inert gas backing for GTAW		
Current type / polarity		

RESULTS

Guided Bend Test :

Type	Result	Type	Result	Type	Result
N.A	N.A	N.A	N.A	N.A	N.A
N.A	N.A	N.A	N.A	N.A	N.A

Visual examination results ACCEPTABLE

Radiographic test results Lab.Name

Fillet Weld - Fracture test Length & %age of defects

Macro examination Fillet size

Concavity/convexity

Welding test conducted by

Welding test witnessed by

We certify that the statements in this record are correct and that the test coupons were prepared, welded and tested in accordance with the requirements.

This is valid up to

CONTRACTOR	BHEL
Name :	
Signature :	
Date :	
Engineer	Erection Engineer

Figure A6.11: BHEL issued Welder Qualification Certificate

SECTION A4.4-WELDER PERFORMANCE MONITORING

1.0 PURPOSE:

1.1 This procedure deals with monitoring the performance of welders engaged at sites. This procedure is applicable where radiography is performed.

2.0 PROCEDURE:

2.1 The welder performance shall be monitored on a calendar month basis.

2.2 Extent of radiography shall be representative of weekly outputs of the welder.

2.3 Quantum of radiography shall be as per contractual requirements.

2.4 Evaluation of welds radiographed shall be as per NDE manual or other documents as specifically applicable.

2.5 **Welder performance evaluation:**

2.5.1 **For welds having diameter≤ 88.9 mm:**

2.5.1.1 The percentage of defects shall be calculated as a percentage of number of unaccepted welds to those radiographed.

2.5.1.2 Upto and including 5% defects: Performance is satisfactory else unsatisfactory.

2.5.2 **For welds having diameter>88.9 mm and plate welds:**

2.5.2.1 The percentage of defects shall be calculated as a percentage of length of defects to the length radiographed.

2.5.2.2 Upto and including 2.5% defects: performance is satisfactory else unsatisfactory.

2.6 When a welder gives unsatisfactory performance for a continuous period of 3 months, he shall be re-qualified.

2.6..1 Requalification of welder shall be called for when there is a specific reason to question his ability to make acceptable welds. This shall override requirements of clause 2.6.

2.7 Welds produced during any month shall be radiographed and evaluated latest by 10th of the succeeding month.

2.7..1 Under circumstances when clause 2.7 is not satisfied for any particular welder, he may be disengaged from the job till such time his performance is evaluated for the month in study.

2.7..2 Site in-charge may waive the restriction imposed in 2.7.1reviewing the situations for non-compliance with Cl.2.7 and may allow engagement of the welder in question for a period not exceeding one successive month to the month in study.

3.0 RECORDS:

3.1 Welding in-charge shall prepare and maintain Welder Performance Records, welder-wise as per the Annexure VI.

ANNEXURE VI: WELDERS PERFORMANCE MONITORING RECORD

WELDERS PERFORMANCE MONITORING RECORD - MONTH/YEAR :						
	Dia ≤ 88.9 mm (Note -1)			Dia > 88.9mm (Note-2)		
Welder Code	No of joints RT taken	No of defective joints	%age of defects	Length Radiographed	Length of defects	%age of defects

Note : 1. Upto and including 5% defects., performance is satisfactory else unsatisfactory.
2. Upto and including 2.5% defects, peformance is satisfactory else unsatisfactory.

CHAPTER – A5
INSPECTION OF WELDING

1.0 SCOPE:

1.1 This procedure provides details for performing visual inspection of weld fit-ups, welding in progress and completed welds.

2.0 REFERENCE:

2.1 Contract drawings.

2.2 Field Welding Schedule (supplied by Units) or equivalent.

2.3 Welding Procedure Specification, where supplied.

2.4 Indian Boiler Regulations (for boilers erected in India)

3.0 GENERAL REQUIREMENTS:

3.1 Ensure that the components to be welded are in accordance with the contract drawings, Welding Schedule and other relevant documents.

3.2 The condition of welded surfaces to be inspected shall be clean and dry.

3.3 There shall be sufficient lighting to allow proper interpretation of visual inspection.

4.0 WELD FIT-UP INSPECTION:

4.1 The surface to be welded shall be smooth and free from deep notches, irregularities, scale, rust, oil, grease and other foreign materials.

4.2 Positive Material Identification (PMI) shall be carried out for all alloy steel and stainless steel materials for the parent metal before fit-up and for weld after welding.However, in case of tubes random PMI check shall be done on the parent metal and on 10% of the welds made by each welder per day. The procedure recommended by the PMI equipment manufacturer shall be followed for testing.

4.3 Piping, tubing and headers to be joined shall be aligned within allowable tolerances on diameters, wall thicknesses and out-of-roundness as below:

Maximum permissible misalignment at bore

Bore (mm)	Max. Misalignment (mm)	
	For GTAW	For SMAW
Up to 100	1.0	1.0
Over 100 to 300	1.6	1.6
Over 300	1.6	2.4

4.4 While fit up, components to be welded shall not show any appreciable off-set or misalignment when viewed from positions apart.

4.5 The root opening of components to be joined shall be adequate to provide acceptable penetration.

4.6 On fillet welds, the parts to be joined shall be brought as close to contact as practical, although in most instances a small opening between the parts is desirable.

4.7 Weld area shall be protected from drafts and wind, to maintain inert gas shield.

5.0 CHECKS DURING WELDING OPERATION:

5.1 Ensure the required minimum preheat temperature is maintained during welding. Preheating shall be done using resistance heating or induction heating or LPG burners. Preheating by cutting/ heating torches is not permitted.

5.2 Ensure correct electrode / filler metal is used for welding.

5.3 Tack welds shall be examined by the welder before they are incorporated in the final weld.

5.4 Ensure proper drying / holding of electrodes prior to use.

5.5 Ensure inter pass temperature mentioned in WPS is not exceeded during welding.

5.6 Ensure proper cleaning of weld between beads.

6.0 CHECKS ON THE COMPLETED WELD:

6.1 There shall be no visible cracks, pin-holes or incomplete fusion.

6.2 The weld surface must be sufficiently free of coarse ripples, grooves, overlaps, abrupt ridges and valleys, visible slag inclusions, porosity and adjacent starts and stops.

6.3 Undercuts shall not exceed 0.8 mm (0.4 mm for tubes) or 10% of wall thickness whichever is less.

6.4 Where inside surface is readily accessible, the same shall be inspected for excess penetration and root concavity. The permissible limits are given below:

- Root concavity: max of 2.5 mm or 20% of thickness at weld, whichever is lesser, provided adequate reinforcement is present.
- Excess penetration: up to and including 3.2 mm.

6.5 For plate butt welds, the weld reinforcement shall not exceed 3.2 mm.

6.6 For circumferential joints in piping and tubing the maximum weld reinforcements permitted are given below :

Maximum Permissible Reinforcements (ASME Sec I –PW 35)

Thickness of base metal in mm	Reinforcement in mm
Up to 3.0	2.5
Over 3 to 5	3.0
Over 5 to 13	4.0
Over 13 to 25	5.0
Over 25 to 50	6.0
Over 50	Max of 6.0 or 1/8 of weld width

6.7 There shall be no overlaps.The faces of fillet welds are not excessively convex or concave and the weld legs are of proper length.

6.8 In case of weld joints in pressure parts and joints like ceiling girder, the weld joint shall be suitably identified.

CHAPTER – A6
SAFE PRACTICES IN WELDING

(This is included for information purposes only)

1.0 This covers many of the basic elements of safety general to arc welding processes. It includes many, but not all, of the safety aspects related to structural welding. The hazards that may be encountered and the practices that will minimize personal injury and property damage are reviewed here.

2.0 **Electrical Hazards**

2.1 Electric shock can kill. However, it can be avoided. Live electrical parts should not be touched. Read and understand the manufacturer's instructions and recommended safe practices. Faulty installation, improper grounding, and incorrect operation and maintenance of electrical equipment are all sources of danger.

2.2 **All electrical equipment and the work-pieces should be grounded.** A separate connection is required to ground the work-piece. The work lead should not be mistaken for a ground connection.

2.3 To prevent shock, the work area, equipment, and clothing should be kept dry at all times. Dry gloves and rubber soled shoes should be worn. The welder should stand on a dry board or insulated platform.

2.4 Cables and connections should be kept in good condition. Worn, damaged or bare cables should not be used. In case of electric shock, the power should be turned off immediately. If the rescuer must resort to pulling the victim from the live contact, non-conducting materials should be used. A physician should be called and CPR continued until breathing has been restored, or until a physician has arrived.

3.0 Fumes and Gases

3.1 Many welding, cutting, and allied processes produce fumes and gases which may be harmful to one's health. Fumes and solid particles originate from welding consumables, the base metal, and any coating present on the base metal. Gases are produced during the welding process or may be produced by the effects of process radiation on the surrounding environment. Everyone associated with the welding operation should the possible effects of over-exposure to fumes and gases range from irritation of eyes, skin, and respiratory system to more severe complications. Effects may occur immediately or at some later time. Fumes can cause symptoms such as nausea, headaches, dizziness, and metal fumes fever. Sufficient ventilation, exhaust at the arc,

or both, should be used to keep fumes and gases from breathing zones and the general work area.

4.0 Noise

4.1 Excessive noise is a known health hazard. Exposure to excessive noise can cause a loss of hearing. This loss of hearing can be either full or partial, and temporary or permanent. Excessive noise adversely affects hearing capability. In addition, there is evidence that excessive noise affects other bodily functions and behaviour. Personal protective devices such as ear muffs or ear plugs may be employed. Generally, these devices are only accepted when engineering controls are not fully effective.

5.0 Burn Protection

5.1 Molten metal, sparks, slag, and hot work surfaces are produced by welding, cutting and allied process. These can cause burns if precautionary measures are not used.

5.2 Workers should wear protective clothing made of fire resistance material. Pant cuffs or clothing with open pockets or other places on clothing that can catch and retain molten metal or sparks should not be worn. High top shoes or leather leggings and fire resistant gloves should be worn. Pant legs should be worn over the outside of high top boots. Helmets or hand shields that provide protection for the face, neck, and ears, should be worn, as well as head covering to protect. Clothing should be kept free of grease and oil. Combustible materials should not be carried in pockets. If any combustible substance is spilled on clothing it should be replaced with fire resistance clothing before working with open arc or flame.

5.3 Appropriate eye protection should be used at all times. Goggles or equivalent also should be worn to give added eye protection.

Insulated gloves should be worn at all times when in contact with hot items or handling electrical equipment.

6.0 Fire Prevention

6.1 Molten metal, sparks, slag, and hot work surfaces are produced by welding, cutting, and allied processes. These can cause fire or explosion if precautionary measures are not used.

6.2 Explosions have occurred where welding or cutting has been performed in spaces containing flammable gases, vapours, liquid, or dust. All combustible material should be removed from the work area. Where possible, move the work to a location well

away from combustible materials. If neither action is possible, combustibles should be protected with a cover or fire resistant material. All combustible materials should be removed or safely protected within a radius of 35 ft. (11m) around the work area.

6.3 Welding or cutting should not be done in atmospheres containing dangerously reactive or flammable gases, vapours, liquid, or dust. Heat should not be applied to a container that has held an unknown substance or a combustible material whose contents when heated can produce flammable or explosive vapours. Adequate ventilation should be provided in work areas to prevent accumulation of flammable gases, vapours or dusts. Containers should be cleaned and purged before applying heat.

7.0 Radiation

7.1 Welding, cutting and allied operations may produce radiant energy (radiation) harmful to health. Everyone should acquaint themselves with the effects of this radiant energy.

7.2 Radiant energy may be ionizing (such as X-rays) or non-ionizing (such as ultraviolet, visible light, or infrared). Radiation can produce a variety of effects such as skin burns and eye damage, if excessive exposure occurs.

7.3 Some processes such as resistance welding and cold pressure welding ordinarily produce negligible quantities of radiant energy. However, most arc welding and cutting processes (except submerged arc when used properly), laser welding and torch welding, cutting, brazing, or soldering can produce quantities of non-ionizing radiation such that precautionary measures are necessary.

1. Welding arcs should not be viewed except through welding filter plates.
2. Transparent welding curtains are not intended as welding filter plates, but rather, are intended to protect passersby from incidental exposure.
3. Exposed skin should be protected with adequate gloves and clothing as specified.
4. The casual passersby to welding operations should be protected by the use of screens, curtains, or adequate distance from aisles, walkways, etc.
5. Safety glasses with ultraviolet protective side shields have been shown to provide some beneficial protection from ultraviolet radiation produced by welding arcs.

GENERAL GUIDELINES FOR INSULATION WORKS

This booklet is given as a general guideline to this tenderers about insulation works, However instructions given in the drawings & other schedule issued during execution of the work shall be final and binding of the contractor.

Bharat Heavy Electricals Limited
(A Govt. Of India Undertaking)
Power Sector Southern Region
690, Anna Salai , Nandanam,
Chennai – 600 035

GENERAL NOTES ON ERECTION OF INSULATION

1. It is important that the sheet metal covering is done, by a experienced and competent tinsmith.

2. Person, who is doing the actual job, can alter the following said methods of fixing the sheet metal, as and when necessary, only after consulting the BHEL Erection Engineer.

3. Fixing pin of corresponding thickness of insulation shall be welded by **STUD WELDING** process.

4. Circumferential and axial overlapping of outer casing should be 50 mm unless specified otherwise.

5. **FOR HORIZONTAL AND INCLINED DUCT AND PIPE:**

   1) All overlapping in axial direction should be at the bottom of the duct and pipe. Provision of beading and Sealing compound is not required.

   2) For circumferential overlapping of inclined duct and pipe, provision of beading and Sealing compound is not required.

   3) For circumferential overlapping of horizontal pipe and duct, provide beading. Apply Sealing compound if necessary.

5A. **FOR VERTICAL DUCT AND PIPE:**

   1) For overlapping in the axial direction provide beading. Apply Sealing compound if necessary.

   2) For circumferential overlapping provision of beading and Sealing compound is not required.

6. The joints of wool mattresses should be staggered in both circumferential and axial direction. The Wire netting at the joints of Wool mattresses are to be sewn together by G.I. sewing wire dia 0.71 mm.

7. In case more than one layer of Wool mattress is to be applied for pipe insulation the inner layer should be tied by two turns of G.I binding wire dia 1.22 mm at a pitch of 240 mm, and the outer layer should be tied by two turns of G.I. binding wire dia 1.22 mm at a pitch of 160 mm. The ends of the wire should be twisted and pressed in to the insulation.

8. All the overlapping of outer casing should be made such that no rain water enters into the insulation through the joints.

9. Incase of insulation fixing pin welding to tubes, equal circumferential pitch is to be maintained. Use a minimum number of 4 pins, at 90 degree radial spacing.

10. The inner side of the Aluminum / G.I sheet of outer casing should be painted with two coats of anticorrosive Paint (IS:158). Retainer – Type A must be coated with Aluminum paint to avoid bi-metal corrosion or Neoprene strip must be provided between Retainer – Type A and Casing support.

    The above mentioned paints are not in BHEL scope of supply

11. Self tapping screws should be fixed over the circumferential overlapping. The axial joints should be on the Casing supports and outer casing should be fixed to Casing supports with Self tapping screws at a pitch of 150 mm approximately.

12. The outer casing should be wound tightly around the insulation and then fixed with Self tapping screws when there is not any Fixing pin for insulation.

13. Loose wool can be taken from the Wool mattresses wherever required.

14. Clean the surface to be insulated of rust, dust, grease, loose scale, oil, moisture, etc.

15. Care shall be taken that flexible insulation is not unduly compressed.

16. After insulating the equipment with Calcium silicate / Mineral wool mattress, all voids in the joints shall be filled with Moldable insulation / loose mineral wool respectively.

17. Each day application of insulation should be weather proofed overnight by either with the final protective casing or with some temporary weatherproof covering so that it does not get drenched in rain.

18. The indicated thickness of insulation is the minimum requirement which should be provided. Any alteration in the thickness of insulation should be done only after getting the prior approval from the Design Engineer.

19. The layers of Wool mattresses are to be taken as indicated below:

	LAYER IN mm				
THICKNESS IN mm	1st	2nd	3rd	4th	5th
250	50	50	50	50	50
230	50	60	60	60	
210	50	50	50	60	
200	50	50	50	50	
190	40	50	50	50	
180	60	60	60		

160	50	50	60
150	50	50	50
140	40	50	50
120	60	60	
100	50	50	
80	40	40	

20. Where junctions between two or three bodies or different dia, occur and different insulation thickness is specified the greater thickness shall be continued for a length equal to one dia of the smaller body then smoothly tapered to the required smaller thickness over a length equal to two dia of the smaller body. When there is a differential thermal expansion between these bodies, they should be insulated individually.

21. The required fixing components and outer casing sheets have been released under PG_32. The insulation materials have been released under PG-33.

22. **STORAGE INSTRUCTIONS**:

22a) Mineral wool mattress:

These materials should be stored under fully covered sheds. Stocking must be done over planks and must be out of contact with ground. Height of stacking should not exceed 3 Meters.

Once drenched in water these materials loose all the desired properties and become unsuitable for use. Drying the material does not restore the desired properties.

22b) Outer casing sheets:

Outer surfaces are meant for improving the appearances also scratch marks, dents, etc, spoil the appearance.

23. Typical insulation arrangement drawings are indicated below.

1)	Tees	4-00-235-08546
2)	Elbows	4-00-235-08547
3)	Flanges	4-00-235-08548
4)	Expansion joint for pipe	4-00-235-08549
5)	Expansion piece for duct	3-00-235-06258 & 3-00-235-06259
6)	Manhole door for duct	3-00-235-06260

INSULATION OF DRUM END

MATERIAL:

1) FLAT 50 X 6
2) FIXING PIN INSLN DIA – 6
3) RETAINER TYPE – A
4) G.L. BINDING WIRE DIA – 1.22 / 0.914
5) WOOL MATTRESS
6) OUTER CASING
7) SELF TAPPING SCREW – M4 X 13
8) G.L. SEWING WIRE DIA – 0.71 / 0.914

APPLICATION:

Install Flat 50 x 6 circumferential bands to fit snugly around the drum.

