1.0 **SCOPE**

This specification covers the requirements of various piping materials used in piping/ pipeline system handling Natural Gas / Regasified Liquid Natural Gas (RLNG) and associated utilities in the pipeline.

2.0 **CODES AND STANDARDS**

2.1 Pipeline and terminal facilities envisaged as a part of this project shall be designed and Engineered primarily in accordance with the provision of ASME B 31.8 – Gas Transmission & Distribution Piping System - Latest edition and OISD Standard 226-Natural Gas Transmission Pipeline and City Gas Distribution Networks.

2.2 All codes standards and specifications referred herein shall be the latest edition of such documents.

2.3 For sake of brevity, the initials of the society to which the codes are referred are omitted in the specification, for example, B16.5 is a code referring to ANSI/ ASME, A 105 is a code referring to ASTM.

2.4 In addition, MECON specifications for various piping and pipeline materials shall also be applicable.

3.0 **MATERIAL SPECIFICATION**

Piping material specifications are classified for the general purpose of selection of material for the class of services. The maximum design pressure and design temperature together with the fluid in line governs the selection of material specifications. Deviation of materials from class specifications may occur due to specific design condition. These deviations are permissible if they are equal or better than the individual class requirements.

4.0 **CLASS DESIGNATION CODE**

The piping class designation consist of three digits numbering system made up of letter, number and letter e. g. A1A, B1A, D1A, etc as follows:

First letter indicates ANSI class rating e. g.
A-Class 150
B-Class 300
D-Class 600

The middle number indicates differences in the specification within the same rating and material.

The last letter indicates type of material e. g.

A-Carbon Steel

5.0 **PIPELINE**

The material for linepipe shall be as per the requirements of specification as indicated in Table-1 and Table-2.

6.0 **PIPING**

6.1 Carbon steel pipe shall be made by open hearth, electric furnace or basic oxygen process only. The steel used shall be fully killed and made with fine grain structure. The grade and wall thickness of various sizes of pipes shall be as per piping material specification for the applicable class.

6.2 Pipe dimension shall be in accordance with ANSI B 36.10 for carbon steel pipes and ANSI B 36.19 for stainless steel pipes.

6.3 All pipe threads shall conform to American Standard taper as per ANSI B 1.20.1 NPT, unless otherwise specified.

6.4 For butt weld end, bevel shall be in accordance to ANSI B 16.25/ API 5L as applicable.

7.0 **FITTINGS**

7.1 Fully killed carbon steel shall be used in the manufacture of fittings.

7.2 Threaded joints, if used shall conform to American Standard taper as per ANSI 1.20.1 NPT.

7.3 Dimension of socket weld/ screwed fittings shall conform to ASME B 16.11

7.4 Bore of socket welded fittings shall suit O. D. of pipe and its thickness.

7.5 Dimensions of butt welded carbon steel fittings shall be as per ASME B 16.9 / MSS-SP-75, as applicable.

7.6 Butt welding ends shall conform to ANSI B 16.25/ API 5L. In case of difference in thickness of matching ends, requirements of ASME B 31.8 shall apply.

7.7 Integrally reinforced forged branch fittings such as sockolet, threadolet, weldolet, nippolet etc. shall be as per MSS-SP-97. Fittings not covered in ASME B 16.9 and MSS-SP-97 shall conform to manufacturer's standard.

7.8 Fittings thickness tolerances shall match pipe thickness tolerance.

8.0 BENDS

8.1 Unless otherwise specified for terminal piping, the elbow of radius R=1.5 D shall only be used.

8.2 The radius of cold field bends shall not be less than 30 times the nominal diameter for pipes upto nominal diameter of 16" and shall not be less than 40 times the nominal diameter for pipes of nominal diameter of 18" and above. Limited use of long radius bends (R = 6D) may be permitted for reason of space constraints.

9.0 FLANGES

9.1 Flange rating shall be same as ANSI B 16.5/MSS-SP-44/ B 16.47 Series A as specified.

9.2 Dimensions of flanges shall be in accordance with ANSI B 16.5/ B 16.47 Series A, as applicable.

9.3 Neck of Weld Neck (WN) flanges to suit pipe bore and thickness.

9.4 Bore of Socket Welded (SW) flanges shall suit pipe O.D. and its thickness.

9.5 Threads for screwed flanges if used shall conform to American Standard taper as per ANSI B 1.20.1 NPT.

9.6 Sizes for blind flanges shall be indicated by nominal pipe sizes.

9.7 Carbon steel flanges faces shall have smooth finish as indicated in the material specification. Flanges faces shall have smooth finish to 125-250 micro inches AARH as per MSS-SP-6.

9.8 Butt welding ends of WN flanges shall conform to ANSI B 16.25.

9.9 Spectacle blind/ spacer & blinds shall be in accordance with ASME B 16.48 / Manufacturer's Standard. Spectacle blind shall be used for sizes up to 8" NB and spacer & blind for 10" & above shall be used.

9.10 Two jack screws 180° apart shall be provided for all spectacle blind assemblies. The jack screws shall be as per MECON's standard.

10.0 **GASKETS**

10.1 Spiral wound metallic gaskets shall conform to B 16.20 and API 601 shall be provided with graphite filler. All spiral wound gaskets shall be provided with stainless steel centering ring.

11.0 **BOLTING**

11.1 Nuts for stud bolts shall be American Standard Hexagonal Heavy series and double chamfered.

11.2 Dimension and tolerances for stud bolts and nuts shall be as per ANSI B 18.2.1 and 18.2.2 with full threading to ANSI B 1.1 Class 2A thread for bolts and Class 2B for nuts. Diameter and length of stud bolts shall be as per ANSI B 16.5/ ASME B 16.47 with full threading.

11.3 Threads for nuts shall be as per ANSI B 1.1, as follows:

Nuts for stud dia ¼" to 1"	:	UNC-2B
Nuts for stud bolts dia $1^{1/8}$" to 3 ¼"	:	8UN-2B

11.4 Threads for stud bolts shall be as per ANSI B 1.1, as follows.

Studs bolts dia ¼" to 1"	:	UNC-2A
Stud bolts dia $1^{1/8}$" to 3 ¼"	:	8UN-2A

11.5 Heads of jack screws shall be heavy hexagonal type. Jack screw end shall be rounded. Stud bolts shall be fully threaded with two hexagonal nuts.

12.0 **THREAD SEALANT**

12.1 Threaded joints shall be made with 1" wide PTFE Jointing tape.

13.0 VALVES

13.1 Valve ends shall be as per piping material specifications (Appendices).

13.2 Flange dimensions and face finish of flanged end valves shall confirm to clause 9.0 of this specification.

13.3 Butt welding ends of Butt Welded valves shall conform to ANSI B 16.25.

13.4 Face to face and end to end dimensions shall conform to applicable standards.

13.5 Buried valves on mainline shall be provided with stem extension, sealant, vent/drain & shall have butt welded ends.

13.6 Sectionalizing Valves (Block valves) installed on the main pipeline shall be Ball valves with butt welded ends and shall be full bore to allow smooth passage of cleaning pigs as well as intelligent pigs.

13.7 Unless specified otherwise. Valves shall confirm to the following standards:

Screwed / Socket welded / Flanged end valves (1 ½" and below)

Ball Valves	-	BS 5351(latest)
Plug Valves	-	BS 5353(latest)
Globe Valves	-	BS 5352(latest)
Gate Valves	-	API 602(latest)

Flanged / Butt weld end Valves (2" and above)

Ball Valves	-	API 6D
Plug Valves	-	API 6D
Check Valves	-	API 6D
Globe Valves	-	BS 1873
Gate Valves	-	API 6D

13.8 Manual Valve operators shall be as indicated below, unless specified otherwise in the P&ID.

a) **Gate and Globe Valves**

i) For ANSI class 150 & 300 - Hand Wheel operated for size ≤12"NB.
Gear operated for size ≥14" NB.

ii) For ANSI class 600 - Hand Wheel operated for size ≤10"NB.
Gear operated for size ≥12" NB.

b) **Ball and Plug Valves**

i) For ANSI class 150, 300, 600 – Wrench operated for size ≤4"NB.
Gear operated for size ≥6"NB.

c) **Actuated Valves**- Actuated valves shall be as per P & ID.

14.0 QUICK OPENING END CLOSURE

Quick opening end closure to be installed on scrapper traps shall be equipped with safety locking devices in compliance with section VIII, division 1, UG-35.2 of ASME Boiler and Pressure Vessel code.

15.0 HYDRO TESTING VENTS AND DRAINS

High point vents and low point drains required for the purpose of hydro testing shall be of size 3/4" and consist of sockolet, Plug/ Ball valve for vent, Globe / Ball Valve for drain, flange & blind flange.

16.0 PIPELINE SPECIALITY ITEMS

Pipeline Specialty items viz., Scrapper Traps, Flow Tee, Insulating Joints, LR bends, QOEC for Venting shall be as per respective data sheets, specifications and Project Specific drawing showing Mainline & Terminal materials.