Flat 50 x 6 lattice bar 8 numbers should be radially placed over the dished end and contouring the same and it is to be welded over circumferential bands.

Weld the Fixing pins to the lattice bars circumferential bands.

Fix the Wool mattress.

Position the Retainer and tack weld to the Pin.

Tie with Binding wire across the Pins.

Fix the outer casing strips by Self tapping screws.

INSULATION OF PIPES AND BUNCH OF TUBES

MATERIAL:

1) WOOL MATTRESS
2) G.L. SEWING WIRE DIA-0.71 / 0.914
3) G.L. BINDING WIRE DIA – 1.22 / 0.914
4) OUTER CASING
5) SELF TAPPING SCREW – M4 x 13

APPLICATION:

Fix the insulation over the bunch of tubes / pipes.

Tie the insulation with G.I. binding wire circumferentially.

Fix the outer casing sheet with self-tapping screws.

INSULATION OF VERTICAL PIPES
(WELDING OF FIXING PINS NOT PERMITTED ON PIPES)

MATERIALS:

1) FIXING PIN INSLN DIA – 6
2) RETAINER TYPE – A
3) CASING SUPPORT – 850MM
4) OUTER CASING
5) WOOL MATTRESS
6) SELF TAPPING SCREW – M4X13
7) CLAMP
8) SUPPORTING SHEET
9) FLAT 50 x 6
10) PACKING CLOTH – 3 MM TK
11) HEX HD BOLT M8X40
12) HEX NUT M8
13) PNCHD WASHER A9
14) GI BINDING WIRE DIA – 1.22 /0.914
15) GI SEWING WIRE DIA – 0.71 / 0.914
16) SHEET 3.15x30x3000

APPLICATION:

At every three meters provide the Clamps over the pipe with bolt but and washer by using packing cloth in between the pipe and clamp. Fix the sheet 3.15x30x3000 over the pipe and weld to the clamps. Weld the fixing pin over the sheet. Consult the Welding engineer before welding.

Weld the Flat to the Clamps.

Weld the Supporting sheets to the Flats.

Fix the insulation.

Position the Retainer Type – A and tack weld to the Pins.

Tie the insulation to the pipe with GI biding wire circumferentially.

Fix the casing support to the Retainer by using two numbers of Self tapping screws, fixed diagonally for each Retainer.

Fix the outer casing sheet with self tapping screws.

INSULATION OF VALVE

MATERIAL:

1) SM CLAMP FOR DETACHABLE INSULATION TYPE – A (To be used up to 200 mm overall dia)

1)a SM CLAMP FOR DETACHABLE INSULATION TYPE – B (To be used above 200 mm overall dia)

2) WOOL MATTRESS

3) OUTER CASING

4) SELF TAPPING SCRES – M4 x 13

5) G.I SEWING WIRE DIA – 0.71

6) SNAP HD RIVET 3 x 8

7) CHS SCREW M4 x 20

8) HEX NUT M4

APPLICATION:

The sheeting shall be made in two halves and the Sheet metal clamp mounted.

Wool mattress thickness according to adjacent pipe lines shall be pressed in to two halves.

The two halves shall be fitted over the valve to be insulated and locked by Sheet metal clamp.

Self tapping screws shall be used for clamping the two edges of the outer sheet casing when the length of the valve is more.

After assembling the Clamp put a bit of GI Binding wire as a pin through 1.6 mm hole provided.

INSULATION OF DUCT / FLAT SURFACE

MATERIALS:

1) FIXING PIN INSLN DIA – 6
2) WOOL MATTRESS
3) OUTER CASING
4) RETAINER TYPE – A
5) GI BINDING WIRE DA – 1.22 / 0.914
6) CASING SUPPORT – 650 MM
7) SELF TAPPING SCREW M4 x 13
8) GI SEWING WIRE DIA – 0.71 / 0.914

APPLICATION:

Weld the Fixing pin over the Duct / Flat surface.

Fix the insulation.

Position the Retainer Type – A and tack weld to the Fixing pins.

The GI Binding wire dia 1.22 shall be wound across the Fixing pins diagonally underneath the Retainer Type – A.

Fix the Casing support – 650 long to the Retainer Type – A by using two numbers of Self tapping screws, fixed diagonally for.

Retainer Type – A.

Fix the outer casing by using Self tapping screws.

DUCT STIFFENERS

When the stiffeners protrudes through the insulation and are exposed to atmosphere, provide an additional 40 mm insulation over the stiffener.

DUCT DAMPER & GATE

Insulation thickness shall be s per the adjacent duct insulation. The stuffing boxes should not be insulated. A clear gap of 50 mm (minimum) should be maintained all around the stuffing boxes.

AIR HEATERS

DO NOT insulate over the axial seal, adjuster seal access covers and basket removal doors insulation should be applied in a manner to permit a free circulation of ambient air around the bearing.

INSULATION OF DUCT
(CLEARING STIFFENERS)

MATERIALS:

1) FIXING PIN INSLN DIA – 6
2) RETAINER TYPE – A
3) RETAINER TYPE – C
4) CASING SUPPORT – 650 MM
5) GI BINDING WIRE DIA – 1.22/0.914
6) GI SEWING WIRE DIA – 0.71 / 0.914
7) OUTER CASING
8) SELF TAPPING SCREW M4X13
9) WOOL MATTRESS
10) WELD MESH
11) CORNER SUPPORT
12) ANGLE 40X40X5 – 100

APPLICATION:

Weld the Fixing pin over the Duct.

Position the Retainer Type – C so that it will be in the same plane as that of the top surface of the stiffener.

Tack weld the Retainer – Type – C to the Fixing pin.

For the top plate of the horizontal duct, spread the Weld mesh over the Retainer Type – C.

This serves as the additional support where people walk over the insulation.

Weld the Corner support to the bottom corners of the duct.

Weld the Angle to the corner support.

This arrangement will help to achieve a sharp corner for the insulation and outr casing.

Fix the insulation.

Position the Retainer Type – A and tack weld to the Fixing pin.

The Biding wire shall be wound across the pins diagonally underneath the Retainer Type – A.

Fix the Casing support - 650 mm long to the Retainer by using 2 numbers of Self tapping screws, fixed diagonally for each Retainer.

Fix the outer casing by using Self tapping screws.

PROCEDURE FOR CURING OF CASTABLE REFRECTORY

CURING OF REFRACTORY WORK

Curing of refractory means retaining the moisture for a minimum period in order to ensure the proper hydration of the binder. Curing of exposed castable surfaces should start after the surface has become firm. This can be tested when a finger rubbed across the surface comes away clean or when the surface feels warm to the touch. Moisture loss for the first 24 hours, after the material has been installed shall be retarded. Initial set occurs within one or two hours.

Castables should be cured for 24 hours. Moist conditions can be maintained by protection with damp sacking or plastic sheet which should not come into immediate contact with the refractory or alternatively by dry coating the castable with an impervious organic based sealing compound. In some instances, satisfactory results can be obtained by sparkling water over the surface. It should be watered for a period of 20 to 24 hours after 4 to 5 hours of construction. The rate of water applicable should be carefully controlled to prevent washing of the fines and to prevent collection of pools in low spots. Shield the surface from direct sunlight at least for about 48 hours. 8 hours after casting and pouring, remove the wooden frames which have no load bearing function in order to permit watering of the lateral parts of the structures. In case of steel frames apply water without stripping them. On completion of the curing period the application of moisture should be stopped. The exposed castable should be allowed to air dry for 24 hours. Naturally air drying of castable after curing will actually cause slight increase in strength. The castable can be all dried indefinitely without adverse effect. Optimum results cane be obtained with a drying period of 48 hours.

Before lighting the boiler for drying the setting the following shall be attended.

1. All dirt and foreign objects sticking to tube surface are to be removed to ensure a thoroughly clean surface.

2. Expansion joints are to be cleaned and inspected for the proper functioning of expansion during operation.

3. Test sample of castable refractory is to be taken from entry door regions to determine the moisture content in the laboratory.

   Sample of castable are to be taken for the determination of moisture content before and after drying. When the moisture content drops below 0.58 the castable is considered to be dry and the boiler is ready for commissioning. All result of measurement should be duly recorded.

CARE OF THE REFRACTORY WORK

The refractory work is subjected to considerable thermal stresses during boiler operation. Sudden application of heat or cooling introduces severe stresses and endangers the refractory work. Even when the boiler is operated in the recommended regime possibilities of damage occurring to the refractories (due to severed reasons such as bad workmanship, poor quality, slag deposition, corrosive atmosphere etc) must be kept in mind. The following simple rules to be observed.

(i) Avoid sudden cooling of the furnace after a shut down. A cooling rate of 20º to 30º per hour for the refractory lining in the initial period is recommended. This means that FD fans must be stopped after a shut down of the boiler. Ventilation of the furnace by natural draft is permissible only after six hours of shut down. Forced cooling can be started only after 16 hours.

(ii) Avoid quick heating of the furnace. Boiler starting diagram is usually a reliable guide.

(iii) Thoroughly examine the refractory work during shot downs for cracks, chipping off spelling etc. During operation also this can be checked periodically by visual examination through observation holes.

Whenever defects are notice arrange for their quick alimentation, by shutting down the boiler at the earliest depending on the scarceness of the defect.

(iv) Abnormal heating of outside metal sheet covering of the boiler and hot spots are usually a good indication of damaged refractory and insulation in this area. The leakage of flue gas will spoil the property of good mattresses within a short time.

(v) Deep the access door, observation doors, etc. properly shut. They are entry points for cold air and this cold air can damage the refractory work by localized cooling.

(vi) Sufficient quantity of water is to be added to the castable refractory for mixing before application as per supplier's recommendations.

METHOD OF APPLICATION AND CURING OF POURABLE INSULATION

(i) Typical application are for insulating behind buckstays and areas such as roofs having multiplicity of hangers, rods and other penetrations.

(ii) The application of pourable insulation cab be pumping and gunning.

(iii) Density of the pourable insulation installed and cured is around 600 to 650 Kgs/ M

(iv) Pourable insulation is a hydraulic setting insulation additive or air entrainment agents shall not be used.

(v) (a) Empty the entire bag at a time and mi the while material so that segregated particles get mixed.

(b) The pourable insulation should be thoroughly mixed with coal clean water to develop casing and pump consistencies.

© The correct quantity of water shall be placed in the mixer before adding the dry pourable insulation normally about 70 to 100 by weight. However this has to be confirmed from the supplier while purchasing this material.

(d) Mixing time shall not to be less than the minutes or more than five minutes.

(e) Dried out material shall not be remixed.

(f) Pourable insulation once mixed must be in place within half an hour.

(vi) (a) All areas where pourable insulation will be placed must be fee of scale, rust, dust or other loose materials.

(b) All porous forms used such as wood etc shall be oiled before pouring.

© All absorbent surface such as insulation brick, concrete, shall be wet down thoroughly to prevent water absorption.

(d) Waiting of wall insulation used as forms at buckstay levels is not required.

(vii) (a) The surface of pourable insulation once in place will become firm in approximately two hours. The surfaces should be kept damp with an occasional light spray or covering with a cloth that is kept damp for the entire 24 hours curing period.

(b) For mixing and spraying the water should be clean and cold.

© Application of moisture after 24 hours should be stopped forms etc should be removed and the materials allowed to air dry for 24 hours.

(viii) The shuttering scaffolding moulds should be removed after about 36 hours of casing.

APPLICATION OF INSULATION FOR BOILER PIPING, PIPING AND EQUIPMENTS / VESSELS AND ACCESSORIES.

Bonded mattress having standard thickness to 25, 10, 50, 60, 75 mm confirming IS 8103 having a density of 150 kg/cubic meter and light bonded mattress having a density of 150 kg/cubic meter and light bounded mattress having standard thickness of 25. 40, 50, 60, 75 mm conforming to IS 9842 having a density of 144 kg/cubic meter and pipe section in the standard thickness of 25, 40, 50, 60, 75 mm confirming IS 9842 having density of 144 kg/cubic meter will be 100 kg/cubic Mtr.

The application of insulation will be done as per general notes/ drawings enclosed. The application commissioning shall be as per latest editions of IS 7413 code of practice for application and finishing of thermal insulation materials between 40° C to 700° C of Bs 5970 code for practice for thermal insulation of pipe work and equipment (in the temperature range – 100° C to + 870° C).

Inspection before application, during the application and after the application of insulation will be carried out by BHEL Field Quality Engineer as per BHEL Field Quality Plan. Every layer of insulation shall be got approved by BHEL Engineer / FQA Engineer.

Prior to applying insulation the surfaces to be insulated shall be made clean and dry and free from dirt and grease. Where cladding is attached to carbons steel or low alloy steels the steel shall be first prime painted with zinc chromate and then painted with Aluminum paintings. Wherever required to provide aluminum foil as protective covering for bolts and other fittings shall be arranged by contactor. The prints wherever required for preservation coating shall be supplied by contractor.

For insulation of piping with performed pipe sections the came shall be applied over pipe and finally be held in position with 15 mm wide aluminum band at greater than 300 mm spacing for mineral wool insulation.

For insulation of piping with mattresses having backing GI wire netting, the required lengths and shapes are to be cut from the blankets and wrapped on the piping and held in position with proper support by fastening the binding to be done circumferential at not greater than 300 mm spacing.

Performed insulation on vertical or near vertical piping must be supported in position by means of metal ring at interval not greater than 960 mm.

The support attachment may be welded or clamped to the pipe, subject to the approval of BHEL Site Engineer Necessary fabrication of support rings to be done as per site requirement.

Piping bends shall be insulated to the same specification as adjacent straight piping and should form a smooth external surface. Where performed material is used it should be cut loster-back fashion and wired or strapped into position.
Pipe insulation shall be cut to fit nearly around hangers and supports. On horizontal lines which are supported directly on pipe racks the insulation and weather proofing shall be sufficiently cut away at the support to accommodate pipe movement.

Protrusions through insulations which themselves do not required insulations such as pipe clamps supports of small pipings instrument take offs etc shall be covered to the same thickness as the adjacent insulation expect for hanger rods.

At outdoor location the hanger rod protraction shall be shielded with metal flashing to deflect rain and protect the insulation from moisture while permitting the movement of the hanger rod.

Arrangement of securing the metal finish even the insulation shall ensure that direct metal contact between the insulated surface and outer meter cladding is avoided. 4mm thick asbestos board packing shall be used at interface to thermally isolate the metal covering from supporting arrangement. All cladding joints shall be vapours tight and shall be able to accommodate thermal movements. Paste type self setting vapours sealing compound shall be used.

Metal cladding on piping shall be screwed with self tapping screws. These joints should be arranged approximately 30º below horizontal centre line so as to shed water on any horizontal pipe line. The screws shall be flat or round head types of 12mm size and overlapping of 50 mm on both longitudinal and circumferential joints. The screws shall be provided at not greater than 150 mm spacing.

Insulation expansion joints shall be provided in all pipelines to allow movements and expansion of the pipe. The recommended intervals of expansion joints are.

Pipe Temperature	Spacing of Insulation Expansion joints
Below 200°C	5.5 M
201° - 300°C	3.5 M
301°C - 400°C	3.0 M
Above 400°C	2.0 M

All joints in the insulation shall be staggered. For multiple layer of insulation the different layers shall be applied so that the butt joints of one layer do not coincide with those of the other layers. At the joint of each layer of insulation loose insulation shall be packed firmly.

Equipments Insulation Application Procedure

For equipment and shells a matrix of insulation support shall be developed by:-

(a) Welding the insulation support lugs on a frame work prepared with 20 mm x 3 mm size MS Straps where direct welding of lugs to he sheet is not permitted.

(b) Welding the directly on shell after written permission by Site Engineer. The material of the support shall be similar to the material of the shell in this case.

The support shell be pitched at 300 mm for vertical and underside surfaces and 500 mm for oppressed surfaces. A support shall be located above each vessel flange at a sufficient distance above the flange bolts to allow for easy removal. The top and bottoms supports shall be slotted suitably for attachments of straps and wires.

The support lugs shall be 6 mm

Insulation with back up GI wire noting, shall be cut to fit the equipments and shall be wrapped on the equipment and held in position with proper support and tie wires. All joints between course shall be staggered and tightly butter and adjacent edges laced together with lacing wire.

Insulation shall be fastened in place with MS Straps of 20 x 3 mm, on approx., 300 mm centers where contour of equipment permits. Straps shall be tightened with a banding machine and champed with seals.

Insulation on top of horizontal heads shall be cut to fit the curvature of the head and shall be secured in place with the help of radial straps fixed in between circumferential rings. Insulation on bottom heads shall be wired to nuts welded to head. Insulation shall also be strapped to bottoms insulation support. For outdoor equipments insulation shall be arranged to be weather proof.

Metal jacketing shell be applied directly over the met insulation and neatly fitted to place. All gaps shall be arranged so as to shed water. Suitable flashing and weather proofing shell be provided at all nozzles, manholes and other projections to prevent the entrance of water.

VALVES & FLANGES INSULATION APPLICATION

The insulation on all valves and flanged joints shall be enclosed in a removable jacketing so that it may be removed without disturbing the concerned equipment or piping. The thickness of insulation shall be same as that of the pipe line in which these valves and fittings are located.

The layout of wool mattresses to be adopted to obtain the specified insulation thickness are as per be on unless otherwise specified:

Thickness of Insulation (mm)	Layer			
	I	II	III	IV
25	25			
40	40	-	-	-
50	50	-	-	-
60	60	-	-	-
65	40	25	-	-
75	75	-	-	-
80	40	40	-	-
100	50	50	-	-
110	60	50	-	-
125	75	50	-	-
135	75	60	-	-
150	75	75	-	-
155	75	40	40	-
160	75	60	25	-
165	75	50	40	-

The material density of boned mineral wool used for pipe having outside diameter more than 355.6 mm is 150 kg/cubic mater 13 8183.

The material density of bonded mineral wool used for pipe having outside diameter less than or equal to 355.6 mm is 144 kg/cubic meter IS 9842.

Cladding material used is galvanised steel sheet as per IS 277 GRADE 375.

Cladding material gauge for pipe outside diameter less than or equal to 300 mm is 24 SWG.

Cladding material gauge for pipe outside diameter greater than 300 is 22 SWG.

For piping up to including 355.6 mm OD, first layer shall be pipe sections and subsequent layer shall be bonded. Wherever pipe sections are not supplied the first layer has to be wrapped using bonded wool material for piping 355.6 mm OD, bonded mattress shall be used or all the layers.

Description of type of insulation and the method of Application for Boiler Feed Pumps

1. **Type of insulation**

   The pumps should be insulated with 125 mm thick flexible wire backed mineral wool mattress of 150 kg/ density.

2. **Method of Application**

   The above insulation is to be applied to 2.0 mm thick flats aluminum sheeting (18 SWG) and secured by 19 mm vide aluminum retaining dips and 1/8 inch diameter aluminum pop rivets, all to be secured by 2 inch long X No.8 spacing to a 40 mm wide x 3 mm thick angle iron frame work of all welded construction bound by 40 mm PVC tape.

SECTION	TITLE	NO. OF SHEETS
A	METHOD OF APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS AND MATERIAL SPECIFICATIONS (ANNEXURE-1)	4
B	THERMAL INSULATION APPLICATION DRAWINGS	13

SECTION - A

THERMAL INSULATION FOR PIPING AND EQUIPMENTS

1.0 INTRODUCTION

In a thermal power station or process plant, thermal insulation or heat lagging of piping and equipment's carrying hot fluids is essential for hest economy and protection of operating personnel. Any pip which is at a temperature higher than it s surroundings will loose heat and the amount of heat lost will depend upon the temperature of the fluid and the thermal conductivity of the piping material/covering.

The heat lost through bare pipe increases with

a) Increase in the temperature of fluid conveyed
b) Decrease in ambient temperature and
c) Increase in wind velocity of the surroundings.

The heat so lost hast potential for work and rapidly increasing cost of fuel in the recent past has promoted to find all possible means to conserve energy. Providing proper and adequate insulation on to the piping and equipments controls heat transfer and maintains the required services temperature.

2.0 METHOD OF APPLICATION

The method of application is highly skilled job. Badly fitted/laid insulation can lead to greater hear loss, higher cold surface temperature than that estimated and frequent maintenance. Following are the important points to be considered in the application of the insulation.

2.1 Before applying insulation, it should be ensured that all instrument tappings, clamps, lugs and other connections on the surface to be insulate d have been properly installed as per relevant drawings.

2.2 All surfaces to be insulated shall be cleaned of all foreign materials such as dirt, grease, loose scale, moisture etc.

2.3 Welding of lugs, attachments, clips etc. on the surface to be insulated for supporting insulation shall not be carried out without the permission of the authorized person.

2.4 All flanged joints shall be insulated only after final tightening and testing.

2.5 The insulation shall be applied to all surfaces when they are at ambient temperature.

2.6 Where more than one layer of insulation is involved, mattresses should have staggered joints (at 60 deg) and they must be held in close contact with face of

pipes/fittings by means of binding wires / Aluminum bands / seals. Circumferential joints of multilayer insulation should also be staggered by at least 150 mm.
(Refer Drg. No. PE-4-999-169-01).

2.7 For the first layer of insulation and in case of multi layer of insulation, mattresses with hexagonal wire netting will be facing on outer side.

2.8 Insulation mattresses shall be held in place by fastening over with binding wire. Care should be taken to see that the flexible insulation mattresses are not unduly compressed. The ends of binding wire shall be lightly twisted together, bent over and pressed into the insulation. For mattresses, binding wire shall be used at intervals of 300mm.

In the addition Aluminium bands shall also be provided at 300 mm intervals for diameters greater than 500mm. (Refer Drg No. PE-4-99-169-01.)

2.9 Where junctions between bodies of different diameters occur and difference in insulation thickness is specified, the greater thickness is to be continued for a length equal to one diameter of the smaller body and then smoothly tapered to the required smaller thickness over a length equal to two diameters of the small body.

2.10 The indicated thickness of insulation are minimum requirement which should be maintained. Any change in the thickness of the insulation should be done only after prior approval of the design engineer.

2.11 The day-to-day insulation work should be covered with suitable protective materials to prevent the rain water entry, if same is expected.

2.12 The insulation shall be cut to fit the piping O.D / equipment and shall be wrapped on the piping / equipments and held in position with proper support and wires. All the joints should be properly staggered and tightly butted and adjacent edges laced (Refer Drg No. PE-4-999/169/01)

2.13 The insulation of valves and flange joints shall be enclosed in a removable jacketing so that it may be removed without disturbing the concerned equipment or piping. The thickness of insulating shall be same as that of the pip line in which these valves and fittings are located. (Refer Drg No. PE-4-999-169-07.)

2.14 Steam / Air / Gas leakages in and around the pipes to be insulated with be attended before applying insulation.

2.15 In order to provide support to Aluminium cladding, support rings made out of 20 x 3 mm M.S. flats shall be fixed at equal intervals of approximately 850 mm spacing and at every circumferential joints. These rings shall be fixed with 'L'

type lugs and shall be fabricated from 20 x 3 mm M.S flats. To reduce that conductivity through these lugs 20 mm x 3 mm size Ceramic mill board shall be used between rings and lugs (Refer Drg No. PE-4-999-169-04 and PE-4-999-169-13).

2.16 Spacing between supporting rings for vertical piping shall be 3 mtrs. Support rings are to be provided only when the vertical height exceeds 3 mtrs. (Refer Drg No. PE-4-999-169-03-and PE-4-999-169-05).

2.17 For vertical pipes since support rings is provided ate every 3 mtrs interval, only two spacer rings shall be provided in between support rings.

2.18 Spacer rings shall be provided at both ends of elbows/bends, valves and flanges pipe having dia more than 89mm.

2.19 Wherever the end of hanger clamp assembly protrudes out of the insulation at the bottom suitable box structure are to be provided. Pipe hangers and supports should be covered in such a way that the moisture cannot penetrate into the insulation.

2.20 It is very important that sheet metal cladding should be done by a well experienced and competent fabricator. Person doing the job can alter the method of fixing of cladding sheet after consulting the concerned design engineer.

2.21 The longitudinal joint in the outer cladding sheet should always be at the lower half of the circumference for horizontal piping so that no rain water enters the insulation through the joints. (Refer Drg No. PE-4-999-169-01).

2.22 The joints of outer cladding should be staggered axially.

2.23 Inside surface of all Aluminium sheet will have two coats of Bituminous paint applied uniformly.

2.24 Aluminium sheets covering on outdoor horizontal pipes will be provided with 3 mm drain hole at the bottom center line at 6 mtr intervals.

2.25 The cladding sheet shall provides directly over the insulation/finishing cement (1F APPLICABLE). Suitable flashing and weather proofing shall be provided at all nozzles, manholes and other projections to prevent the entrance of water.

2.26 Loose wool can be taken from wool mattresses. Wherever gaps and voids have to be filled.

2.27 Sealing compound to be applied on Aluminum cladding sheet joints.

2.28 Support rings/spacer rings shall be provided if the insulation thickness > 40mm and pipe diameter > 89mm.

2.29 Equipment's name plates shall not be insulated.

2.30 Clips made out of sheet be riveted inside the box for insulation of valves and flanges to hold the insulation in box. (Refer Drg No. PE-4-999-169-06).

2.31 The insulation local to the inspection points of the critical piping shall be removable.

3.00 For Thermal Insulation Material Specification related to the project refer Annexure – 1.

IMPORTANT POINTS TO BE TAKEN CARE DURING APPLICATION

I) Binding wires for all layers of insulation will be at distance of 300mm.

ii) In addition Aluminum bands/seals also to be provided at distance of 300 mm for sizes above 500mm.

iii) Aluminum bands/seals to be provided over aluminum sheets at distance of 500mm.

iv) Ceramic mill boards to be used between all 'L' type lugs and the support rings.

v) Inside surface of Aluminum sheets to have 2 coats of bituminous paint applied uniformly.

vi) Gaps to be properly filled with loose wool taken from mattresses.

vii) End of hanger clamp assembly protruding out of insulation at the bottom should be suitably boxed with Aluminum sheets.

viii) Valves to be insulated properly in box structure as given in enclosed drawings.

ix) Multilayer longitudinal and circumferential joints should be staggered.

ANNEXURE – 1

1.0 **Thermal insulating materials shall be per the details given below:-**

1.1 **Lightly Bonded Mineral (Rock) wool Mattresses** of density 150 Kg / Cub. Mt with S.S. wire netting will be applied for the first layer of insulation where hot face temperature greater than 400 degree centigrade. For subsequent layers matters of density 150 Kg / Cub. Mtr with G.S. wire netting will be applied.

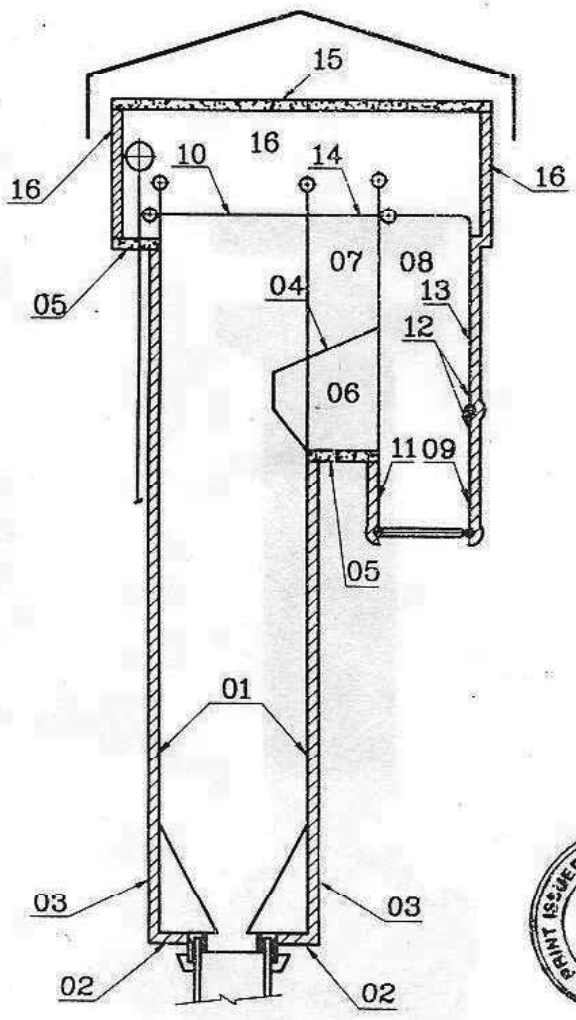
1.2 **Lightly Bonded Mineral (Rock) wool Mattresses** of density 100 Kg/Cub. Mt with G.S. wire netting will be applied for all layers of insulation for host face temperature less than and equal to 400 degree centigrade.

2.0 **Binding and lacing wires:** For insulation matters shall be of stainless steel for all insulation interface temperatures.

3.0 **Aluminum cladding sheet** shall be provided over the Mattresses ad per details given below.

18 SWG (1.22 mm thk.)	For pipes with dia over insulation above 450 MM.
20 SWG (0.91 mm thk.)	For pipes with dia over insulation above 150 MM and less than equal to 450MM.
22 SEG (0.71 mm thk.)	For pipes with dia over insulation less than equal to 150mm.

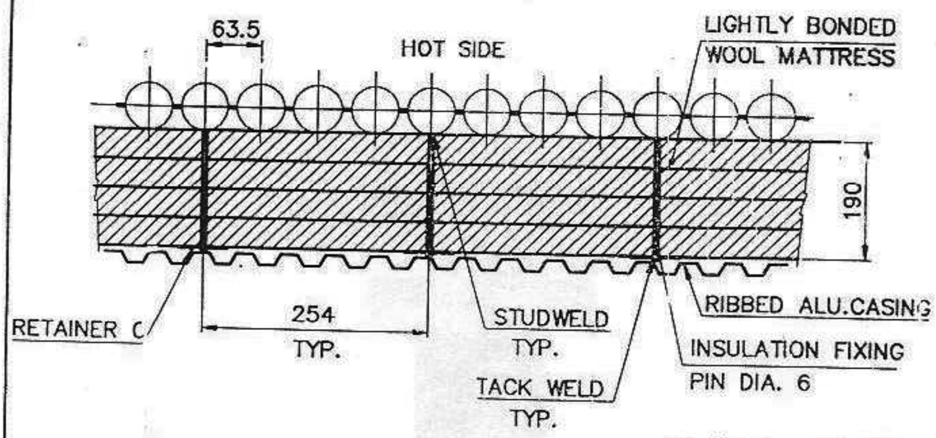
SECTION – B



INSULATION	DRN	C.S		DRG.NO.	REV.NO.
	CHD	C.G.S		4-00-215-08551	00
	APPD	C.G.S			

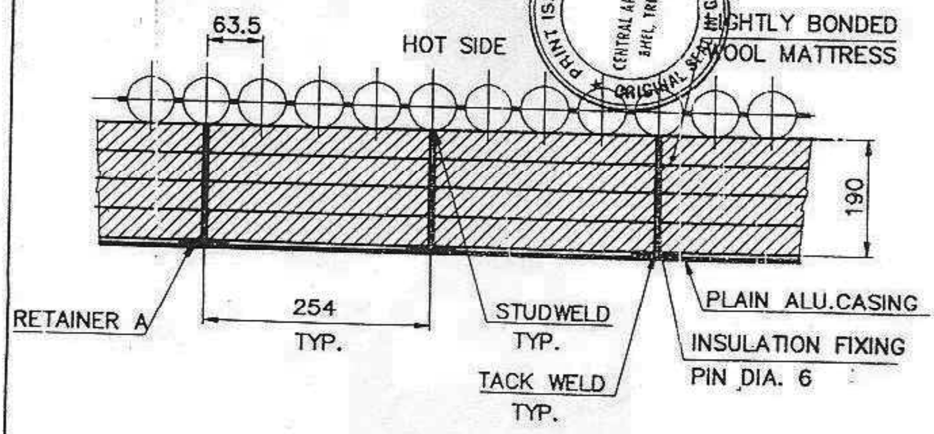
CTS001384-0

DETAIL 01



WT./SQ.M ≃ 32 KGS

DETAIL 02

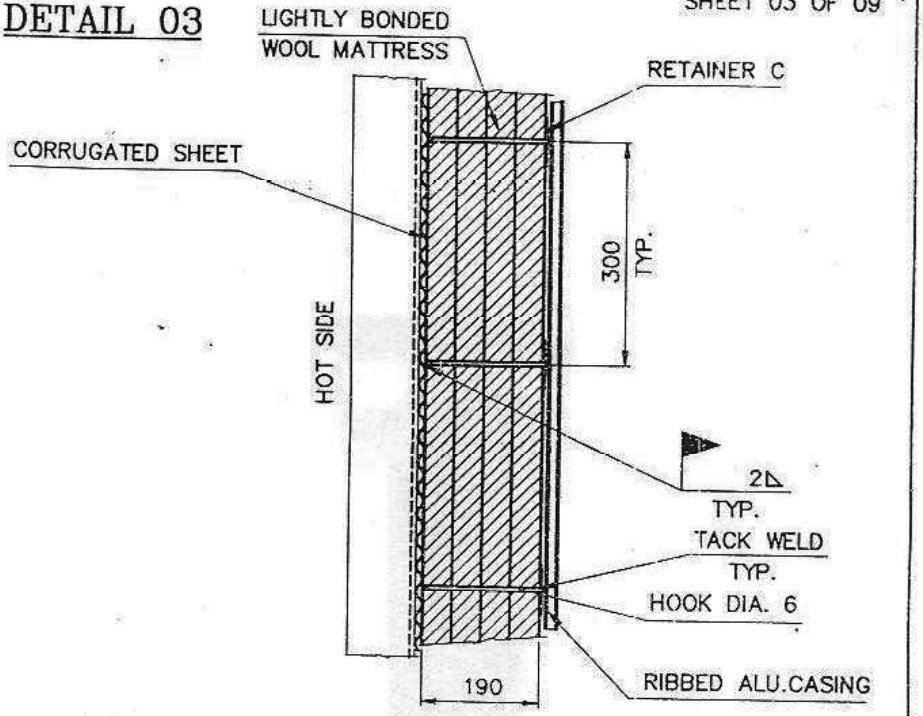


WT./SQ.M. ≃ 29 KGS

INSULATION	DRN	C.S		DRG.NO.	REV.NO.
	CHD	C.G.S		4-00-215-08552	00
	APPD	C.G.S			

CTS001384-0

DETAIL 03



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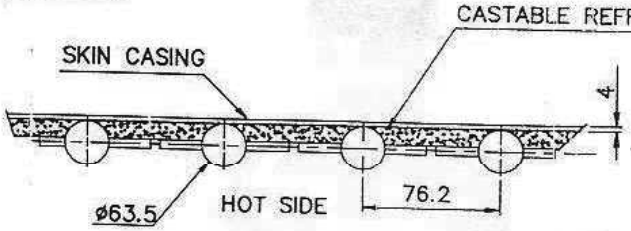
DETAIL 04