TABLE-1

PIPE WALL THICKNESS DETAILS FOR MAINLINE

Sl. No.	Pipe Material Description	Size (NB)	Thickness (mm)	Length
1	API 5L Gr. X-70, PSL-2	24”	10.31	As per SOR Quantity
2	API 5L Gr. X-70, PSL-2	24”	12.7	As per SOR Quantity
3	API 5L Gr. X-70, PSL-2	24”	17.48	As per SOR Quantity

PIPE WALL THICKNESS DETAILS FOR SPURLINE

TABLE-2

Sl. No.	Pipe Material Description	Size (NB)	Thickness (mm)	Length
1	API 5L Gr. X-56, PSL-2	8”	7.04	As per SOR Quantity
2	API 5L Gr. X-56, PSL-2	8”	7.92	As per SOR Quantity

TABLE-3

INDEX OF PIPING MATERIAL SPECIFICATIONS

Class	Service	C.A. (mm)	Basic Material	Design Code	Enclosed as
D1A	Natural Gas / RLNG	1.5	ASTM A 106 Gr. B/ API 5L Gr. B/	ASME B31.8	Appendix-I
D4A	Natural Gas / RLNG	1.5	ASTM A 333 Gr. 6	ASME B31.8	Appendix-II
B1A	Natural Gas / RLNG	1.5	ASTM A 106 Gr. B/ API 5L Gr. B	ASME B31.8	Appendix-III
B4A	Natural Gas / RLNG	1.5	ASTM A 333 Gr. 6	ASME B31.8	Appendix-IV
A1A	Natural Gas / RLNG	1.5	ASTM A 106 Gr. B/ API 5L Gr. B	ASME B31.8	Appendix-V
A4A	Natural Gas / RLNG	1.5	ASTM A 333 Gr. 6	ASME B31.8	Appendix-VI

ANSI CLASS: 600 #	CORROSION ALLOWANCE: 1.5 MM	TEMP °C	−29.0	38.0	50	100	150	200	250
		PRESS. KG/CM^{2}g	104.14	104.14	102.2	95.04	91.97	89.35	85.07
SERVICE : NATURAL GAS		BASE MATERIAL: CARBON STEEL (MATERIAL GROUP 1.1)							

NOTES: −

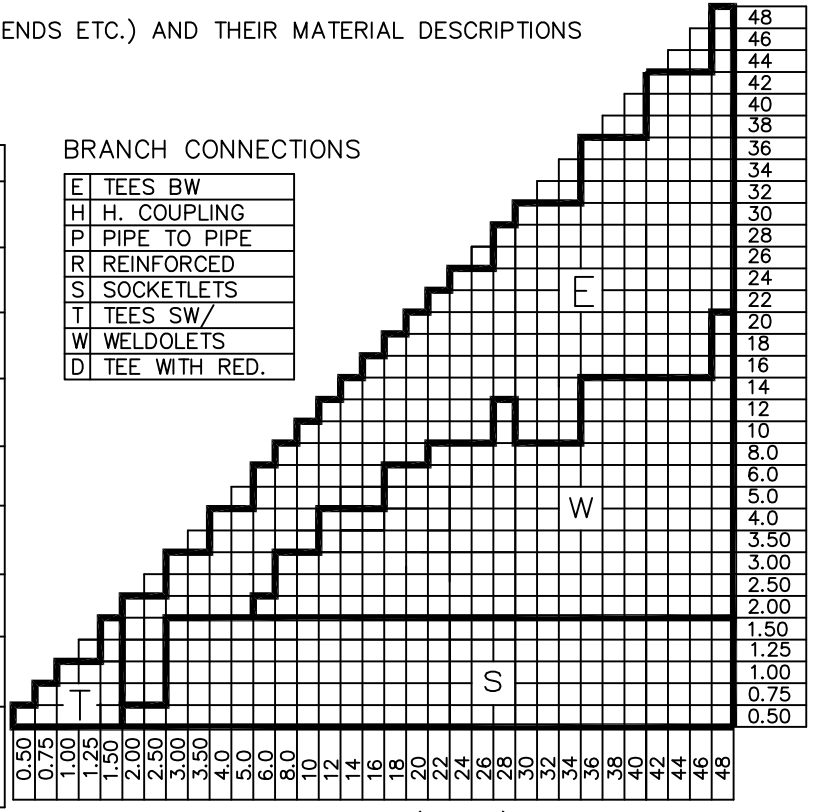
1. ALL VENTS & DRAIN SHALL BE PROVIDED WITH PLUG VALVE UNLESS MENTIONED OTHERWISE IN P&IDs.
2. FITTINGS SHALL BE OF SEAMLESS CONSTRUCTION UP TO 16" AND SHALL BE OF WELDED CONSTRUCTION 18" AND ABOVE.
3. WALL THICKNESS FOR LINEPIPE USED IN VARIOUS SECTIONS SHALL BE AS PER TABLE−1 OF PMS.
4. BALL VALVE TO BE USED IN MAINLINE SHALL HAVE BUTT WELDED ENDS EXCEPT FOR THE VALVES USED FOR HOT TAPPING WHICH SHALL BE ONE SIDE BUTT WELDED AND OTHER SIDE FLANGED.
5. PROCUREMENT OF MATERIALS SHALL BE AS PER DETAILED RELEVANT SPECIFICATIONS.
6. DESIGN PRESSURE & TEMP. FOR PIPELINE AND RELATED FACILITIES ARE 92 Kg/Cm^{2}g & (−29° TO +65°C) RESPECTIVELY.
7. PRESSURE−TEMPERATURE RATING INDICATED ARE FOR FLANGES ONLY IN ACCORDANCE WITH ANSI B 16.5
8. FOR VALVES,STEELPIPE AND ASSOCIATED STEEL COMPONENTS OF 2" AND LARGER NOTCH TOUGHNESS PROPERTIES SHALL BE AS SPECIFIED IN RELEVANT SPECIFICATIONS/CODES, MECON'S STANDARD TECHNICAL SPECIFICATIONS AND DATA SHEETS ETC.
9. AT STATIONS, BRANCH CONNECTIONS SHALL BE AS PER BRANCH CONNECTION TABLE BELOW.
10. ALL BUTT WELDS SHALL BE 100% RADIOGRAPHED.
11. 100% OF SOCKET WELD SHALL BE SUBJECTED TO MPI/DPT.
12. PRESSURE−TEMPERATURE RATING OF VALVE BODY SHALL BE AS PER API 6D.
13. PIPELINE DESIGN CODE − ASME B 31.8 & OISD 226.
14. FOR PIPELINE SPECIALITY ITEMS (SCRAPPER TRAP, FLOW TEE, IJ, LR BENDS ETC.) AND THEIR MATERIAL DESCRIPTIONS REFER DATA SHEET OF RESPECTIVE ITEMS.

STATION PIPING MATERIAL SPECIFICATION

ITEM	SIZE	DESCRIPTION
MAINTENANCE JOINTS	ALL	FLGD., BUT TO BE KEPT MINIMUM
PIPE JOINTS	1.5" & BELOW	SOCKET WELD
	2" & ABOVE	BUTT WELDED
DRAINS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
VENTS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
TEMP. CONN.	1.5"	FLGD. INSTL. AS PER MEC/SD/05/21/15/02
PRESS CONN.	3/4"	SCH. 160 NIPPLE WITH BALL VALVE TO SPEC. INSTALLATION AS PER MEC/SD/05/21/15/05

BRANCH CONNECTIONS

E	TEES BW
H	H. COUPLING
P	PIPE TO PIPE
R	REINFORCED
S	SOCKETLETS
T	TEES SW/
W	WELDOLETS
D	TEE WITH RED.



SECTION: OIL & GAS

APPROVED | DRWN | DSGN | K.P. | NAME | DATE | CHKD | DATE

A.GANGAL

REV NO | DATE | ZONE | DESCRIPTIONS | BY | APPRD

REVISIONS

REFERENCES

NATURAL GAS PIPELINE PROJECT

PIPING MATERIAL SPECIFICATIONS 600# (D1A)

APPENDIX−I

SCALE : N.T.S.

(SH. 1 OF 2)

REV 0

DRG. NO.

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PIPELINE/PIPING DESIGN CODE		ASME B 31.8/ OISD 226									DESIGN FACTOR – 0.5									
ITEM	NOMINAL DIAMETER (INCHES)	0.50	0.75	1.00	1.50	2.00	3.00	4.00	6.00	8.00	10.0	12.0	14.0	16.0	18.0	20.0	24.0	28.0	30.0
PIPE	WALL THICKNESS (MM/SCH)	S160	S160	S80	S80	S80	XS	XS	XS	14.3	XS	S60	14.3	17.5	S60	S60	19.1	22.2	23.8
	MATERIAL	ASTM A106 GR.B				ASTM A106 GR.B (CHARPY)				API 5L GR.B PSL2	API 5L GR.X–52 PSL2								
	DIMENSION STD.	B36.10								API 5L									
	METHOD OF MANUFACTURE, ENDS	SEAMLESS PE				SEAMLESS BE					BE SAW								
FLANGE	MATERIAL AND GRADE	ASTM A 105				ASTM A 105 (CHARPY)					ASTM A 694 GR.F–52 (CHARPY)								
	TYPE, FLANGE FACING	SW. RF 125AARH				WN. THICKNESS TO MATCH PIPE THICKNESS,RF 125AARH													
	DIMENSION STD.	B16.5									B 16.47A								
BLIND FLANGE	MATERIAL AND GRADE	ASTM A 105				ASTM A 105 (CHARPY)													
	FLANGE FACING	RF 125AARH																	
	DIMENSION STD.	B16.5									B 16.47A								
BLANK	MATERIAL AND GRADE	ASTM A 105				ASTM A 105 (CHARPY)					ASTM A 516 GR.–70								
	FLANGE FACING	FF 125AARH																	
	DIMENSION STD.	B16.48									MNF' STD								
	TYPE	FIG.8 FLANGE									SPACER & BLIND								
BOLTING	STUD BOLTS (FULLY THREADED)	A 193 GR B7, B–18.2																	
	NUTS (HEAVY HEXAGONAL)	A 194 GR 2H, B–18.2																	
GASKET	TYPE ,MATERIAL AND Dmn. STD.	SPIRAL 600# , SP.WND SS316+GRAPHITE FILLED, B–16.20–ANSI B16.5,																	
ELBOW–90 ELBOW–45	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)					MSS–SP–75 GR.W PHY–52								
	END DETAIL	SW,6000#		SW,3000#		BW, 1.5D													
	DIMENSION STD.	B–16.11				B–16.9					MSS–SP–75								
T–EQUAL T–RED	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)					MSS–SP–75 GR.W PHY–52								
	END DETAIL	SW,6000#		SW,3000#		BW													
	DIMENSION STD.	B–16.11				B–16.9					MSS–SP–75								
CAP	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)					MSS–SP–75 GR.W PHY–52								
	END DETAIL	SCRF6000		SCRF3000		BW,THICKNESS TO MATCH PIPE THICKNESS													
	DIMENSION STD.	B–16.11				B–16.9					MSS–SP–75								
FITTING	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)					MSS–SP–75 GR.W PHY–52								
	END DETAIL	SW–6000#		SW–3000#		BW,THICKNESS TO MATCH PIPE THICKNESS													
	DIMENSION STD.	B–16.11				B–16.9					MSS–SP–75								
	TYPE	COUPLING FULL,HALF LH.,RED.				RED. CON. RED. ECC.													
O'LET	MATERIAL	ASTM A 105				ASTM A 105 (CHARPY)					ASTM A 694 GR.F–52 (CHARPY)								
	END DETAIL	SW,6000#		SW,3000#		BW					BW								
	DIMENSION STD.	MSS–SP97				MSS–SP97					MSS–SP97								
	TYPE	SOCKOLET				WELDOLET					WELDOLET								

APPROVED A.GANGAL

DRWN

DSGN K.P.

NAME DATE CHKD H.K. DATE

SECTION: OIL & GAS

REV NO DATE ZONE DESCRIPTIONS BY APPRD REVISIONS

REFERENCES

DRG. NO.

NATURAL GAS PIPELINE PROJECT

PIPING MATERIAL SPECIFICATIONS 600# (D1A)

SCALE : N.T.S.

APPENDIX–I

(SH. 2 OF 2)

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ANSI CLASS: 600#	CORROSION ALLOWANCE: 1.5MM	TEMP °C	−45	38	50	100	150	200	
		PRESS. KG/CM^2 g	97.89	97.89	96.77	92.48	89.63	87.02	
SERVICE : RLNG		BASE MATERIAL: CARBON STEEL (MATERIAL GROUP 1.3)							

NOTES: –

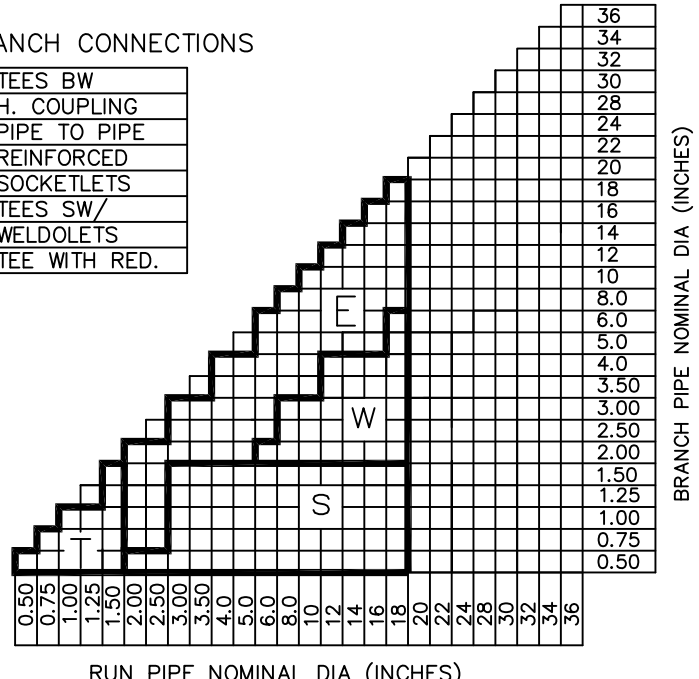
1. ALL VENTS & DRAIN SHALL BE PROVIDED WITH PLUG VALVE UNLESS MENTIONED OTHERWISE IN P&IDs.
2. FITTINGS SHALL BE OF SEAMLESS CONSTRUCTION UP TO 16" AND SHALL BE OF WELDED CONSTRUCTION 18" AND ABOVE.
3. WALL THICKNESS FOR LINEPIPE USED IN VARIOUS SECTIONS SHALL BE AS PER TABLE–1 OF PMS.
4. BALL VALVE TO BE USED IN MAINLINE SHALL HAVE BUTT WELDED ENDS EXCEPT FOR THE VALVES USED FOR HOT TAPPING WHICH SHALL BE ONE SIDE BUTT WELDED AND OTHER SIDE FLANGED.
5. PROCUREMENT OF MATERIALS SHALL BE AS PER DETAILED RELEVANT SPECIFICATIONS.
6. DESIGN PRESSURE & TEMP. FOR PIPELINE AND RELATED FACILITIES ARE 92 Kg/cm² g & (−45° TO +65°C) RESPECTIVELY.
7. PRESSURE–TEMPERATURE RATING INDICATED ARE FOR FLANGES ONLY IN ACCORDANCE WITH ANSI B 16.5
8. FOR VALVES,STEELPIPE AND ASSOCIATED STEEL COMPONENTS OF 2" AND LARGER NOTCH TOUGHNESS PROPERTIES SHALL BE AS SPECIFIED IN RELEVANT SPECIFICATIONS/CODES, MECON'S STANDARD TECHNICAL SPECIFICATIONS AND DATA SHEETS ETC.
9. AT STATIONS, BRANCH CONNECTIONS SHALL BE AS PER BRANCH CONNECTION TABLE BELOW
10. ALL BUTT WELDS SHALL BE 100% RADIOGRAPHED.
11. 100% OF SOCKET WELD SHALL BE SUBJECTED TO MPI/DPT.
12. PRESSURE–TEMPERATURE RATING OF VALVE BODY SHALL BE AS PER API 6D.
13. PIPELINE DESIGN CODE – ASME B 31.8 & OISD 226.
14. FOR PIPELINE SPECIALITY ITEMS (SCRAPPER TRAP, FLOW TEE, IJ, LR BENDS ETC.) AND THEIR MATERIAL DESCRIPTIONS REFER DATA SHEET OF RESPECTIVE ITEMS.

STATION PIPING MATERIAL SPECIFICATION

ITEM	SIZE	DESCRIPTION
MAINTENANCE JOINTS	ALL	FLGD., BUT TO BE KEPT MINIMUM
PIPE JOINTS	1.5" & BELOW	SOCKET WELD
	2" & ABOVE	BUTT WELDED
DRAINS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
VENTS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
TEMP. CONN.	1.5"	FLGD. INSTL. AS PER MEC/SD/05/21/15/02
PRESS CONN.	3/4"	NIPPLE WITH BALL VALVE TO SPEC. INSTALLATION AS PER MEC/SD/05/21/15/05

BRANCH CONNECTIONS

E	TEES BW
H	H. COUPLING
P	PIPE TO PIPE
R	REINFORCED
S	SOCKETLETS
T	TEES SW/
W	WELDOLETS
D	TEE WITH RED.



SECTION: OIL & GAS

APPROVED A.GANGAL | DRWN | DSGN B.B. | CHKD S.K. | NAME | DATE | DATE | DATE

NATURAL GAS PIPELINE PROJECT

PIPING MATERIAL SPECIFICATIONS LOW TEMP SERVICE 600# (D4A)

SCALE : N.T.S. APPENDIX–II (SH. 1 OF 2)

REV 0

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REVISIONS | REV NO | DATE | ZONE | DESCRIPTIONS | BY | APPRD | REFERENCES | DRG. NO.

PIPELINE/PIPING DESIGN CODE		ASME B 31.8/ OISD 226									DESIGN FACTOR – 0.5								
ITEM	NOMINAL DIAMETER (INCHES)	0.50	0.75	1.00	1.50	2.00	3.00	4.00	6.00	8.00	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	
PIPE	WALL THICKNESS (MM/SCH)	S160	S160	XS	XS	XS	STD	XS	XS	XS	XS	19.0	20.6	22.2	25.4	22.2	25.4	26.3	
	MATERIAL	ASTM A333 GR.6																	
	DIMENSION STD.	B36.10																	
	METHOD OF MANUFACTURE, ENDS	SEAMLESS PE				SEAMLESS BE								BE SAW					
FLANGE	MATERIAL AND GRADE	ASTM A 350 GR. LF2, CL–I																	
	TYPE, FLANGE FACING	SW. RF 125AARH				WN. THICKNESS TO MATCH PIPE THICKNESS, RF 125AARH													
	DIMENSION STD.	B16.5																	
BLIND FLANGE	MATERIAL AND GRADE	ASTM A 350 GR. LF2, CL–I																	
	FLANGE FACING	RF 125AARH																	
	DIMENSION STD.	B16.5																	
BLANK	MATERIAL AND GRADE	ASTM A 350 GR. LF2, CL–I																	
	FLANGE FACING	FF 125AARH																	
	DIMENSION STD.	B16.48																	
	TYPE	FIG.8 FLANGE									SPACER & BLIND								
BOLTING	STUD BOLTS (FULLY THREADED)	A 320 GR L7, B–18.2																	
	NUTS (HEAVY HEXAGONAL)	A 194 GR 4, B–18.2																	
GASKET	TYPE, MATERIAL AND Dmn. STD.	SPIRAL, SP.WND SS316+GRAPHITE FILLED, B–16.20–ANSI B16.5,																	
ELBOW–90 ELBOW–45	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								A 420 GR.WPL6.W					
	END DETAIL	SW,6000#		SW,3000#		BW, 1.5D													
	DIMENSION STD.	B–16.11				B–16.9													
T–EQUAL T–RED	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								ASTM A 420 GR.WPL6.W					
	END DETAIL	SW,6000#		SW,3000#		BW													
	DIMENSION STD.	B–16.11				B–16.9													
CAP & PLUG (UPTO 1.5")	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6													
	END DETAIL	SCRF6000		SCRF3000		BW, THK TO MATCH PIPE THICKNESS													
	DIMENSION STD.	B–16.11				B–16.9													
FITTING	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								ASTM A 420 GR.WPL6.W					
	END DETAIL	SW–6000		SW–3000		BW, THICKNESS TO MATCH PIPE THICKNESS													
	DIMENSION STD.	B–16.11				B–16.9													
	TYPE	COUPLING FULL,HALF LH.,RED.				RED. CON. RED. ECC.													
O'LET	MATERIAL	ASTM A350 GR.LF2																	
	END DETAIL	SW,6000#		SW,3000#		BW													
	DIMENSION STD.	MSS–SP97				MSS–SP97													
	TYPE	SOCKOLET				WELDOLET													

SECTION: OIL & GAS

APPROVED | DRWN | DSGN K.P. | NAME | DATE | CHKD | DATE

A.GANGAL

REV NO | DATE | ZONE | DESCRIPTIONS | BY | APPRD

REVISIONS

REFERENCES

DRG. NO.