WT./SQ.M. ≃ 72 KGS

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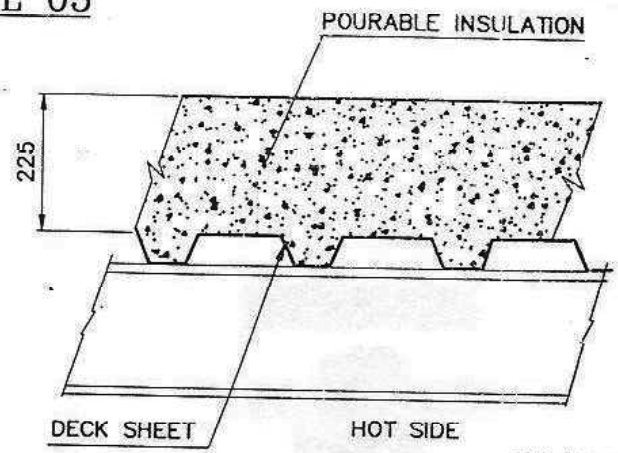
	CHD	C.G.S		4–00–215–08553	00
	APPD	C.G.S			

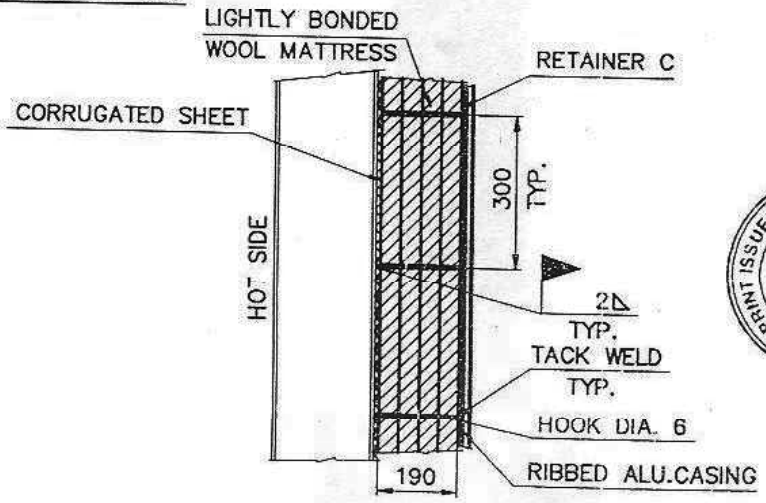
CTS001384-0

DETAIL 05



WT./SQ.M ≃ 193 KGS

DETAIL 06



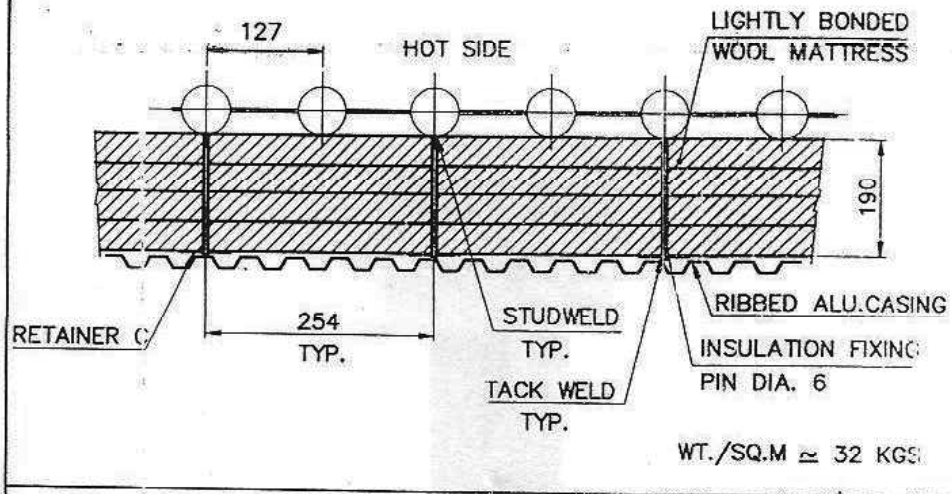
WT./SQ.M ≃ 45 KGS

INSULATION	DRN	C.S		DRG.NO. 4-00-215-08554	REV.NO. 00
	CHD	C.G.S			
	APPD	C.G.S			

CTS001384-0

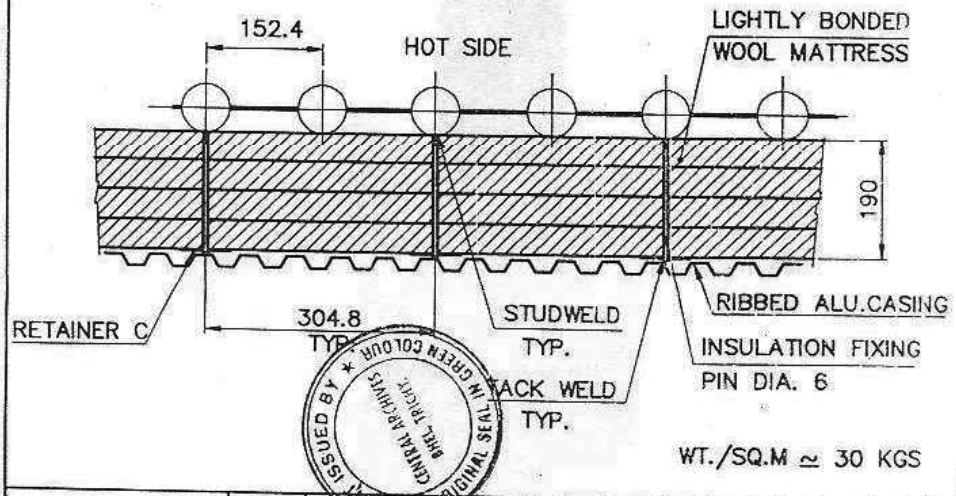
DETAIL 07

SHEET 05 OF 09



WT./SQ.M ≃ 32 KGS

DETAIL 08



WT./SQ.M ≃ 30 KGS

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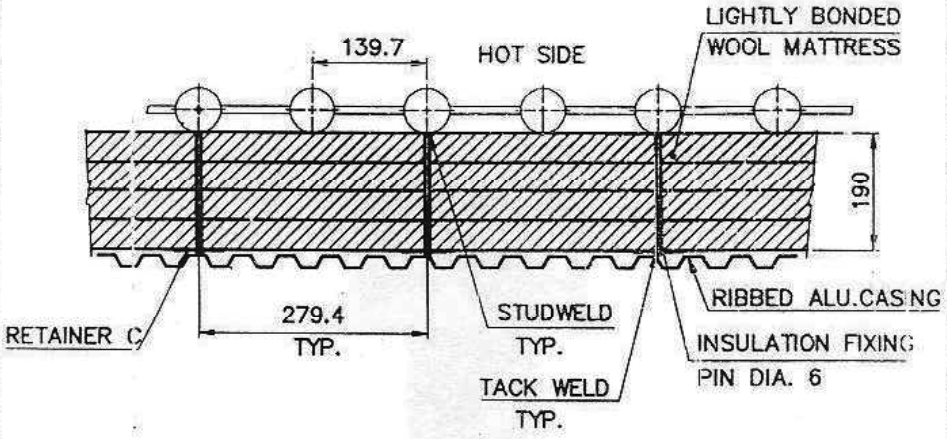
	CHD	C.G.S	4-00-215-08555	00
	APPD	C.G.S		

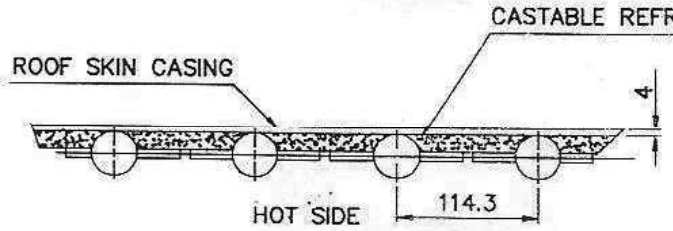
CTS001384-0

DETAIL 09



WT./SQ.M ≃ 30 KGS

DETAIL 10

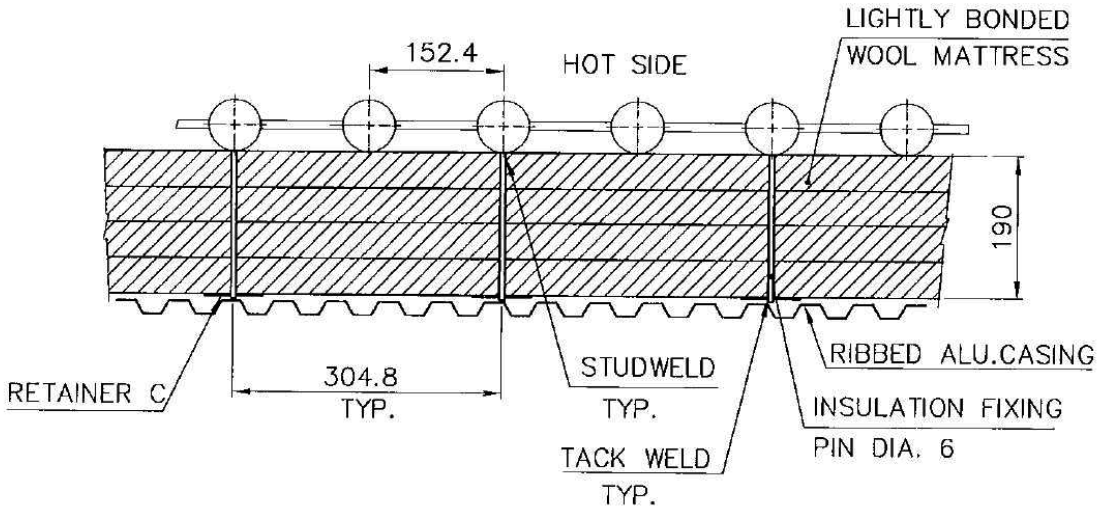


WT./SQ.M. ≃ 75 KGS

INSULATION	DRN	C.S		DRG.NO. 4-00-215-08556	REV.NO. 00
	CHD	C.G.S			
	APPD	C.G.S			

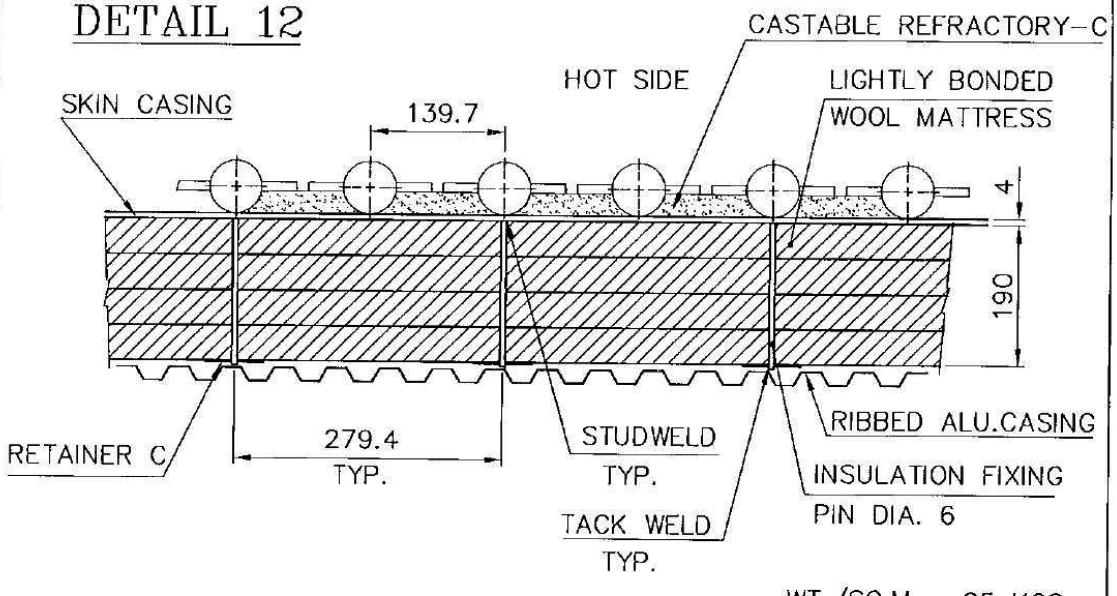
CTS001384-0

DETAIL 11



WT./SQ.M ≃ 30 KGS

DETAIL 12



WT./SQ.M ≃ 85 KGS

INSULATION	DRN	C.S		DRG.NO. 4-00-215-08557	REV.NO. 00
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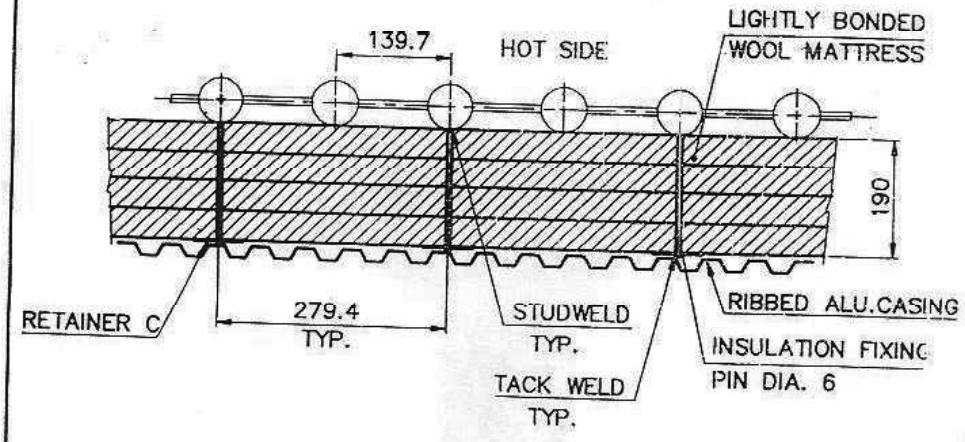
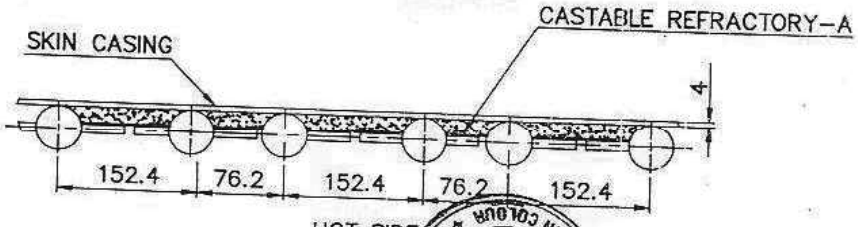
	APPD	C.G.S			

DETAIL 13



WT./SQ.M ≃ 30 KGS

DETAIL 14

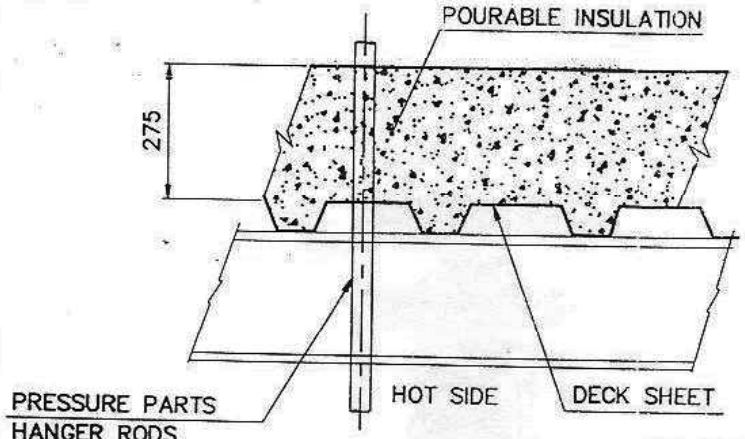


WT./SQ.M. ≃ 75 KGS

INSULATION	DRN	C.S	DRG.	4-00-215-08558	REVISED 00
	CHD	C.G.S			
	APPD	C.G.S			

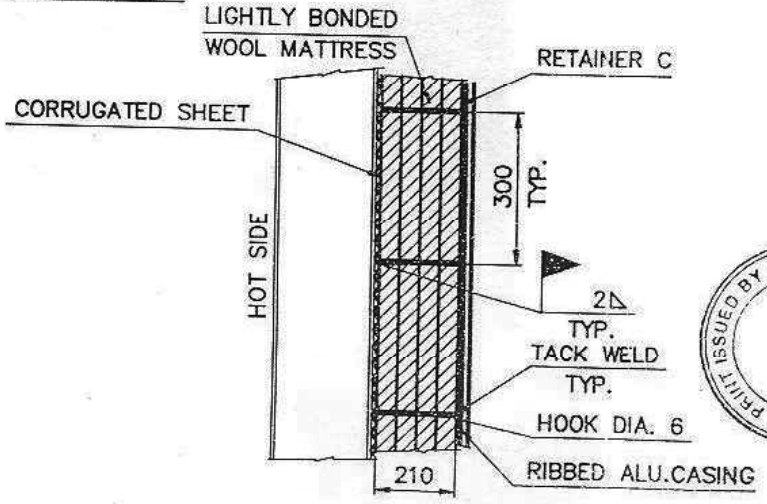
CTS001384-0

DETAIL 15



WT./SQ.M ≃ 233 KGS

DETAIL 16



WT./SQ.M ≃ 46 KGS

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	CHD	C.G.S		4-00-215-08559	00
	APPD	C.G.S			

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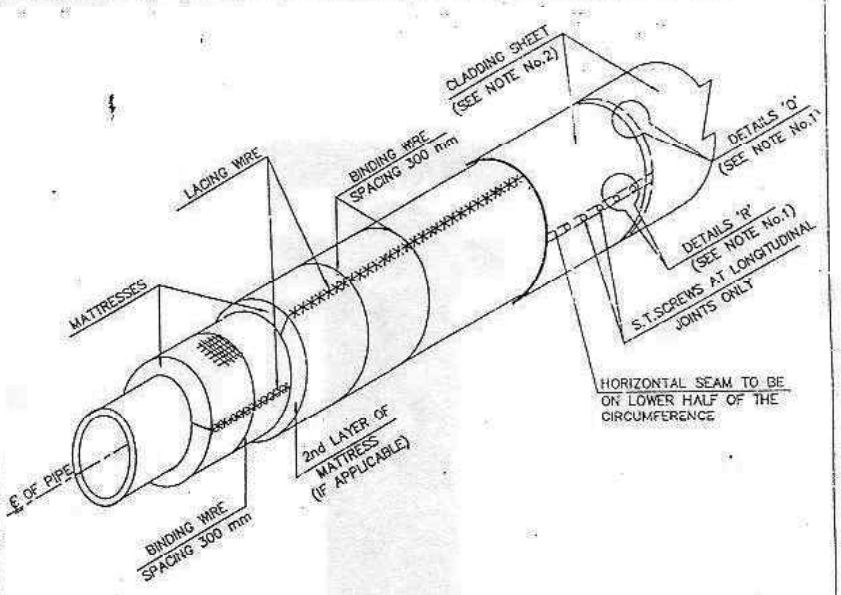

NOTES:–

1. FOR DETAILS 'Q' AND 'R' REFER DRG No. PE–4–999–169–12
2. FOR SHEET SUPPORT REFER DRG No. PE–4–999–169–04
3. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS".
4. IN ADDITION TO BINDING WIRE ALUMINIUM BANDS TO BE PROVIDED FOR DIAMETERS > 500 MM.