NATURAL GAS PIPELINE PROJECT

PIPING MATERIAL SPECIFICATIONS LOW TEMP SERVICE 600# (D4A)

APPENDIX–II

SCALE : N.T.S.

(SH. 2 OF 2)

REV 0

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MECON LIMITED

ANSI CLASS: 300 #	CORROSION ALLOWANCE: 1.5 MM	TEMP °C	−29.0	38.0	50	100	150	200
		PRESS. KG/CM^{2}g	52.1	52.1	51.10	47.52	45.98	44.60
SERVICE : NATURAL GAS		BASE MATERIAL: CARBON STEEL (MATERIAL GROUP 1.1)						

NOTES: −

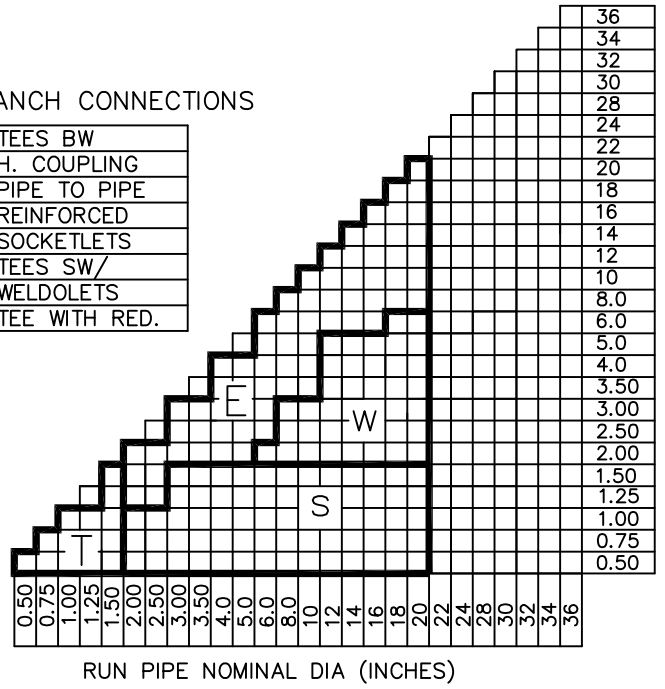
1. ALL VENTS & DRAIN SHALL BE PROVIDED WITH PLUG VALVE UNLESS MENTIONED OTHERWISE IN P&IDs.
2. FITTINGS SHALL BE OF SEAMLESS CONSTRUCTION UP TO 16" AND SHALL BE OF WELDED CONSTRUCTION 18" AND ABOVE.
3. WALL THICKNESS FOR LINEPIPE USED IN VARIOUS SECTIONS SHALL BE AS PER TABLE−1 OF PMS.
4. BALL VALVE TO BE USED IN MAINLINE SHALL HAVE BUTT WELDED ENDS EXCEPT FOR THE VALVES USED FOR HOT TAPPING WHICH SHALL BE ONE SIDE BUTT WELDED AND OTHER SIDE FLANGED.
5. PROCUREMENT OF MATERIALS SHALL BE AS PER DETAILED RELEVANT SPECIFICATIONS.
6. DESIGN PRESSURE & TEMP. FOR PIPELINE AND RELATED FACILITIES ARE 49 Kg/cm² g & (−29° TO +65°C) RESPECTIVELY.
7. PRESSURE−TEMPERATURE RATING INDICATED ARE FOR FLANGES ONLY IN ACCORDANCE WITH ANSI B 16.5
8. FOR VALVES,STEELPIPE AND ASSOCIATED STEEL COMPONENTS OF 2" & LARGER NOTCH TOUGHNESS PROPERTIES SHALL BE AS SPECIFIED. IN RELEVANT SPECIFICATIONS/CODES, MECON'S STANDARD TECHNICAL SPECIFICATIONS AND DATA SHEETS ETC.
9. AT STATIONS, BRANCH CONNECTIONS SHALL BE AS PER BRANCH CONNECTION TABLE BELOW
10. ALL BUTT WELDS SHALL BE 100% RADIOGRAPHED.
11. 100% OF SOCKET WELD SHALL BE SUBJECTED TO MPI/DPT.
12. PRESSURE−TEMPERATURE RATING OF VALVE BODY SHALL BE AS PER API 6D.
13. PIPELINE DESIGN CODE − ASME B 31.8 & OISD 226.
14. FOR PIPELINE SPECIALITY ITEMS (SCRAPPER TRAP, FLOW TEE, IJ, LR BENDS ETC.) AND THEIR MATERIAL DESCRIPTIONS REFER DATA SHEET OF RESPECTIVE ITEMS.

STATION PIPING MATERIAL SPECIFICATION

ITEM	SIZE	DESCRIPTION
MAINTENANCE JOINTS	ALL	FLGD., BUT TO BE KEPT MINIMUM
PIPE JOINTS	1.5" & BELOW	SOCKET WELD
	2" & ABOVE	BUTT WELDED
DRAINS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
VENTS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
TEMP. CONN.	1.5"	FLGD. INSTL. AS PER MEC/SD/05/21/15/02
PRESS CONN.	3/4"	SCH. 160 NIPPLE WITH BALL VALVE TO SPEC. INSTALLATION AS PER MEC/SD/05/21/15/05

BRANCH CONNECTIONS

E	TEES BW
H	H. COUPLING
P	PIPE TO PIPE
R	REINFORCED
S	SOCKETLETS
T	TEES SW/
W	WELDOLETS
D	TEE WITH RED.



SECTION: OIL & GAS

APPROVED | DRWN | DSGN K.P. | CHKD H.K. | NAME | DATE | CHKD | DATE

A.GANGAL

REVISIONS | REV NO | DATE | ZONE | DESCRIPTIONS | BY | APPRD | REFERENCES | DRG. NO.

NATURAL GAS PIPELINE PROJECT

PIPING MATERIAL SPECIFICATIONS 300# (B1A)

APPENDIX−III

SCALE : N.T.S. (SH. 1 OF 2)

REV 0

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MECON LIMITED

PIPELINE/PIPING DESIGN CODE		ASME B 31.8/ OISD 226								DESIGN FACTOR – 0.5					
ITEM	NOMINAL DIAMETER (INCHES)	0.50	0.75	1.00	1.50	2.00	3.00	4.00	6.00	8.00	10.0	12.0	14.0	16.0	18.0	20.0
PIPE	WALL THICKNESS (MM/SCH)	S160	S160	XS	XS	XS	STD	S40	S40	7.9	STD	S40	S40	S40	S40	15.9
	MATERIAL	ASTM A106 GR.B				ASTM A106 GR.B (CHARPY)				API 5L GR.B PSL2						
	DIMENSION STD.	B36.10								API 5L						
	METHOD OF MANUFACTURE, ENDS	SEAMLESS PE				SEAMLESS BE							BE SAW			
FLANGE	MATERIAL AND GRADE	ASTM A 105				ASTM A 105 (CHARPY)										
	TYPE, FLANGE FACING	SW. RF 125AARH				WN. THICKNESS TO MATCH PIPE THICKNESS,RF 125AARH										
	DIMENSION STD.	B16.5														
BLIND FLANGE	MATERIAL AND GRADE	ASTM A 105				ASTM A 105 (CHARPY)										
	FLANGE FACING	RF 125AARH														
	DIMENSION STD.	B16.5														
BLANK	MATERIAL AND GRADE	ASTM A 105				ASTM A 105 (CHARPY)										
	FLANGE FACING	FF 125AARH														
	DIMENSION STD.	B16.48														
	TYPE	FIG.8 FLANGE									SPACER & BLIND					
BOLTING	STUD BOLTS (FULLY THREADED)	A 193 GR B7, B–18.2														
	NUTS (HEAVY HEXAGONAL)	A 194 GR 2H, B–18.2														
GASKET	TYPE ,MATERIAL AND Dmn. STD.	SPIRAL 300# , SP.WND SS316+GRAPHITE FILLED, B–16.20–ANSI B16.5,														
ELBOW–90 ELBOW–45	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)										
	END DETAIL	SW,6000#		SW,3000#		BW, 1.5D										
	DIMENSION STD.	B–16.11				B–16.9										
T–EQUAL T–RED	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)										
	END DETAIL	SW,6000#		SW,3000#		BW, THICKNESS TO MATCH PIPE THICKNESS										
	DIMENSION STD.	B–16.11				B–16.9										
CAP	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)										
	END DETAIL	SCRF6000#		SCRF3000#		BW,THICKNESS TO MATCH PIPE THICKNESS										
	DIMENSION STD.	B–16.11				B–16.9										
FITTING	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)										
	END DETAIL	SW,6000#		SW,3000#		BW,THICKNESS TO MATCH PIPE THICKNESS										
	DIMENSION STD.	B–16.11				B–16.9										
	TYPE	COUPLING FULL,HALF LH.,RED.				RED. CON. RED. ECC.										
O'LET	MATERIAL	ASTM A 105				ASTM A 105 (CHARPY)										
	END DETAIL	SW,6000#		SW,3000#		BW										
	DIMENSION STD.	MSS–SP97				MSS–SP97										
	TYPE	SOCKOLET				WELDOLET										

APPROVED
DRWN
DSGN K.P.
A.GANGAL
NAME DATE CHKD H.K. DATE

SECTION: OIL & GAS

REV NO | DATE | ZONE | DESCRIPTIONS | BY | APPRD

REVISIONS

REFERENCES

DRG. NO.

NATURAL GAS PIPELINE PROJECT

PIPING MATERIAL SPECIFICATIONS 300# (B1A)

SCALE : N.T.S.

APPENDIX–III

(SH. 2 OF 2)

REV 0

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MECON LIMITED

ANSI CLASS: 300#	CORROSION ALLOWANCE: 1.5MM	TEMP °C	−45	38	50	80	100	120	150
		PRESS. KG/CM^{2}g	48.95	48.95	48.44	46.72	46.19	45.54	44.76
SERVICE : RLNG		BASE MATERIAL: CARBON STEEL (MATERIAL GROUP 1.3)							

NOTES: –

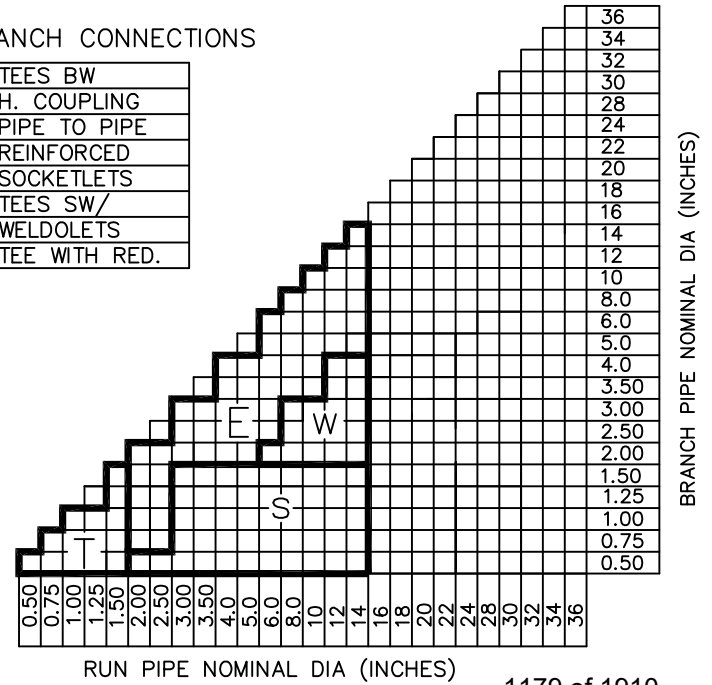
1. ALL VENTS & DRAIN SHALL BE PROVIDED WITH PLUG VALVE UNLESS MENTIONED OTHERWISE IN P&IDs.
2. FITTINGS SHALL BE OF SEAMLESS CONSTRUCTION UP TO 16" AND SHALL BE OF WELDED CONSTRUCTION 18" AND ABOVE.
3. WALL THICKNESS FOR LINEPIPE USED IN VARIOUS SECTIONS SHALL BE AS PER TABLE–1 OF PMS.
4. BALL VALVE TO BE USED IN MAINLINE SHALL HAVE BUTT WELDED ENDS EXCEPT FOR THE VALVES USED FOR HOT TAPPING WHICH SHALL BE ONE SIDE BUTT WELDED AND OTHER SIDE FLANGED.
5. PROCUREMENT OF MATERIALS SHALL BE AS PER DETAILED RELEVANT SPECIFICATIONS.
6. PRESSURE–TEMPERATURE RATING INDICATED ARE FOR FLANGES ONLY IN ACCORDANCE WITH ANSI B 16.5
7. FOR VALVES,STEELPIPE AND ASSOCIATED STEEL COMPONENTS OF 2" & LARGER NOTCH TOUGHNESS PROPERTIES SHALL BE AS SPECIFIED. IN RELEVANT SPECIFICATIONS/CODES, MECON'S STANDARD TECHNICAL SPECIFICATIONS AND DATA SHEETS ETC.
8. AT STATIONS, BRANCH CONNECTIONS SHALL BE AS PER BRANCH CONNECTION TABLE BELOW
9. ALL BUTT WELDS SHALL BE 100% RADIOGRAPHED.
10. 100% OF SOCKET WELD SHALL BE SUBJECTED TO MPI/DPT.
11. PRESSURE–TEMPERATURE RATING OF VALVE BODY SHALL BE AS PER API 6D.
12. PIPELINE DESIGN CODE – ASME B 31.8 & OISD 226.
13. FOR PIPELINE SPECIALITY ITEMS (SCRAPPER TRAP, FLOW TEE, IJ, LR BENDS ETC.) AND THEIR MATERIAL DESCRIPTIONS REFER DATA SHEET OF RESPECTIVE ITEMS.
14. DESIGN PRESSURE &TEMP. FOR PIPELINE AND RELATED FACILITIES ARE 49 KG/cm^{2}g &(−45° TO +65° C) RESPECTIVELY.

STATION PIPING MATERIAL SPECIFICATION

ITEM	SIZE	DESCRIPTION
MAINTENANCE JOINTS	ALL	FLGD., BUT TO BE KEPT MINIMUM
PIPE JOINTS	1.5" & BELOW	SOCKET WELD
	2" & ABOVE	BUTT WELDED
DRAINS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
VENTS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
TEMP. CONN.	1.5"	FLGD. INSTL. AS PER MEC/SD/05/21/15/02
PRESS CONN.	3/4"	NIPPLE WITH BALL VALVE TO SPEC. INSTALLATION AS PER MEC/SD/05/21/15/05

BRANCH CONNECTIONS

E	TEES BW
H	H. COUPLING
P	PIPE TO PIPE
R	REINFORCED
S	SOCKETLETS
T	TEES SW/
W	WELDOLETS
D	TEE WITH RED.



APPROVED A.GANGAL | DRWN | DSGN K.P. | CHKD H.K. | NAME | DATE | DATE

SECTION: OIL & GAS

NATURAL GAS PIPELINE PROJECT

PIPING MATERIAL SPECIFICATIONS LOW TEMP SERVICE 300# (B4A)

SCALE : N.T.S. APPENDIX–IV (SH. 1 OF 2)

REV 0

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REVISIONS | REV NO | DATE | ZONE | DESCRIPTIONS | BY | APPRD | REFERENCES | DRG. NO.

PIPELINE/PIPING DESIGN CODE		ASME B 31.8/ OISD 226									DESIGN FACTOR – 0.5								
ITEM	NOMINAL DIAMETER (INCHES)	0.50	0.75	1.00	1.50	2.00	3.00	4.00	6.00	8.00	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	
PIPE	WALL THICKNESS (MM/SCH)	S160	S160	XS	XS	XS	STD	STD	STD	STD	STD	S40	S40	S30	S30	S30	S30	S30	
	MATERIAL	ASTM A333 GR.6																	
	DIMENSION STD.	B36.10																	
	METHOD OF MANUFACTURE, ENDS	SEAMLESS PE				SEAMLESS BE								BE, SAW					
FLANGE	MATERIAL AND GRADE	ASTM A 350 GR. LF2, CL–I																	
	TYPE, FLANGE FACING	SW. RF 125AARH				WN. THICKNESS TO MATCH PIPE THICKNESS, RF 125AARH													
	DIMENSION STD.	B16.5																	
BLIND FLANGE	MATERIAL AND GRADE	ASTM A 350 GR. LF2, CL–I																	
	FLANGE FACING	RF 125AARH																	
	DIMENSION STD.	B16.5																	
BLANK	MATERIAL AND GRADE	ASTM A 350 GR. LF2, CL–I																	
	FLANGE FACING	FF 125AARH																	
	DIMENSION STD.	B16.48																	
	TYPE	FIG.8 FLANGE									SPACER BLIND								
BOLTING	STUD BOLTS (FULLY THREADED)	A 320 GR L7, B–18.2																	
	NUTS (HEAVY HEXAGONAL)	A 194 GR 4, B–18.2																	
GASKET	TYPE, MATERIAL AND Dmn. STD.	SPIRAL, SP.WND SS316+GRAPHITE FILLED, B–16.20–ANSI B16.5,																	
ELBOW–90 ELBOW–45	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								ASTM A 420 GR.WPL6W					
	END DETAIL	SW,6000#		SW,3000#		BW, 1.5D													
	DIMENSION STD.	B–16.11				B–16.9													
T–EQUAL T–RED	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								ASTM A 420 GR.WPL6W					
	END DETAIL	SW,6000#		SW,3000#		BW													
	DIMENSION STD.	B–16.11				B–16.9													
CAP & PLUG (UPTO 1.5")	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								ASTM A 420 GR.WPL6W					
	END DETAIL	SCRF6000		SCRF3000		BW, THK TO MATCH PIPE THICKNESS													
	DIMENSION STD.	B–16.11				B–16.9													
FITTING	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								ASTM A 420 GR.WPL6W					
	END DETAIL	SW–6000		SW–3000		BW, THICKNESS TO MATCH PIPE THICKNESS													
	DIMENSION STD.	B–16.11				B–16.9													
	TYPE	COUPLING FULL,HALF LH.,RED.				RED. CON. RED. ECC.													
O'LET	MATERIAL	ASTM A350 GR.LF2																	
	END DETAIL	SW,6000#		SW,3000#		BW													
	DIMENSION STD.	MSS–SP97				MSS–SP97													
	TYPE	SOCKOLET				WELDOLET													