MATERIALS REQUIRED:–

1. MATTRESSES
2. BANDS AND SEALS
3. CLADDING SHEET
4. S.T.SCREWS
5. SEALING COMPOUND
6. LACING WIRE
7. BINDING WIRE

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MP	M	N.T.S.	—	—	—

TITLE:–
INSULATION APPLICATION
(HORIZONTAL PIPES WITH MATTRESSES)

	NAME	SIGN	DATE
DRN	S.C.S.		9.6.97
DESN	S.C.S.		9.6.97
CHD	D.B.S.		9.6.97
APPD	S.K.J.		11.6.97

CARD CODE	DRAWING NO.	REV.
—	PE–4–999–169–01	00

SHEET 1 OF 1

DL

A4

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM)

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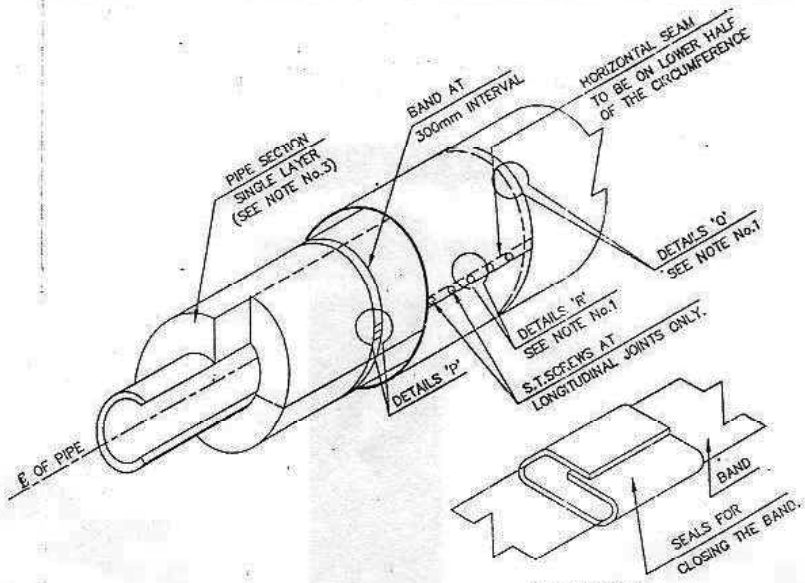
JOB NO. STANDARD



DETAILS 'P'

NOTES:–

1. FOR DETAILS 'Q' AND 'R' REFER DRG. No. PE–4–999–169–12
2. FOR CLADDING SHEET SUPPORT REFER DRG. No. PE–4–999–169–04
3. 2nd & 3rd LAYER IF ANY SHALL BE OF MATTRESSES.
4. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS"

MATERIALS REQUIRED:–

1. PIPE SECTIONS
2. BANDS AND SEAL
3. CLADDING SHEET
4. S.T. SCREWS
5. SEALING COMPOUND

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S.	—	—	—

TITLE:–
INSULATION APPLICATION
(HORIZONTAL PIPES WITH PIPE SECTION)

	NAME	SIGN	DATE
DRN	S.C.S.		
DESN	S.C.S.		6.6.97
CHD	D.B.S.		9.6.97
APPD	S.K.J.		11.6.97

CARD CODE —

DRAWING NO. PE–4–999–169–02

SHEET 1 OF 1 REV. 00

D2

A4

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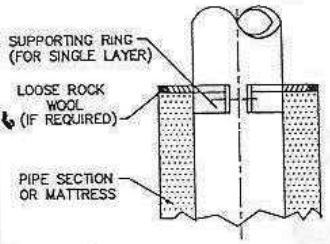
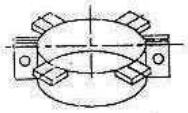
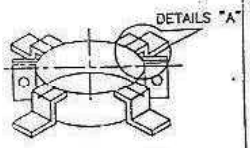
JOB NO. STANDARD

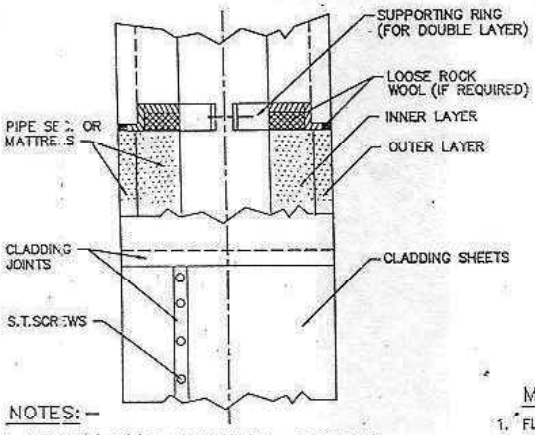


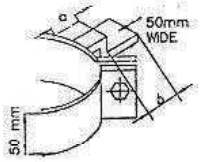


SUPPORT RING
(FOR SINGLE LAYER)



SUPPORT RING
(FOR DOUBLE LAYER)





DETAIL 'A'

NOTES:—

1. LENGTH 'a' & 'b' TO BE 12 TO 50mm LESS THAN SPECIFIED INSULATION THICKNESS.
2. SUPPORT RING TO BE FABRICATED OUT OF MS FLATS/STRAPS.
3. SUPPORT RING REQUIRED FOR PIPE 80 Nb & LARGER IF INSULATION THICKNESS LARGER THAN 30mm.
4. SUPPORT RINGS REQUIRED FOR MATTRESS ONLY.
5. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS"

MATERIALS REQUIRED:—

1. FLATS/STRAPS
2. MATTRESSES/PIPE SECTIONS
3. CLADDING SHEET
4. NUTS AND BOLTS
5. SELF TAPPING SCREWS
6. SEALING COMPOUND
7. SUPPORT RINGS (FOR MATTRESSES ONLY)

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S.	—	—	—

TITLE:—
INSULATION APPLICATION
(VERTICAL PIPING)

	NAME	SIGN	DATE
DRN	S.C.S.		9.6.97
DESN	S.C.S.		9.6.97
CHD	D.B.S.		9.6.97
APPD	S.K.J.		9.6.97

CARD CODE —

DRAWING NO. PE-4-999-169-03

SHEET 1 OF 1 REV. 00

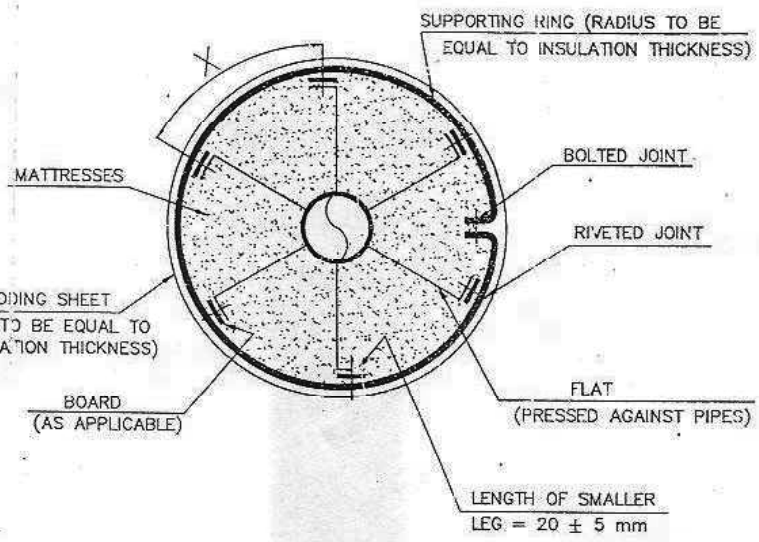
D3

A4

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM)

REV.	DATE	ALTERED / CHECKED	REV.	DATE	ALTERED / CHECKED

JOB NO. STANDARD



X = 150 mm TO 200 mm SO THAT NUMBER OF WEBS IS EVEN NUMBER

MATERIAL REQUIRED:–

1. FLATS
2. RIVETS
3. BOLTS AND NUTS
4. BOARD

NOTE:–

1. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS".

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S.	—	—	—

TITLE:– INSULATION APPLICATION (CLADDING SHEET, SUPPORT RING FOR HOR. PIPE O.D>114.3mm & HOR. EQUIPMENTS)

	NAME	SIGN	DATE
DRN	S.C.S.		
DES'N	S.C.S.		9.6.92
CHD	D.B.S.		9.6.92
APP'D	S.K.J.		11.6.92

CARD CODE —

DRAWING NO. PE-4-999-169-01

SHEET 1 OF 1 REV. 00

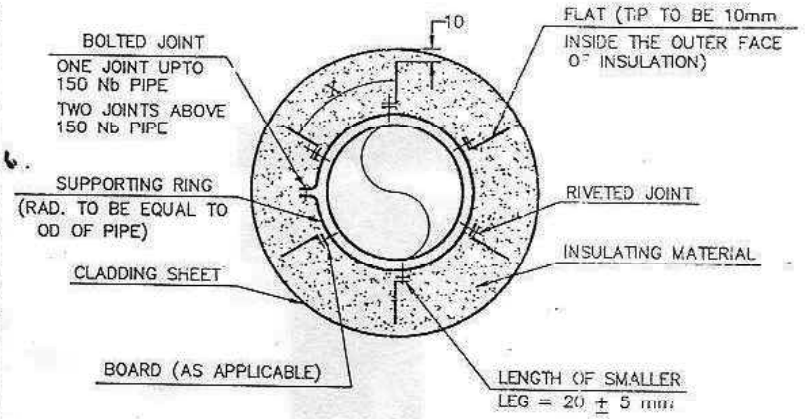
AL-11

A4

FIRST ANGLE PROJECTION ALL DIMENSIONS ARE IN MM

REV.	DATE	ALTERED / CHECKED	REV.	DATE	ALTERED / CHECKED

JOB NO. STANDARD



X = 150 mm TO 200 mm SO THAT NUMBER OF WEBS IS EVEN NUMBER

MATERIAL REQUIRED:–

1. FLATS
2. RIVETS
3. BOLTS AND NUTS
4. BOARD

NOTES:–

1. INSULATION DETAILS ON VERTICAL PIPING SHALL BE SAME AS PER FOR HORIZONTAL PIPES.
2. SPACING BETWEEN SUPPORTING RINGS SHALL BE 3 Mtrs.
3. FOR INSULATION OF END OF VERTICAL EQUIPMENTS REFER DRG. No. PE–4–999–169–09.
4. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS.
5. FLATS/RINGS OF REQUIRED LENGTH/DIA SHALL BE MADE BY ERECTING AGENCY AT SITE FROM MS FLATS/STRAPS.

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG)	REF. TO ASSY. DRG	ITEM
M-L	M	N.T.S.			

TITLE:– INSULATION APPLICATION (INSULATION SUPPORT RING FOR VERTICAL PIPING & VERTICAL EQUIPMENTS)

	NAME	SIGN	DATE
DRN	S.C.S.		9.6.97
DESN	S.C.S.		9.6.97
CHD	D.B.S.		11.6.97
APPD	S.K.J.		

CARD CODE

DRAWING NO. PE–4–999–169–05

SHEET 1 OF 1 REV. 00

AL–222

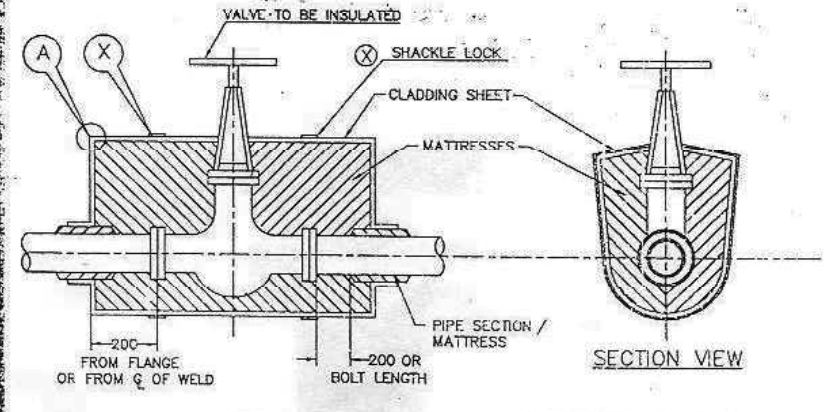
DE

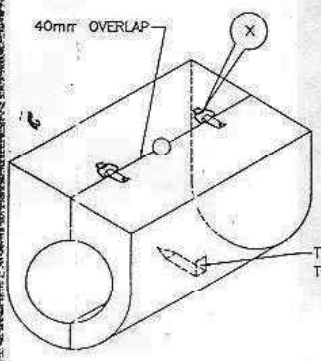
A4

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM)

REV.	DATE	ALTERED / CHECKED	REV.	DATE	ALTERED / CHECKED

JOB NO. STANDARD





ASSEMBLED VALVE BOX

MATERIALS REQUIRED:–

1. MATTRESSES
2. CUPS OF SHACKLE LOCKS FABRICATED OUT OF CLADDING SHEET
3. CLADDING SHEET
4. RIVETS
5. SHACKLE LOCKS CONNECTING BUCKLES. (REF. DRG. PE–4–999–169–10)
6. SELF TAPPING SCREWS
7. SEALING COMPOUND.

NOTE:–

1. FOR DETAIL A & X REFER DRG No. PE–4–999–169–10
2. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS".

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S.	—	—	—

TITLE:–

INSULATION APPLICATION
(VALVES)

	NAME	SIGN	DATE
DRN	S.C.S.		5.6.97
DESN	S.C.S.		5.6.97
CHD	D.B.S.		5.6.97
APPD	S.K.J.		11.6.97

CARD CODE	DRAWING NO.	
—	PE–4–999–169–06	
	SHEET 1 OF 1	REV. 00

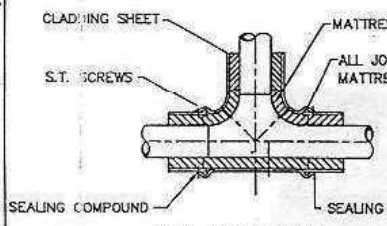
D8

A4

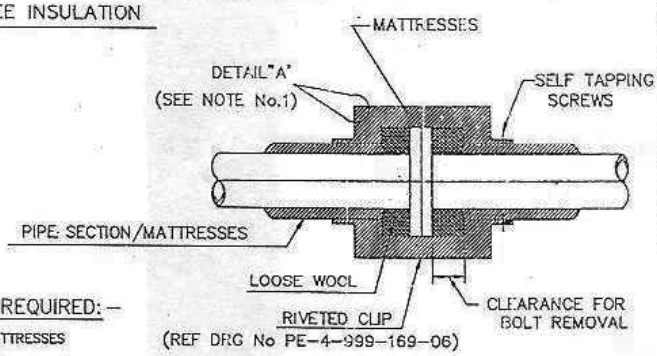
FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM)

REV.	DATE	ALTERED / CHECKED	REV.	DATE	ALTERED / CHECKED

JOB NO. STANDARD



TEE INSULATION



(REF DRG No PE-4-999-169-06)

FLANGE JOINT INSULATION

MATERIALS REQUIRED:-

1. PIPE SECTION/MATTRESSES
2. STITCHING WIRE .
3. CLADDING SHEET
4. BINDING WIRE
5. SELF TAPPING SCREWS
6. SEALING COMPOUND

NOTE:-

1. FOR DETAIL "A" REFER DRG No. PE 4 999-169-10
2. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS.

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S.	—	—	—

TITLE:-
INSULATION APPLICATION
(TEES AND FLANGE JOINTS)

	NAME	SIGN	DATE
DRN	S.C.S.		
DESN	S.C.S.		9.6.97
CHD	D.B.S.		9.6.97
APPD	S.K.J.		11.6.97

CARD CODE	DRAWING NO.	REV.
—	PE-4-999-169-07	00

SHEET 1 OF 1

L-6

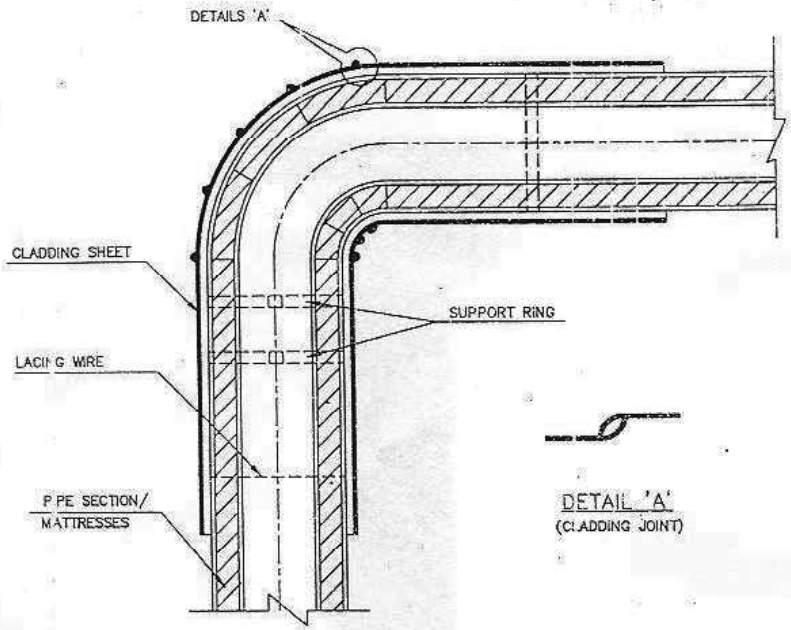
DZ

A4

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM)

REV.	DATE	ALTERED / CHECKED	REV.	DATE	ALTERED / CHECKED

JOB NO. STANDARD



MATERIALS REQUIRED:–

1. MATTRESSES
2. PIPE SECTION (IF APPLICABLE)
3. LACING WIRE
4. CLADDING SHEET
5. BINDING WIRE
6. SELF TAPPING SCREWS
7. SEALING COMPOUND

NOTES:–

1. TWO SELF TAPPING SCREWS TO BE USED FOR EACH SHEET SEGMENT AT INNER SIDE OF BEND.
2. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS.

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S.	—	—	—

TITLE:–
INSULATION APPLICATION
(ELBOWS & BENDS SIZE EXCEEDING 150mm)

	NAME	SIGN	DATE
DRN	S.C.S.		9.6.97
DESN	S.C.S.		9.6.97
CHD	D.B.S.		9.6.97
APPD	S.K.J.		11.6.97

CARD CODE —

DRAWING NO. PE-4-999-169-08

SHEET 1 OF 1 REV. 00

L-7

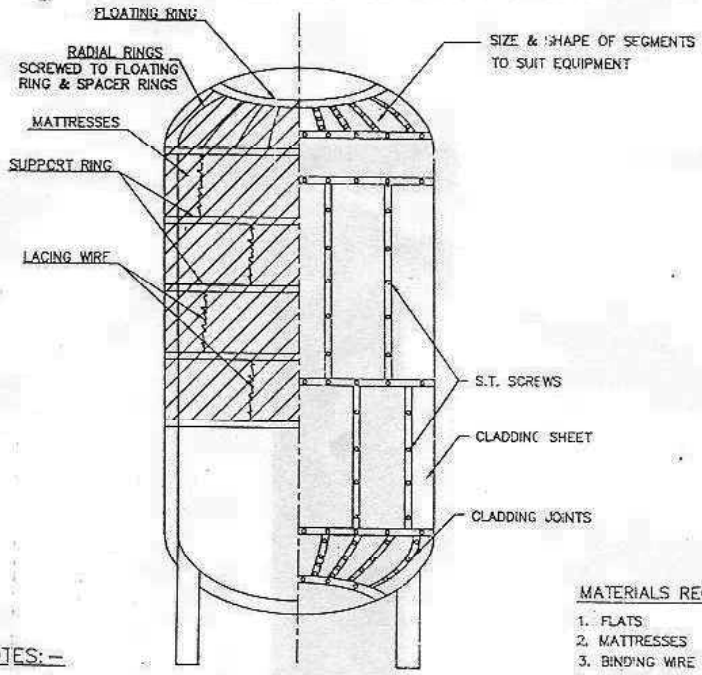
D8

A4

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM)

REV.	DATE	ALTERED / CHECKED	REV.	DATE	ALTERED / CHECKED

JOB NO. STANDARD



MATERIALS REQUIRED:-

1. FLATS
2. MATTRESSES
3. BINDING WIRE
4. LACING WIRE
5. CLADDING SHEET
6. GLASS FABRIC/BOARDS (AS APPLICABLE)
7. RIVETS
8. SELF TAPPING SCREWS
9. SEALING COMPOUND
10. STRAPS/BANDS

NOTES:-

1. STRAPS/BANDS CUT FROM SHEET, WITH SEAL SHALL BE USED OVER FINAL LAYER AT 300mm INTERVALS.
2. INSULATION OF HOR. EQPTS. SHALL BE AS FOR HOR. PIPES. REFER DRG No. PE-4-999-169-01 & PE-4-999-169-02
3. FOR CLADDING SHEET SUPPORT REF. DRG. No. PE-4-999-169-04.
4. FOR INSULATION SUPPORT REF. DRG. No. PE-4-999-169-05.
5. INSULATION OF ENDS OF HOR. EQPTS. SHALL BE SIMILAR TO THIS DRG.
6. WELDING TO EQUIPMENT NOT PERMITTED.
7. FOR GEN. INF. ON APPLICATION OF INSULATION REF. DOC. "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING & EQPTS".

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S.	—	—	—

TITLE:-
INSULATION APPLICATION
(EQUIPMENT)

	NAME	SIGN	DATE
DRN	S.C.S.		9.6.97
DESN	S.C.S.		9.6.97
CHD	D.B.S.		9.6.97
AFPD	S.K.J.		11.6.97

CARD CODE —

DRAWING NO. PE-4-999-169-09

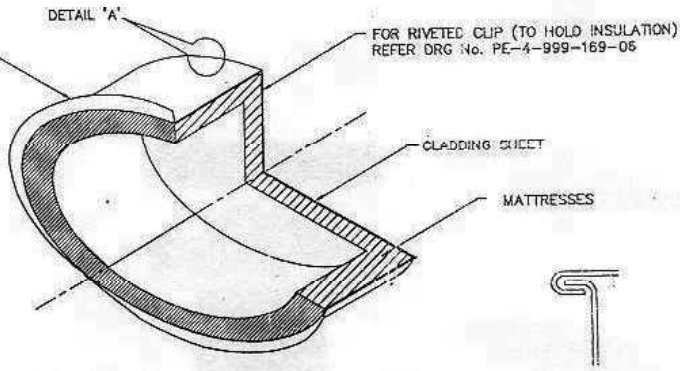
SHEET 1 OF 1 REV. 00

D9

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM)

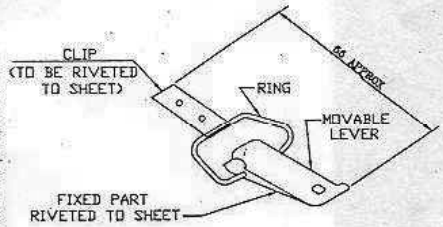
REV.	DATE	ALTERED / CHECKED	REV.	DATE	ALTERED / CHECKED

JOB NO. STANDARD



INSULATING COVER FOR MAN HOLE

DETAILS 'A'
(LOCKING OF SHEETS)



G.I. SHACKLE LOCK CONNECTING BUCKLE

DETAILS 'X'

MATERIAL REQUIRED:-
(FOR SHACKLE LOCK)

1. CLIP (MADE FROM CLADDING SHT.)
2. RIVETS

MATERIAL REQUIRED:-
(MAN HOLE)

1. MATTRESSES
2. CLADDING SHEET
3. SELF TAPPING SCREWS
4. RIVETS
5. CLIPS (TO BE MADE AT SITE)
6. SEALING COMPOUND

NOTES:-

1. FOR GENERAL INFORMATION ON APPLICATION INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS".

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S.	—	—	—

TITLE:- INSULATION APPLICATION
(FABRICATED HEAT INSULATING COVER FOR MAN-HOLE)

	NAME	SIGN	DATE
DRN	S.C.S.		9.5.97
DESN	S.C.S.		9.5.97
CHD	D.B.S.		9.5.97
APPD	S.K.J.		4.6.97

CARD CODE	DRAWING NO.	REV.
—	PE-4-999-169-10	00

SHEET 1 OF 1

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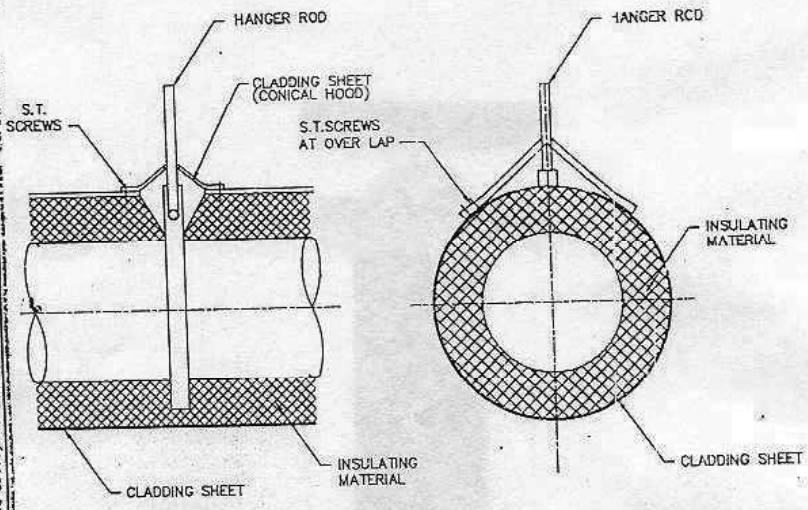
A4

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM)

REV.	DATE	ALTERED	REV.	DATE	ALTERED
01	10.5.12	CHECKED			CHECKED

NOTE 2 ADDED.

JOB NO. STANDARD



MATERIALS REQUIRED:-

1. MATTRESSES/PIPE SECTIONS
2. CLADDING SHEET
3. SELF TAPPING SCREWS
4. SEALING COMPOUND

NOTES:-

1. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS".
2. WHEREVER THE END OF CLAMP PROTRUDES OUT OF INSULATION AT THE BOTTOM, SUITABLE BOX STRUCTURE TO BE PROVIDED MADE OF ALUMINIUM.

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S.	—	—	—

TITLE:- INSULATION APPLICATION (METAL FLASHING ON HANGER ROD PROTRUSION)

	NAME	SIGN	DATE
DRN	S.C.S.		8.5.12
DESN	S.C.S.		8.5.12
CHD	D.B.S.		8.5.12
APPD	S.K.J.		11.5.12

CARD CODE —

DRAWING NO. PE-4-999-169-11

SHEET 1 OF 1 REV. 00

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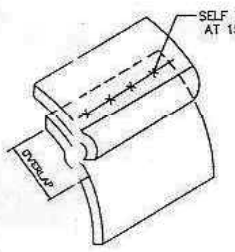
L-10

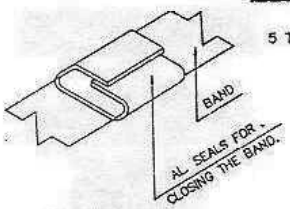
FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM)

REV.	DATE	ALTERED / CHECKED	REV.	DATE	ALTERED / CHECKED

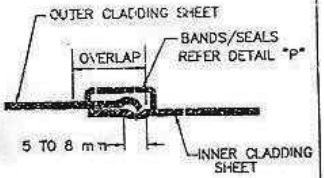
JOB NO. STANDARD



**DETAIL 'R'
(LONGITUDINAL JOINT)



DETAIL 'P'



*DETAIL 'Q'
(CIRCUMFERENCIAL JOINT)

**

1. JOINTS TO BE MADE AT 45° FROM BOTTOM
2. JOINTS TO BE ON LOWER HALF OF THE CURCUMFERENCE FOR HORIZONTAL PIPES AND EQUIPMENTS.
3. SEALING COMPOUND WILL BE USED ON ALL LONGITUDINAL JOINTS.

*

1. TELESCOPIC SLIDING JOINTS SHALL HAVE 5 TO 8mm SPACING.
2. THE OVERLAPING OF TELESCOPIC JOINTS SHALL BE AS BELOW:-

CIRCUMFERENCE OF SHEET(mm)	LONGITUDINAL OVERLAP(mm)
≤ 400	30
401 - 500	40
> 500	50

3. TELESCOPIC JOINT SHALL BE PLAIN.

NOTE:-

1. ALL JOINTS NEAR OIL PIPING TO HAVE SEALING COMPOUND.
2. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING AND EQUIPMENTS".

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S.	—	—	—

TITLE:- INSULATION APPLICATION (DETAILS OF "P", "Q" AND "R")

	NAME	SIGN	DATE
DRN	S.C.S.		9.9.97
DESN	S.C.S.		9.9.97
CHD	D.B.S.		9.9.97
APPD	S.K.J.		11.9.97

CARD CODE —

DRAWING NO. PE-4-999-169-12

SHEET 1 OF 1 REV. 00

L-11

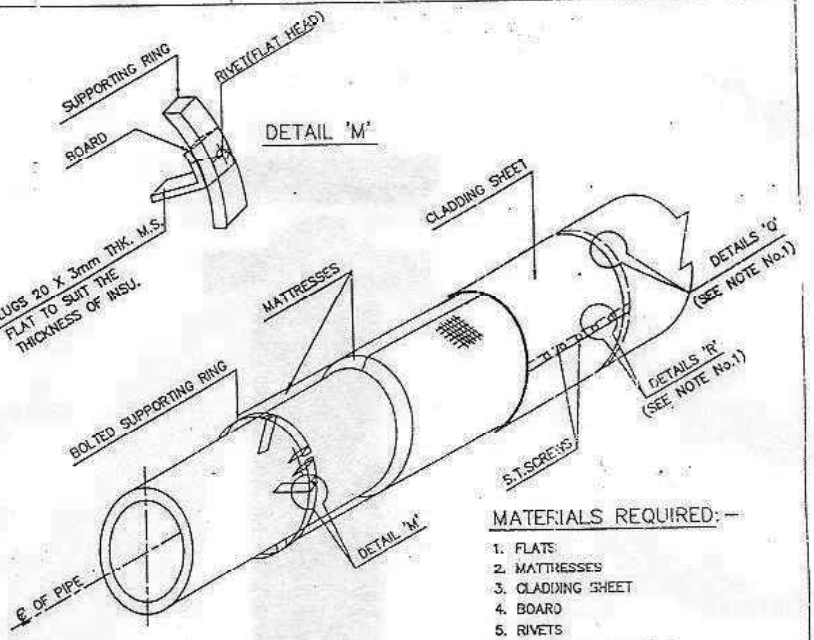
D12

A4

FIRST ANGLE PROJECTION (ALL DIMENSIONS ARE IN MM)

REV.	DATE	ALTERED / CHECKED	REV.	DATE	ALTERED / CHECKED

JOB NO. STANDARD



MATERIALS REQUIRED:–

1. FLATS
2. MATTRESSES
3. CLADDING SHEET
4. BOARD
5. RIVETS
6. SELF TAPPING SCREWS
7. SEALING COMPOUND
8. BOLTS & NUTS.

DETAILS OF LUGS:

PIPE Nb(mm)	No. OF LUGS
1. 33 – 150	4
2. 200 – 300	6
3. 350 – 450	8
4. 500 – 600	10

NOTES:–

1. FOR DETAILS 'Q' AND 'R' REFER DRG No. PE–4–999–169–12
2. FOR GENERAL INFORMATION ON APPLICATION OF INSULATION REFER DOCUMENT "INSTRUCTIONS FOR APPLICATION OF THERMAL INSULATION FOR PIPING & EQUIPMENTS".

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECTS ENGINEERING MANAGEMENT
NEW DELHI

DEPT.	CODE	SCALE	WEIGHT (KG.)	REF. TO ASSY. DRG	ITEM
MPL	M	N.T.S	—	—	—

TITLE:–
INSULATION APPLICATION
(SUPPORT RING FOR PIPE O.D.>168.3mm)

	NAME	SIGN	DATE
DRN	S.C.S.		7.6.97
DES'N	S.C.S.		7.6.97
CHD	D.B.S.		9.6.97
APPD	S.K.J.		