ANSI CLASS: 150 #	CORROSION ALLOWANCE: 1.5 MM	TEMP °C	−29	38.0	50	100	150	200
		PRESS. KG/CM^{2}g	19.98	19.98	19.57	18.05	16.11	14.07
SERVICE : NATURAL GAS		BASE MATERIAL: CARBON STEEL (MATERIAL GROUP 1.1)						

NOTES: −

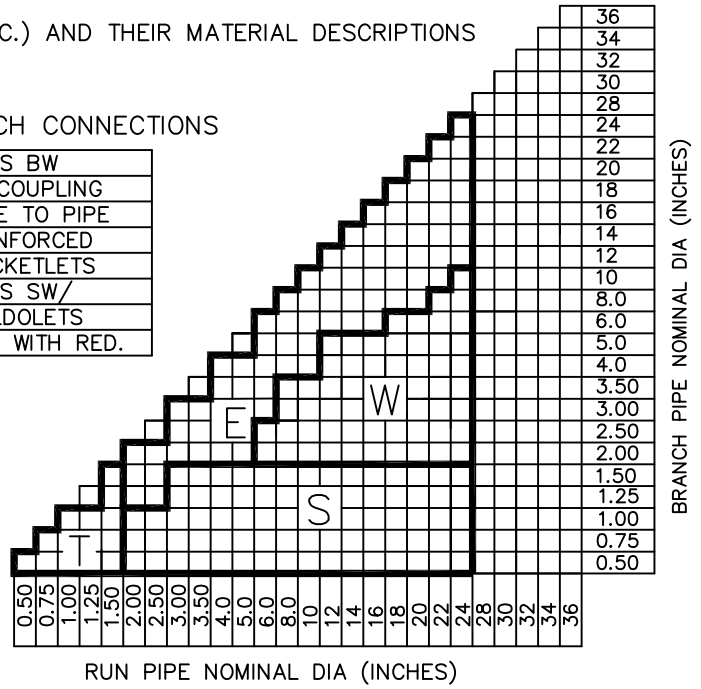
1. ALL VENTS & DRAIN SHALL BE PROVIDED WITH PLUG VALVE UNLESS MENTIONED OTHERWISE IN P&IDs.
2. FITTINGS SHALL BE OF SEAMLESS CONSTRUCTION UP TO 16" AND SHALL BE OF WELDED CONSTRUCTION 18" AND ABOVE.
3. WALL THICKNESS FOR LINEPIPE USED IN VARIOUS SECTIONS SHALL BE AS PER TABLE−1 OF PMS.
4. BALL VALVE TO BE USED IN MAINLINE SHALL HAVE BUTT WELDED ENDS EXCEPT FOR THE VALVES USED FOR HOT TAPPING WHICH SHALL BE ONE SIDE BUTT WELDED AND OTHER SIDE FLANGED.
5. PROCUREMENT OF MATERIALS SHALL BE AS PER DETAILED RELEVANT SPECIFICATIONS.
6. DESIGN PRESSURE & TEMP. FOR PIPELINE AND RELATED FACILITIES ARE 19 Kg/Cm^{2}g & (−29° TO +65°C) RESPECTIVELY.
7. PRESSURE−TEMPERATURE RATING INDICATED ARE FOR FLANGES ONLY IN ACCORDANCE WITH ANSI B 16.5
8. FOR VALVES,STEELPIPE AND ASSOCIATED STEEL COMPONENTS OF 2" AND LARGER NOTCH TOUGHNESS PROPERTIES SHALL BE AS SPECIFIED IN RELEVANT SPECIFICATIONS/CODES, MECON'S STANDARD TECHNICAL SPECIFICATIONS AND DATA SHEETS ETC.
9. AT STATIONS, BRANCH CONNECTIONS SHALL BE AS PER BRANCH CONNECTION TABLE BELOW
10. ALL BUTT WELDS SHALL BE 100% RADIOGRAPHED.
11. 100% OF SOCKET WELD SHALL BE SUBJECTED TO MPI/DPT.
12. PRESSURE−TEMPERATURE RATING OF VALVE BODY SHALL BE AS PER API 6D.
13. PIPELINE DESIGN CODE − ASME B 31.8 & OISD 226.
14. FOR PIPELINE SPECIALITY ITEMS (SCRAPPER TRAP, FLOW TEE, IJ, LR BENDS ETC.) AND THEIR MATERIAL DESCRIPTIONS REFER DATA SHEET OF RESPECTIVE ITEMS.

STATION PIPING MATERIAL SPECIFICATION

ITEM	SIZE	DESCRIPTION
MAINTENANCE JOINTS	ALL	FLGD., BUT TO BE KEPT MINIMUM
PIPE JOINTS	1.5" & BELOW	SOCKET WELD
	2" & ABOVE	BUTT WELDED
DRAINS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
VENTS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
TEMP. CONN.	1.5"	FLGD. INSTL. AS PER MEC/SD/05/21/15/02
PRESS CONN.	3/4"	SCH. 160 NIPPLE WITH BALL VALVE TO SPEC. INSTALLATION AS PER MEC/SD/05/21/15/05

BRANCH CONNECTIONS

E	TEES BW
H	H. COUPLING
P	PIPE TO PIPE
R	REINFORCED
S	SOCKETLETS
T	TEES SW/
W	WELDOLETS
D	TEE WITH RED.



SECTION: OIL & GAS

APPROVED A.GANGAL

DRWN | DSGN K.P. | CHKD H.K. | NAME | DATE | DATE

NATURAL GAS PIPELINE PROJECT

PIPING MATERIAL SPECIFICATIONS 150# (A1A)

SCALE : N.T.S.

APPENDIX−V

(SH. 1 OF 2)

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MECON LIMITED

REVISIONS | REV NO | DATE | ZONE | DESCRIPTIONS | BY | APPRD | REFERENCES | DRG. NO.

PIPELINE/PIPING DESIGN CODE		ASME B 31.8/ OISD 226																	DESIGN FACTOR – 0.5
ITEM	NOMINAL DIAMETER (INCHES)	0.50	0.75	1.00	1.50	2.00	3.00	4.00	6.00	8.00	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	
PIPE	WALL THICKNESS (MM/SCH)	S160	S160	XS	XS	XS	STD	STD	STD	S20	S20	S20	S10	S10	S10	7.1	7.9	8.7	
	MATERIAL	ASTM A106 GR.B				ASTM A106 GR.B (CHARPY)				API 5L GR.B PSL2									
	DIMENSION STD.	B36.10								API 5L									
	METHOD OF MANUFACTURE, ENDS	SEAMLESS PE				SEAMLESS BE							SAW, BE						
FLANGE	MATERIAL AND GRADE	ASTM A 105				ASTM A 105 (CHARPY)													
	TYPE, FLANGE FACING	SW. RF 125AARH				WN. THICKNESS TO MATCH PIPE THICKNESS, RF 125AARH													
	DIMENSION STD.	B16.5																	
BLIND FLANGE	MATERIAL AND GRADE	ASTM A 105				ASTM A 105 (CHARPY)													
	FLANGE FACING	RF 125AARH																	
	DIMENSION STD.	B16.5																	
BLANK	MATERIAL AND GRADE	ASTM A 105				ASTM A 105 (CHARPY)													
	FLANGE FACING	FF 125AARH																	
	DIMENSION STD.	B16.48																	
	TYPE	FIG.8 FLANGE									SPACER & BLIND								
BOLTING	STUD BOLTS (FULLY THREADED)	A 193 GR B7, B–18.2																	
	NUTS (HEAVY HEXAGONAL)	A 194 GR 2H, B–18.2																	
GASKET	TYPE, MATERIAL AND Dmn. STD.	SP. WND SS 316+GRAPHITE FILLED AS PER B 16.20/ANSI B 16.5																	
ELBOW–90 ELBOW–45	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)								ASTM A 234 GR.WPB–W (CHARPY)					
	END DETAIL	SW,6000#		SW,3000#		BW, 1.5D													
	DIMENSION STD.	B–16.11				B–16.9													
T–EQUAL T–RED	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)								ASTM A 234 GR.WPB–W (CHARPY)					
	END DETAIL	SW,6000#		SW,3000#		BW													
	DIMENSION STD.	B–16.11				B–16.9													
CAP	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)													
	END DETAIL	SCRF6000		SCRF3000		BW, THICKNESS TO MATCH PIPE THICKNESS													
	DIMENSION STD.	B–16.11				B–16.9													
FITTING	MATERIAL	ASTM A 105				ASTM A 234 GR.WPB (CHARPY)								ASTM A 234 GR.WPB–W (CHARPY)					
	END DETAIL	SW,6000#		SW,3000#		BW, THICKNESS TO MATCH PIPE THICKNESS													
	DIMENSION STD.	B–16.11				B–16.9													
	TYPE	COUPLING FULL,HALF LH.,RED.				RED. CON. RED. ECC.													
O'LET	MATERIAL	ASTM A 105				ASTM A 105 (CHARPY)													
	END DETAIL	SW,6000#		SW,3000#		BW													
	DIMENSION STD.	MSS–SP97				MSS–SP97													
	TYPE	SOCKOLET				WELDOLET													

ANSI CLASS: 150#	CORROSION ALLOWANCE: 1.5MM	TEMP °C	−45	38	50	100	150	
		PRESS. KG/CM^{2}g	18.76	18.76	18.55	17.74	16.11	
SERVICE : RLNG		BASE MATERIAL: CARBON STEEL (MATERIAL GROUP 1.3)						