CARD CODE —

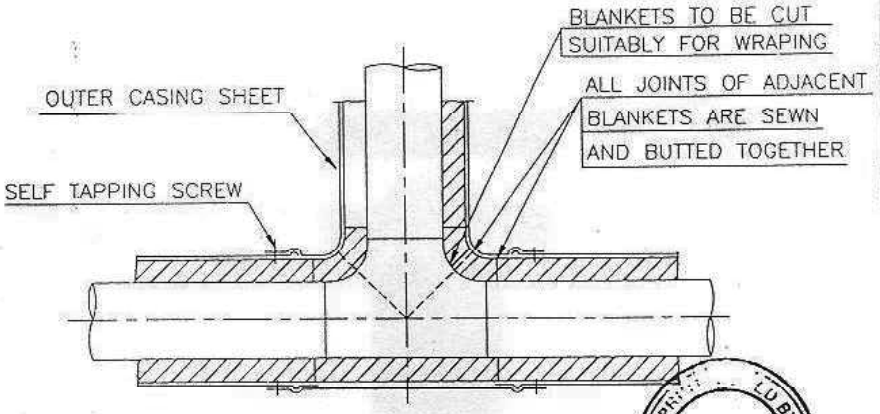
DRAWING NO. PE-4-999-169-13

SHEET 1 OF 1 REV. 00

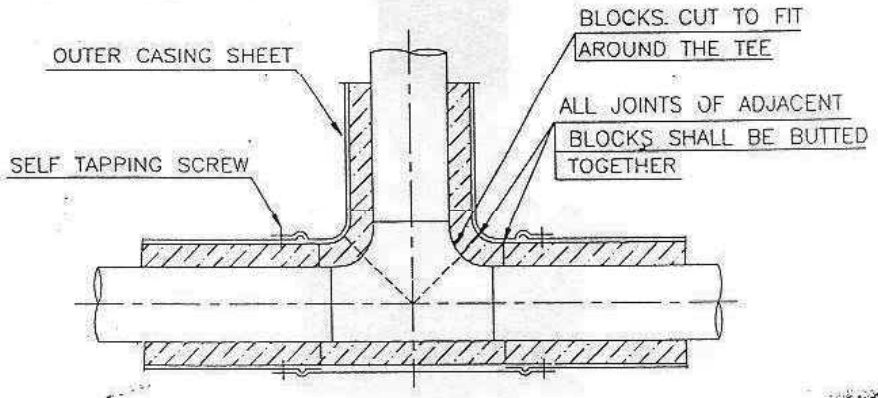
L-3

D13

TEE INSULATION



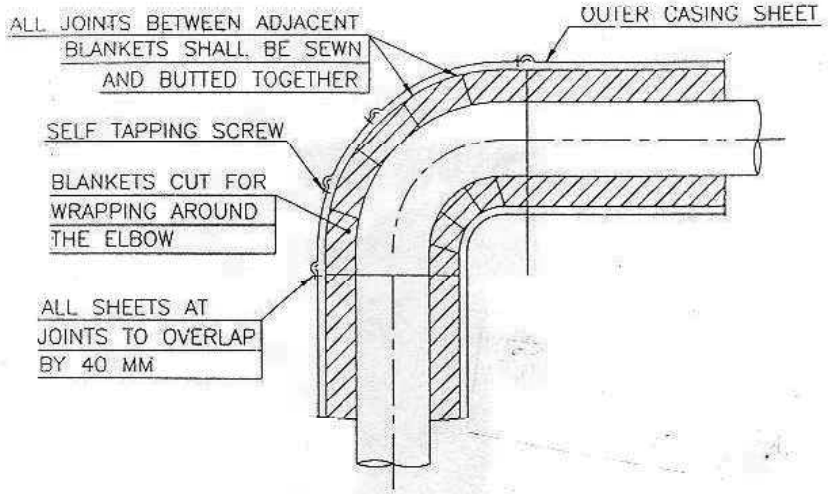
TEE INSULATION
(WITH WOOL MATTRESS)



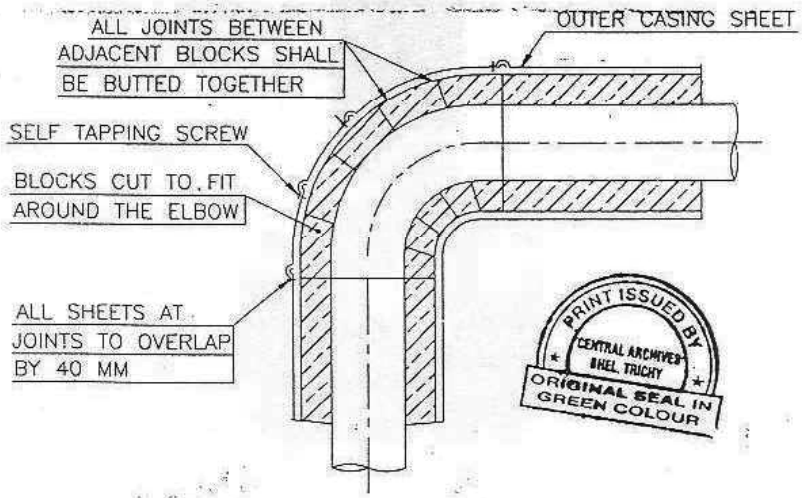
TEE INSULATION
(WITH CALCIUM SILICATE)

INSULATION	PREPARED	A.R.JOTHIGURUNATHAN	SIGNATURE	DATE 04.12.03	DRAWING NO : 4-00-235-08546	REV.
	CHECKED	K.KALIRAJAN				
	APPROVED	C.GUNASEKARAN				

ELBOW INSULATION



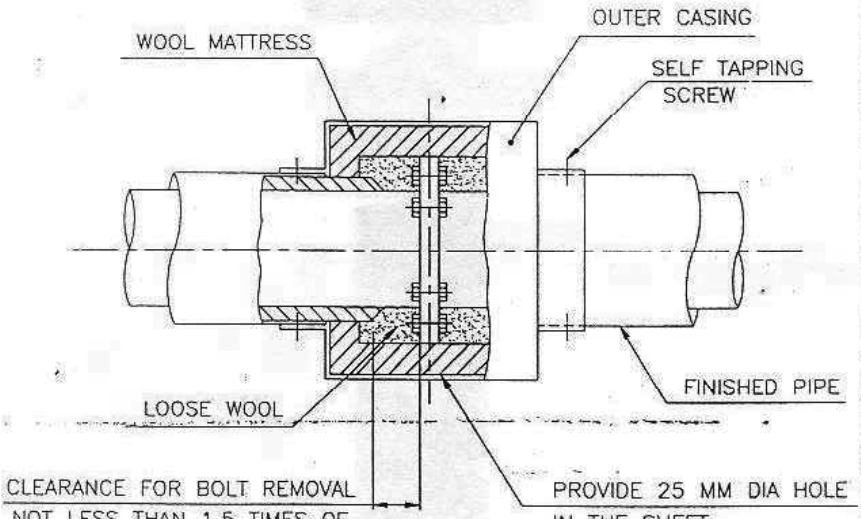
WITH WOOL MATTRESS



WITH CALCIUM SILICATE

INSULATION	PREPARED	A.R.JOTHIGURUNATHAN		DATE 04.12.03	DRAWING NO : 4-00-235-08547	REV
	CHECKED	K.KALIRAJAN				
	APPROVED	C.GUNASEKARAN				

FLANGE INSULATION

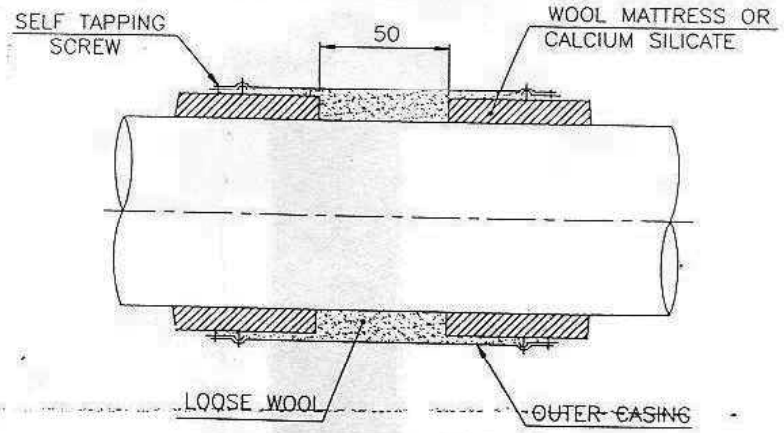


NOTE:-

1. WHEREEVER THE FLANGES ARE ENVISAGED FOR DISMANTLING, THIS TYPICAL ARRANGEMENT IS TO BE FOLLOWED.

INSULATION	PREPARED	A.R.JOTHI GURUNATHAN		DATE 04.12.03	DRAWING NO : 4-00-235-08548	REV
	CHECKED	K.KALIRAJAN				
	APPROVED	C.GUNASEKARAN				

EXPANSION JOINT FOR PIPES

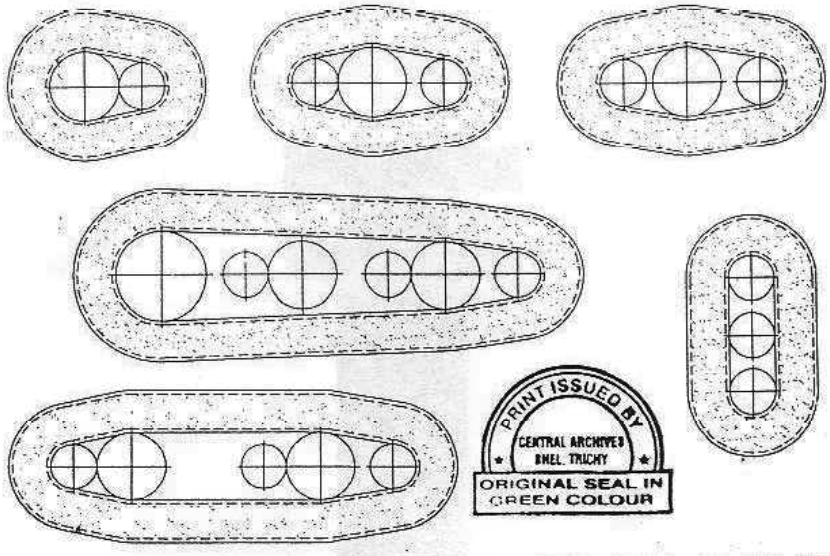


NOTE:-

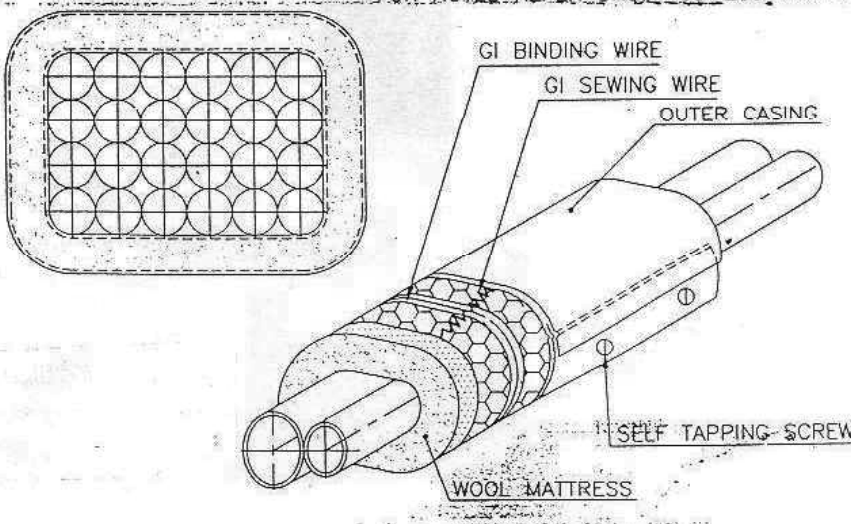
1. THIS ARRANGEMENT IS APPLICABLE FOR BOTH HORIZONTAL AND VERTICAL PIPE LINES,AT EVERY 5 METRES.
2. WHEN THE OPERATING TEMPERATURE IS BELOW 230°C,EXPANSION JOINTS ARE NOT REQUIRED.
3. FOR PIPES,WHERE THE FLOW IS ONLY INTERMITTANT,EXPANSION JOINTS ARE NOT REQUIRED.

INSULATION					
	PREPARED	A.R.JOTHI GURUNATHAN	SIGNATURE	DATE 04.12.03	DRAWING NO : 4-00-235-08549
	CHECKED	K.KALIRAJAN			REV
	APPROVED	C.GUNASEKARAN			

BUNCH INSULATION



FOR NOTES REFER DRG 4-00-235-08541

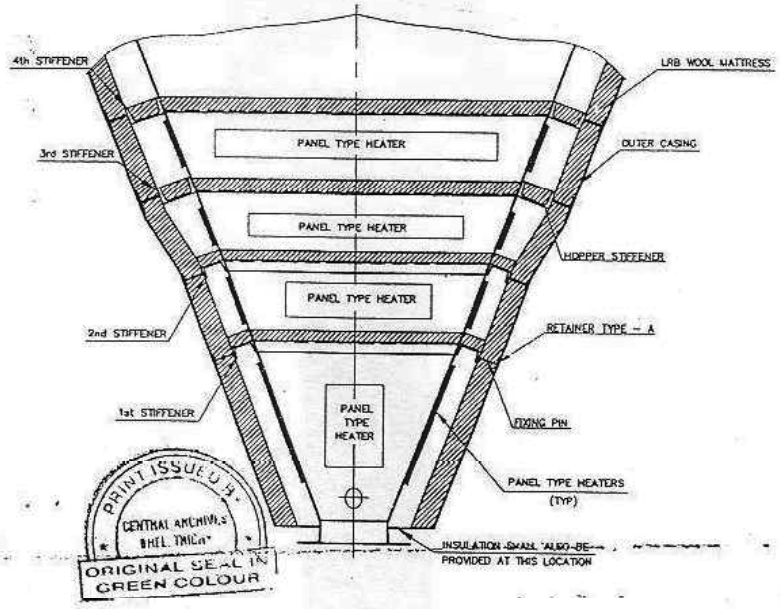


INSULATION	PREPARED	A.R.JOTHISURYANATHAN	SIGNATURE	DATE 04.12.03	DRAWING NO : 4-00-235-08550
	CHECKED	K.KALIRAJAN			REV
	APPROVED	C.GUNASEKARAN			

REV	DATE	ALTERED : A.R.J
01	01.10.05	CHD & APPD : C.G.S

DRAWING ALTERED

FOR TOLERANCES OF UNTOLERANCED DIMENSIONS DURING MANUFACTURE REFER PLANT STD. NO TP 023 0299



NOTE:

01. THE INSULATION SHOWN IS FOR TYPICAL PANEL HEATER HOPPERRS.THIS IS TO BE FOLLOWED WHERE EVER PANEL TYPE HEATERS ARE ENVISAGED.

02. INSULATION FIXING PINS AND RETAINERS SHOULD NOT FOUL WITH THE PANEL HEATERS .

03. FOR OTHER INSULATION DETAILS, REFER DRG. 1-00-235-06654.

Bharat Heavy Electricals Ltd
UNIT: HIGH PRESSURE BOILER PLANT
TIRUCHIRAPALLI - 620014

355-056

	NAME	SIGNATURE	DATE
DRN	A.R.J		20.09.05
CHD	C.G.S		22.09.05
APPD	C.G.S		22.09.05

DEPT	ALL DIMENSIONS ARE IN MM	PROJECTION	SCALE	WEIGHT (Kg)	REF TO ASSY / OLD DWG
CODE 123					

TITLE

HOPPER INSULATION DETAIL FOR PANEL TYPE HEATERS

DRAWING NO : 4-00-235-08702 REV 01

GUIDELINES FOR SELECTION OF NDE AND HEAT TREATMENT AGENCIES AT SITE

(to be deployed by BHEL's E&C Associates)

Bharat Heavy Electricals Limited

Power Sector Eastern Region

Kolkata - 700091

Doc. No. : PP-QLY-AA-DC-106/01-20

Rev. No. : 0

Title : Guidelines for Selection of NDE and Heat Treatment Agencies at Site
(to be deployed by BHEL's E&C Associates)

Prepared By Committee	Smarak Kumar Sahoo / Dy Engr. (Member)	On behalf of the committee
	Sontosh Pal / Addl. Engineer Gr.II (Co-opted)	
	Subhradip Joarder / Engineer (Co-opted)	
	Saurav Srivastava / Dy. Manager (Member)	
	Tathagata Dutta / Dy. Manager (Member)	
	Rajesh Das / Dy. Manager (Member)	
	Arup Ratan Paul / Engineer (Convener)	Arup Ratan Paul DN: c=IN, o=BHARAT HEAVY ELECTRICALS LIMITED, ou=BHEL-PSER-HQ, postalCode=700091, st=West Bengal, 2.5.4.20=b6355c0e40c2ad6bdcd8[illegible]a564865593, cn=ARUP RATAN PAUL Date: 2020.09.14 17:24:20 +05'30'
	Mridul Taisum / Sr. Manager (Chairman of the committee)	
Approved By	Head/ QLY & BE	Digitally signed by SUMANTA CHATTERJEE DN: c=IN, o=BHARAT HEAVY ELECTRICALS LIMITED, ou=BHEL-PSER-HQ, postalCode=700091, st=West Bengal, 2.5.4.20=b8585eb2e62f6511c82073907e19d5[illegible]fa875666724bfa32fed52c3c0d8bcded, cn=SUMANTA CHATTERJEE Date: 2020.09.14 17:25:36 +05'30'

ISSUE CONTROL:

DOCUMENT NO.	PP-QLY-AA-DC-106/01-20
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REVISION NO. & DATE	Rev. No. : 0, Date : 14/09/2020
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ISSUED TO	
DATE OF ISSUE	
PURPOSE :	
ISSUED BY (SIGNATURE & DESIGNATION)	

STATUS OF REVISIONS

SL. NO.	REFERENCE OF SHEETS REVISED	REVISION NO. & DATE	REMARKS
01	All	0, Dtd.: 14/09/20	New guidelines developed. Valuable comments / guidelines from CQ&BE and QA-Trichy incorporated in the document.

1.0 Object

Object of the guidelines is to enable BHEL engineers to make informed decision regarding selection/acceptance of NDE & Heat Treatment agencies; those are deployed by BHEL's E&C associates at site and to evaluate the performance of the agencies.

2.0 General Guidelines

A. BHEL's E&C associates have to take prior permission/approval before deployment of NDE & Heat Treatment agencies at site. All relevant documents along with the filled-up format as per Annex-A & Annex-B to be submitted by BHEL's E&C associates.

B. The personnel, proposed by the agency for NDE, should have sufficient experience in testing of welds/castings/forgings/plates and should be capable to interpret the given procedure and carry out the test. Trained, experienced and certified personnel qualified as Level I / II / III (as required) as per SNT-TC-1A of ASNT or BSEN 473 of EN through ASNT / ISNT / CSWIP or its Accredited Agencies should only be deployed.

C. The personnel, proposed by the agency for Heat Treatment job, should have sufficient experience in heat treatment of welds/castings/forgings/plates and should be capable to interpret the given procedure and carry out the test.