NOTES: −

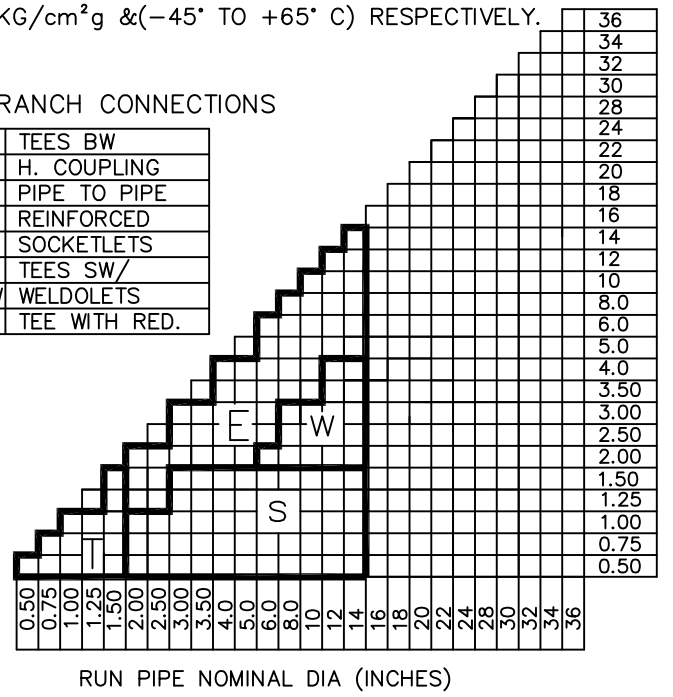
1. ALL VENTS & DRAIN SHALL BE PROVIDED WITH PLUG VALVE UNLESS MENTIONED OTHERWISE IN P&IDs.
2. FITTINGS SHALL BE OF SEAMLESS CONSTRUCTION UP TO 16" AND SHALL BE OF WELDED CONSTRUCTION 18" AND ABOVE.
3. WALL THICKNESS FOR LINEPIPE USED IN VARIOUS SECTIONS SHALL BE AS PER TABLE−1 OF PMS.
4. BALL VALVE TO BE USED IN MAINLINE SHALL HAVE BUTT WELDED ENDS EXCEPT FOR THE VALVES USED FOR HOT TAPPING WHICH SHALL BE ONE SIDE BUTT WELDED AND OTHER SIDE FLANGED.
5. PROCUREMENT OF MATERIALS SHALL BE AS PER DETAILED RELEVANT SPECIFICATIONS.
6. PRESSURE−TEMPERATURE RATING INDICATED ARE FOR FLANGES ONLY IN ACCORDANCE WITH ANSI B 16.5
7. FOR VALVES,STEELPIPE AND ASSOCIATED STEEL COMPONENTS OF 2" AND LARGER NOTCH TOUGHNESS PROPERTIES SHALL BE AS SPECIFIED IN RELEVANT SPECIFICATIONS/CODES, MECON'S STANDARD TECHNICAL SPECIFICATIONS AND DATA SHEETS ETC.
8. AT STATIONS, BRANCH CONNECTIONS SHALL BE AS PER BRANCH CONNECTION TABLE BELOW
9. ALL BUTT WELDS SHALL BE 100% RADIOGRAPHED.
10. 100% OF SOCKET WELD SHALL BE SUBJECTED TO MPI/DPT.
11. PRESSURE−TEMPERATURE RATING OF VALVE BODY SHALL BE AS PER API 6D.
12. PIPELINE DESIGN CODE − ASME B 31.8 & OISD 226.
13. FOR PIPELINE SPECIALITY ITEMS (SCRAPPER TRAP, FLOW TEE, IJ, LR BENDS ETC.) AND THEIR MATERIAL DESCRIPTIONS, REFER DATA SHEET OF RESPECTIVE ITEMS.
14. DESIGN PRESSURE&TEMP. FOR PIPELINE AND RELATED FACILITIES ARE 19 KG/cm^{2}g &(−45° TO +65° C) RESPECTIVELY.

STATION PIPING MATERIAL SPECIFICATION

ITEM	SIZE	DESCRIPTION
MAINTENANCE JOINTS	ALL	FLGD., BUT TO BE KEPT MINIMUM
PIPE JOINTS	1.5" & BELOW	SOCKET WELD
	2" & ABOVE	BUTT WELDED
DRAINS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
VENTS	ON LINES ≤ 1.5"	3/4", AS PER MEC/SD/05/21/15/03
	ON LINES ≥ 2"	3/4" OR AS PER P&ID, MEC/SD/05/21/15/01
TEMP. CONN.	1.5"	FLGD. INSTL. AS PER MEC/SD/05/21/15/02
PRESS CONN.	3/4"	NIPPLE WITH BALL VALVE TO SPEC. INSTALLATION AS PER MEC/SD/05/21/15/05

BRANCH CONNECTIONS

E	TEES BW
H	H. COUPLING
P	PIPE TO PIPE
R	REINFORCED
S	SOCKETLETS
T	TEES SW/
W	WELDOLETS
D	TEE WITH RED.



SECTION: OIL & GAS

	NAME	DATE
DRWN		
DSGN	K.P.	
CHKD	H.K.	
APPROVED	A.GANGAL	

REVISIONS: REV NO | DATE | ZONE | DESCRIPTIONS | BY | APPRD | REFERENCES | DRG. NO.

NATURAL GAS PIPELINE PROJECT

PIPING MATERIAL SPECIFICATIONS LOW TEMP SERVICE 150# (A4A)

SCALE : N.T.S. APPENDIX−VI (SH. 1 OF 2) REV 0

MECON LIMITED

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PIPELINE/PIPING DESIGN CODE		ASME B 31.8/ OISD 226												DESIGN FACTOR – 0.5
ITEM	NOMINAL DIAMETER (INCHES)	0.50	0.75	1.00	1.50	2.00	3.00	4.00	6.00	8.00	10.0	12.0	14.0	
PIPE	WALL THICKNESS (MM/SCH)	S160	S160	XS	XS	XS	STD	STD	STD	STD	STD	STD	STD	
	MATERIAL	ASTM A333 GR.6												
	DIMENSION STD.	B36.10												
	METHOD OF MANUFACTURE, ENDS	SEAMLESS PE				SEAMLESS BE								
FLANGE	MATERIAL AND GRADE	ASTM A 350 GR. LF2, CL–I												
	TYPE, FLANGE FACING	SW. RF 125AARH				WN. THICKNESS TO MATCH PIPE THICKNESS, RF 125AARH								
	DIMENSION STD.	B16.5												
BLIND FLANGE	MATERIAL AND GRADE	ASTM A 350 GR. LF2, CL–I												
	FLANGE FACING	RF 125AARH												
	DIMENSION STD.	B16.5												
BLANK	MATERIAL AND GRADE	ASTM A 350 GR. LF2, CL–I												
	FLANGE FACING	FF 125AARH												
	DIMENSION STD.	B16.48												
	TYPE	FIG.8 FLANGE												SPACER & BLIND
BOLTING	STUD BOLTS (FULLY THREADED)	A 320 GR L7, B–18.2												
	NUTS (HEAVY HEXAGONAL)	A 194 GR 4, B–18.2												
GASKET	TYPE, MATERIAL AND Dmn. STD.	SPIRAL, SP.WND SS316+GRAPHITE FILLED, B–16.20–ANSI B16.5,												
ELBOW–90 ELBOW–45	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								
	END DETAIL	SW,6000#		SW,3000#		BW, 1.5D								
	DIMENSION STD.	B–16.11				B–16.9								
T–EQUAL T–RED	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								
	END DETAIL	SW,6000#		SW,3000#		BW								
	DIMENSION STD.	B–16.11				B–16.9								
CAP & PLUG (UPTO 1.5")	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								
	END DETAIL	SCRF6000		SCRF3000		BW, THK TO MATCH PIPE THICKNESS								
	DIMENSION STD.	B–16.11				B–16.9								
FITTING	MATERIAL	ASTM A350 GR.LF2				ASTM A 420 GR.WPL6								
	END DETAIL	SW–6000		SW–3000		BW, THICKNESS TO MATCH PIPE THICKNESS								
	DIMENSION STD.	B–16.11				B–16.9								
	TYPE	COUPLING FULL,HALF LH.,RED.				RED. CON. RED. ECC.								
O'LET	MATERIAL	ASTM A350 GR.LF2				ASTM A 350 GR.LF2								
	END DETAIL	SW,6000#		SW,3000#		BW								
	DIMENSION STD.	MSS–SP97				MSS–SP97								
	TYPE	SOCKOLET				WELDOLET								

APPROVED
DRWN
DSGN K.P.
A.GANGAL
NAME DATE CHKD DATE
H.K.

SECTION: OIL & GAS

REV NO DATE ZONE DESCRIPTIONS BY APPRD
REVISIONS

REFERENCES

DRG. NO.

NATURAL GAS PIPELINE PROJECT

PIPING MATERIAL SPECIFICATIONS LOW TEMP SERVICE 150# (A4A)

SCALE : N.T.S.