D. On receipt of proposal along with all necessary supporting documents from E&C associates at site, concerned BHEL Erection engineer & BHEL FQA engineer shall jointly review the proposal and record the details of the accepted agencies as per Annex-C and share with the Construction manager and Head/ Quality & BE/ BHEL-PSER HQ.

E. The FQA engineer shall also take necessary clearance / acceptance from customer, if required, before acceptance of the proposed agency and maintain a record for that. If customer approval is not required, prior intimation shall be given to the customer through memo.

F. The NDE / Heat Treatment agency shall meet the requirements of this document plus any additional qualification requirements specified in latest revision of the BHEL NDE Manual (AA/CQ/GL/011 Part III-NDEM), as applicable.

G. Based on the feedback from BHEL FQA engineers, a controlled list (with revision number & date) of accepted NDE & Heat Treatment agencies with their BHEL-approved personnel shall be maintained by PSER-HQ Quality department and this list shall be uploaded in PSER intranet portal.

H. Monthly performance of the accepted agency/s shall be monitored by BHEL FQA Engineer and the evaluation report to be sent to Head/ Quality & BE/ BHEL-PSER HQ, in MSQR.

I. The agency may be disqualified/debarred on following grounds:
   i. if a re-inspection of material or a recheck of NDE / Heat Treatment data shows significant variation from the agency's report, as determined by BHEL FQA engineer
   ii. if a significant discrepancy or issue (*viz.* or malpractices like usage of modified/ manipulated Reports/ Charts, other fraudulent activity) is noted during the process audit / routine site inspection..
   iii. if any of the agency's BHEL-approved personnel has changed without taking prior approval from BHEL FQA In-charge.

iv. if the equipment mobilised by the agency no longer meets the requirements for approved usage.

v. if the Agency is not able to ensure re-qualification of his personnel/ equipment on expiry of certification or is not able to replace such personnel/ equipment in time with permission of the FQA.

J. The debarred / disqualified agency may apply for re-acceptance only after three months with a written clarification of its previous misconduct and corrective action taken to avoid occurrence of the same incidence. A standing committee of FQA Engineers shall be constituted by Head/Quality & BE/PSER, which shall scrutinise the documents

K. If, for any of the above reasons, the agency is debarred / disqualified, the same shall be immediately intimated by BHEL FQA engineer to Head/ Quality & BE/ BHEL-PSER Site CM and Main Sub-Contractor with intimation for immediate replacement.. The same shall be updated in controlled list of accepted agencies.

L. This guideline does not specifically provide any recommendation for safety measures to be taken during NDE & Heat Treatment work. Suitable safety analysis & hazard identification is to be done at site as per the project HSE manual & standard OCP.

3.0 Specific Guidelines for selection of NDE Agency for PAUT (Phase Array UT)

A. The NDE agency should have executed at least 30% of the proposed work quantity in a single job. In case, multiple agencies are proposed to be deployed, each agency should have executed at least 30% of proposed quantity in a single job. The necessary documents (*viz.* copy of Work Order, End User Performance Certificate, *etc.*) for above to be produced by agency.

B. The Agency to submit their organizational setup, supervision arrangement and list of resources to be deployed at site.

C. For PAUT, the agency shall be capable of mobilising the PAUT equipment & accessories and manpower as follows –

i. **PAUT equipment**: Omni scan MX/MX2/X3 or equivalent Phased Array equipment shall be used coupled with Scanner (16:68 or higher configuration), having

- Weld inspection features including setting up of weld profile.
- Multi grouping capability.
- Capability of using two PAUT probes simultaneously. Necessary adapter/splitter (if required) for attaching two probes for simultaneously working should be available for inspection.
- Operation with battery.
- A-scan, B-scan, C-scan, S-scan, Linear scan, Sectional scan
- Calibration: Velocity, Wedge delay, Sensitivity, TCG, DAC, Encoder calibration features.
- Data analysis and report building
- Encoder recognition.

- Probes: At least two numbers of low profile suitable PAUT probes for (MS and Alloy Steel) of 7.5 -10 Mhz frequency,16-32 element with more than 2 meters of cable length. The probes shall have couplant supply mechanism (passage of couplant) to test surface & required accessories for the same.
- Suitable probes for SS to be made available for inspection of SS joints.
- For Circumferential weld Inspection of Small-Diameter Pipes Advanced semi-automated scanning equipment/ Cobra scanner

ii. **Wedges:** Specially designed wedges to fit in the above probes and having reference angle of 50 to 60 Degree sheer wave in steel will be required. Wedges should have suitable contour to fit around required range of tubes OD (NORMALLY 25 TO 100mm).

iii. **Scanner:** A manual/automated scanner capable for scanning of required OD (normally 25 mm to 100 mm) tubes. The scanner should have encoder with it for precise data acquisition. The scanner should be able to hold two low profile phased array probes and wedges, as mentioned above for complete inspection of the weld in one rotation of the scanner. The design of scanner, probe & wedges shall allow complete inspection of circumferential weld on tube having gap more than 15 mm with any adjacent tubes, supports and structures etc.

iv. **Manpower**: The NDE agency shall deploy minimum two persons for performing non-destructive testing. They shall be qualified and certified in accordance with NDE written practice for Training, Examination, and Qualification & Certification of NDE Personnel as PAUT Level-II. The personnel who acquires the data, scan the job, does the calibration and analyse Phased Array data shall be trained on same specific technique and certified as PAUT level II. However, data evaluation and analysis shall be performed by a PAUT Level II or UT Level III. The necessary document/certificate for above to be produced by agency.

D. **Test Plan** / **Scan Plan:** The agency shall be capable of submitting the written inspection procedure for PAUT of weld complying with the requirement of latest BHEL NDE Manual (AA/CQ/GL/011 Part III-NDEM), duly approved by a UT Level-III person. The procedure / test plan shall be qualified at site as per latest BHEL NDE Manual (AA/CQ/GL/011 Part III-NDEM).

E. **Calibration:** Velocity, wedge delay, sensitivity, TCG, encoder calibration shall be performed by PAUT operator before inspection and as per frequency of code. Verification shall be done by BHEL FQA engineer regarding competency of the personnel deployed by the agencies, prior to start of job.

F. **Reference block:** Tubes with similar dia & wall thk (within 10% as per code) and circumferential notches/groves shall be used as reference block. The reference block should have length not less than 200 mm. It should have two circumferential grooves/notches (one each on ID & OD) having depth of 10% of wall thickness. 1 to 1.5 mm width & length between 25 to 50 mm. These two grooves should be located at opposite ends of the tube. The notches should be separated from adjacent tube edge by about 50 mm. These two grooves should be located at opposite ends of the tube. The notches should be separated from adjacent tube edge by about 50 mm. The length of reference block and

location of reflectors (notches/grooves) should comply the requirement of calibration for angle beams. Agency to take tube samples in advance so that Machine calibration work can be completed before start of work.

G. **Data Storage:** The calibration data and inspection data should be in the equipment and should be available for verification. Inspection data file to be stored by giving identifiable marking for reporting & interpretation. Agency must be capable to hand over data in suitable media (DVD / Flash Drive).

H. **Test Result:** The test result submitted by the agency for each tested tube should provide information on type of defects (like lack of penetration, porosity, lack of fusion etc), their location, length, height, depth etc. The final report with above information to be given in an excel sheet along with PAUT inspection data file & images for all the tested joints. Sample copy of test result of previous job to be submitted by the agency.

4.0 Specific Guidelines for selection of NDE Agency for RT (Radiography Test)

A. The NDE agency should have executed at least 30% of the proposed work quantity in a similar single job. In case, multiple agencies are proposed to be deployed, each agency should have executed at least 30% of proposed quantity in a similar single job. The necessary documents (*viz.* copy of Work Order, End User Performance Certificate, *etc.*) for above to be produced by agency.

B. Agency will submit their organizational setup, supervision arrangement and list of radiography sources to be deployed at site.

C. Agency to submit the documents of BARC / AERB Level- I & II personnel for doing RT & Interpretation of films, respectively. Personnel's skill & capability will be reviewed by FQA before engaging them in job.

D. The agency shall comply with all safety norms as per BARC/AERB & agency must submit source movement authorization for the subject site from BARC/AERB before start of work. The source movement within the site shall also be maintained by the agency in the log book. The agency shall fulfil all the safety precautions as per statutory requirements including Radiological safety at their own cost.

E. Manpower & Resources:

i. For a single unit, The agency shall deploy one BARC/AERB certified site in-charge and minimum of two numbers of BARC/AERB qualified Level-I radiographers for deployment of each number of source and one number of Trained, experienced and BARC/AERB qualified RT Level-II film interpreter. Personnel's skill & capability will be reviewed by FQA before engaging them in job.

ii. Agency shall mobilize one full time Radiation Safety Officer (RSO) and one site in-charge at site and maintained as per BARC and BHEL OCP guidelines.

iii. For a single unit, the NDE agency shall have permission from BARC/AERB for mobilizing a minimum of two radioactive sources (as per contractual guidelines) of sufficient strength all the time (minimum of 10 Curie). The source should be replaced immediately after decay to 10 Curie. Agency shall be capable to arrange additional source on emergency.

iv. The Agency has to submit the decay chart and all records regarding movement of the source.
v. The agency should be responsible for security of their source in the plant or during movement of camera at site.
vi. All employees of the agency to use TLD badges & pocket dosimeters while doing radiography testing at site. Also submit annual dose report of radiation workers.
vii. The agency to calculate cordon-off distance & provide 'Radiography warning sign boards & symbols' with cordon-off rope & warning alarm while carrying out the radiography.
viii. Radiography team to be available at site round the clock
ix. Equipment, Film and other consumables used shall be BHEL approved brands.

F. Agency has to demonstrate and establish various parameters for the quality of radiograph (*e.g.* Image density, sensitivity, source size, source to film distance, geometric unsharpness etc.,) to the satisfaction of BHEL.

5.0 Specific Guidelines for selection of NDE Agency for UT & MPI

A. The NDE agency should have executed at least 30% of the proposed work quantity in a similar single job. In case, multiple agencies are proposed to be deployed, each agency should have executed at least 30% of proposed quantity in a similar single job. The necessary documents (viz. copy of Work Order, End User Performance Certificate, etc.) for above to be produced by agency.
B. Agency will submit their organizational setup, supervision arrangement and list of resources to be deployed at site.
C. For a single unit, the NDE agency shall deploy a minimum of two number Digital type Pulse Echo A Scan UT equipment (preferably of OLYMPUS, EINSTEIN-II & Krautkramer) along with required calibration block at site.
D. For a single unit, the NDE agency shall deploy a minimum of two numbers of Trained, experienced and certified Level-I UT technicians and one number of Trained, experienced and certified Level-II Interpreter in UT.
E. For a single unit in MPI work, the NDE agency shall deploy a minimum of two sets of magnetic yokes, pie indicators, iron oxide particles, colour contrast, etc. Should have portable AC/HWAC equipment delivering current of minimum of 1000 amps and portable AC/DC electromagnetic yokes. Calibrated Equipment/ Ammeters shall be used for testing. The equipment should be capable of testing with visual and fluorescent magnetic particles.
F. The agency shall deploy a minimum of two numbers of Trained, experienced and certified Level-I technician in MPI and one number of Trained, experienced and certified Level-II Interpreter in MPI.

6.0 Specific Guidelines for selection of Heat Treatment Agency

A. The NDE agency should have executed at least 30% of the proposed work quantity in a similar single job. In case, multiple agencies are proposed to be deployed, each agency should have executed at least 30% of proposed quantity in a similar single job. The necessary documents (viz. copy of Work Order, End User Performance Certificate, etc.) for above to be produced by agency.

B. Agency will submit their organizational setup, supervision arrangement and list of resources to be deployed at site. This must coresponf to the requirement mentioned in Sl. No. F

C. The T & P's for Resistance Heating being deployed by Heat Treatment agency at site *viz.* PID Control Heating panels, Thermocouples, heating elements, Recorders shall be of renowned make/ branded having provision for digital display (*e.g.* temperature, Amp/ Voltage *etc.*), calibrated and in good working condition. Also to be noted that insulation being used should be in workable condition.

D. The T & P's for Induction Heating being deployed by Heat Treatment agency at site *viz.* Induction Heating equipment, induction cables, Thermocouples, auto-recorders shall be of renowned make/ branded having provision for digital display (e.g. temperature, Amp/ Voltage etc.),calibrated and in good working condition. The Induction heating equipment should be inverter type (IGBT H Bridge) and output frequency should be 7.5-10 KHz. Also, to be noted that insulation being used should be in workable condition.

E. Guidelines of BHEL Heat Treatment manuals shall also be referred.

F. The agency shall be capable of mobilising required number of machines and against each machine one experienced operator & one technician-cum-electrician must be deployed. One experienced supervision staff must be engaged by the agency exclusively for HT job. Qualification of the supervision staff shall be minimum Diploma in Mechanical/ Metallurgical engineering. The competency of operator & condition of equipment must be verified at site, as elaborated in Sl. No. H.

G. The agency should have capability of mobilising flexible ceramic pads as & when advised by BHEL.

H. One trial Heat Treatment must be conducted by BHEL engineers before acceptance of the HT equipment and the manpower, to assess the competency of the deployed persons and the condition of the machinery. The thickness & material to be selected based on the maximum thickness & material to be heat treated at site. All results to be recorded by BHEL engineer for future reference. The following are to be monitored and assessed -

1) For resistance heating process:
   i. Equipment's condition and calibration documents
   ii. Competency of the operator to follow SR job card instruction/ WPS instruction
   iii. Competency of the operator for selection of Resistance coil gauge
   iv. Wrapping skill of the operator for single tube/pipe
   v. Wrapping skill of the operator for bunching of tubes
   vi. Insulating skill of the operator
   vii. Competency of the operator for Thermocouple fixing skill
   viii. Competency of the operator for Programming of PID controller
   ix. Competency of the operator for selection of ROH/ROC
   x. Performance after completion of PWHT
2) For Induction heating process:
   i. Equipment's condition and calibration documents
   ii. Competency of the operator to follow SR job card instruction/ WPS instruction
   iii. Competency of the operator for Induction coil/ annealing cable rotation

iv. Wrapping skill of the operator for single tube/pipe
v. Insulating skill of the operator
vi. Competency of the operator for Thermocouple fixing skill
vii. Competency of the operator for programming in auto controller of IHE
viii. Competency of the operator for selection of ROH/ROC
ix. Performance after completion of PWHT
x. Competency of the operator to download PWHT graph from auto controller recorder

One mock power failure shall be staged during the trial process to verify readiness of the agency & BHEL's E&C associate for contingency. Acceptability shall depend on the hardness achieved (as measured by UCI machine)

7.0 Revision of this Guidelines

A. Revision in this Guideline, as may be felt from time to time, shall be decided by the standing committee of FQA Engineers constituted by Head/Quality & BE/BHEL-PSER.

******

Annex-A

Application for approval of NDE / Heat Treatment Agency at …….

(Name of Project)

Name of the NDE / Heat Treatment Agency : ……

Address : ……

Name of the Proprietor : ……

PAN / TIN of agency : ……

Contact No. : ……

Email address : ……

1. Details of Qualified / Certified NDT Personnel (ASNT / ISNT)
   (*Including BARC certified Radio grapher-RT-1, Site In-charge-RT-2, RSO*)

Sl. No.	Name	NDT Method	Level	Date of first Certification	Certificate Valid upto	Certifying Authority

2. Details of Heat Treatment Personnel

Sl. No.	Name	Qualification	Previous Experience

3. Details of NDE / HT Equipment proposed to be mobilised

Sl. No.	Equipment (Make/Model)	Type (RT/ UT/ MPI/ PAUT/ HT)	Quantity	Specification / Rating	Calibration Status	Capacity of the Equipment

4. Details of Previous work done (in past 3 years):

Sl. No.	Project Name & Customer	Type of Job (RT/ UT/ MPI/ PAUT/ HT)	Number Tube Joints completed	Number of Pipe Joints Completed

…… ……

Signature of the Owner of the Agency & seal Signature of BHEL's E&C Associate & seal

Note : Applicant shall submit supporting documents along with this application and fill the Annex-B

Annex-B

Check list for Annex-A

Note : Applicant shall fill the following details and no column shall be left blank		
Sl. No.	***Description***	
A.	Name of the Proposed Agency	
B.	Quantum of job being proposed for the agency	
C.	Copy of agencies Govt. Registration	Page no.
D.	Duly filled in Annex-A	Page no.
E.	Certificates for Individuals as mentioned in Sl. No. 1 of Annex-A (Not applicable for HT agency)	Page no. from ….. to …..
F.	AERB approval certificate (for RT agency Only)	Page no. from ….. to …..
G.	Supporting documents for previous work Experience as mentioned in Sl. No. 2 of Annex-A	Page no. from ….. to …..
H.	Supporting documents for previous work Experience as mentioned in Sl. No. 3 of Annex-A	Page no. from ….. to …..

……

Signature of BHEL's E&C Associate & seal

Annex-C

Agencies Authorised for conducting NDE / Heat Treatment at ……

(Name of Project)

Date : ……

Proposed By (Name of BHEL E&C Associate) : ……..

SL. No	Name & Address of Agency	Type of Job (RT/ UT/ MPI/ PAUT/ HT)	Name of the Persons	Method	Level	Certificate Valid upto	Contact Person, Contact number

Tick (√) applicable

1. Credentials of the above agencies have been reviewed as per Guideline and found acceptable.
2. Trial Heat Treatment has been performed by the HT agency and found to be satisfactory
3. The agencies' personnel have been interviewed and found to possess knowledge of the process & equipment

…… ……

(BHEL Erection Engineer) (BHEL FQA Engineer)

Distribution:

1. Construction Manager / BHEL Site
2. Head / Quality & BE, BHEL-PSER