APPENDIX–VI

(SH. 2 OF 2)

REV 0

मेकॉन लिमिटेड
MECON LIMITED

Rev. : 0
Edition : 1

SPECIFICATION
FOR
FLUSHING AND TESTING OF
PIPING SYSTEMS

SPECIFICATION NO.: MEC/S/05/21/11

(OIL & GAS SBU)
MECON LIMITED
DELHI 110 092

CONTENTS

SL. NO.	DESCRIPTION
1.0	SCOPE
2.0	REFERENCES
3.0	INSPECTION
4.0	FLUSHING
5.0	TESTING
5.1	EXTENT OF TESTING
5.2	GENERAL REQUIREMENT/TEST PREPARATION FOR TESTING
5.3	TESTING MEDIA, TEST PRESSURE AND TEST PRESSURE GAUGES.
5.4	TESTING PROCEDURE
5.5	COMPLETION OF TESTING
5.6	TEST RECORDS

1.0 SCOPE

This specification covers the general requirements for Inspection, flushing and testing of piping systems. However testing of steam lines falling under IBR shall also be governed by Indian Boiler Regulations.

Flushing and testing of all piping system shall be witnessed by the Consultant Representative / Engineer-in- Charge.

2.0 REFERENCE

ASME B31.3-2004 : Process Piping

IBR : Indian Boiler Regulations

3.0 INSPECTION

During various stage and after completion fabrication and erection, the piping system shall be inspected by the Consultant Representative / Engineer- in - Charge to ensure that :

- Proper piping material has been used.
- Piping has been erected as per drawings and the instruction of the engineer- in charge.
- All supports have been installed correctly.

- Test preparations mentioned in this specification have been carried out.

4.0 FLUSHING

Flushing of all lines shall be done before pressure testing.

Flushing shall be done by 'fresh potable water' or 'dry compressed air, wherever water flushing is not desirable' to clean the pipe of all dirt, debris or loose foreign materials.

Required pressure of water, flushing shall meet the fire hydrant pressure or utility water pressure. For air flushing the line, system will be pressurised by compressed air at the required pressure which shall be 50 psi maximum. The pressure shall then be released by quick opening of a valve, already in the line for this purpose. This procedure shall be repeated as many times as required till the inside of the pipe is fully cleaned.

In line instruments like control valves, orifice plates, rotameters, safety valves and other instruments like thermowells which may interfere with flushing shall not be included i m the flushing circuit.

From all permanent strainers the screens/meshes shall be removed before flushing. Screens/meshes shall be re- installed after flushing but before testing.

During flushing temporary strainers shall be retained. These shall be removed, cleaned and reinstalled after flushing, but, before testing.

In case an equipment such as column, vessel, exchanger etc. forms part of a piping circuit during flushing, this shall be done with the approval of Engineer- in - Charge. However equipment thus included in the circuit, shall be completely cleaned and dried with comprss4ed air, after flushing is completed.

During flushing discharged water/air shall be drained at the place directed the Engineer- in - Charge. If necessary, proper temporary drainage shall be provided by the contractor.

Care shall be taken during flushing so as not to damage/spoil work of other agencies. Precautions shall also be taken to prevent entry of water/foreign matter into equipment, electric motors, instruments, electrical installations etc. in the vicinity of lines being flushed.

The contractor shall carry out all the activities required before, during and after the flushing operation, arising because of flushing requirements, such as but not limited to the following.

Dropping of valves, specials, distance pieces, online instruments and any other piping part before flushing. The flanges to disengaged for this purpose shall be envisaged by the contractor and approved by the Engineer-in-Charge. These flanges shall be provided with temporary gaskets at the time of flushing.

After flushing is completed and approved, the valve, distance pieces, piping specials etc. shall be re-installed by the contractor with permanent gaskets. However, flanges of equipment nozzles and other places where isolation is required during testing, only temporary gaskets shall be provided.

Records in triplicate shall be prepared and submitted by the Contractor for each piping system for the flushing done in the proforma provided / approved by EIC.

5.0 TESTING

Pressure testing, in general shall be as per clause 345 of ASME B31.3, unless otherwise specified, herein. Lines carrying highly hazardous / poisonous fluids must have a sensitive leak test. For IBR lines, 'IBR Regulations' shall also be followed.

5.1 Extent of testing

With the exclusion of instrumentation. piping system fabricated or assembled in the field shall be tested irrespective of whether or not they have been pressure tested prior to site welding of fabrication.

To facilitate the testing of piping systems, vessels and other equipments may be included in the system with the prior approval of Engineer-in-charge, if the test pressure specified is equal to or less than that for the vessels and other equipments.

Pumps, compressors and other votary equipments shall not be subjected to field test pressures.

Lines which are directly open to atmosphere such as vents, drains, safety valves, discharge need not be tested, but all joints shall be visually inspected wherever necessary such lines shall be tested by continuous flow of fluid to eliminate the possibility of blockage. However, such lines if provided with block valve shall be pressure tested upto the first block valve.

Seats of all vales shall not be subjected to a pressure in excess of the maximum cold welding pressure of the valve. Test pressure applied to vales shall not be grater than the manufacturer is recommendation nor less than that required by the applicable code. Where desirable set pressure is less than test pressure, test shall be made through an open valve.

Instruments in the system to be tested, shall be excluded from the test by isolation or removal, unless approved otherwise by the Engineer-in-charge. Restrictions which interfere with filling, venting and drawing such as orifice plates etc. shall not be installed unless testing is complete.

Control valves shall not be included in the test system. Where by-passes are provided test shall be performed through the by-pass end/or necessary spool shall be used in place of the control valve.

Pressure gauges which are part of the finished system, but cannot withstand test pressure shall not be installed until the system has been tested. Where piping systems to be tested are directly connected at the battery limits to piping for which the responsibility tests with other agencies, the piping to be tested shall be isolated from such piping by physical disconnection such as valves or blinds.

5.2 General Requirement/Test preparation for Testing

Test shall be carried out with permanent gaskets installed unless specified otherwise or instructed by the Engineer-in- charge.

No pressure test shall be carried out against close valve unless approved by the Engineer-in-charge.

The Engineer-in-charge shall be notified in advance by the contractor, of the testing sequence and programme, to enable him to be present for witnessing the test. The contractor shall be fully responsible for making arrangements with the local boiler inspector to witness the tests for steam lines falling under IBR. IBR certificates for these tests shall be obtained in the relevant IBR forms and furnished to the Engineer-in-charge. Before testing, all piping shall be cleaned by flushing to make it free from dist loose scale, debris and other loose foreign materials.

All piping systems to be hydrostatically tested shall be vented at the high points and the systems purged of air before the test pressure is applied.

Wherever in the line any void is existing due to any reasons, for absence of control valve, safety valve, check valves etc. it shall be filled with temporary spools.

All joints welded, screwed or flanged shall be left exposed for examination during the test. Before pressuring the lines, each weld joint shall be cleaned by wire brush to free it from rest and any other foreign matter.

Where a system is to be isolated of a pair of companion flanges, a blank shall be inserted between the companion flanges. Minimum thickness of the blank shall be designed in accordance with applicable design code.

Open ends of piping system where blanks cannot be used, such as pumps, compressors, turbines or wherever equipment or pipe spool have been receivered or disconnected prior to hydrostatic testing, shall be blinded – off by using standard blind flanges of same rating as the piping system being tested.

Pressure gauges used in testing shall be installed as close as possible to the lowest point in the piping system to be tested, to avoid overstressing of any of the lower portion of the system. For longer lines and vertical lines, two or more pressure gauges shall be installed at locations selected by the Engineer-in-charge. For lines containing check valves any of the following alternatives shall be adopted for pressure testing. Wherever possible pressurise up-stream side of valve.

Replace the valve by a temporary spool and re-install the valve after testing.

Provide blind on valve flanges and test the upstream and downstream of the line separately and remove the blind after testing. All these flanges, temporary gaskets shall be provided during testing and shall be replaced by permanent gaskets subsequently. For check valves in lines 1-1/2" and below, flapper or seat shall be

removed during testing (if possible). After completion of testing the flopper/ seat shall be refitted.

Gas lines when hydrostatically tested shall be provided with additional temporary supports during testing as directed by Engineer-in-charge.

Piping which is spring or counter – weight supported shall be temporarily supported, where the weight of the fluid would overload the support. Retaining pins for spring supports shall be removed only after testing is completed and test fluid is completely drained.

When testing any piping system, air or steam of approximately 2 kg/cm^2 (g) may be used as preliminary test to detect missing gaskets etc. as this avoids the necessity of purging the gas to make repairs. However, this method may not be used for this purpose, if the steam temperature is more than the design temp. of the line.

For jacketed pipes testing of core pipes shall be done on individual pieces where the pipe is continuously packed, before it is jacketed. The outer jacket shall be tested separately as a system for piping with discontinuous jacketing, the core pipe and the jacket shall be tested as separate system.

5.3 Testing Modes, Test pressure and Test Pressure Gauges

5.3.1 Testing Modes

In general all pressure test shall be hydrostatic using iron free water, which is clean and free of silt. Maximum clorine content in water for hydrostatic testing for MS piping shall be 15-20 ppm. Air shall be used for testing only if water would cause corrosion of the system or overloading of supports etc. in special cases as directed by Engineer-in-charge.

If operating fluid in the line is much lighter than testing fluid, the additional weight of testing fluid may render piping supports (as designed) inadequate. This will call for additional temporary supports. The typical examples are flare and vapor lines. It is preferable that hydrostatic testing is avoided in such systems and instead pneumatic testing may be specified.

Where air/water tests are undesirable substitute fluid such as gas, oil, methanol etc. shall be used as the testing medium, with due consideration to the hazards involved. These test fluids shall be specified in the line list given to the contractor.

5.3.2 Test Pressure

The hydrostatic/pneumatic test pressure shall be as indicated in the line list or as per the instruction of Engineer-in-charge.

The selection of the piping system for one individual test shall be based on the following :-

Test pressure required as per line list.

Maximum allowable pressure for the material of construction of piping depending upon the above requirements and based on construction progress, maximum length of piping shall be included in each test.

5.3.3 Test Pressure Gauge

All gauge used for field testing shall have suitable range so that the test pressure of the various system falls in 35% to 65% of gauge scale range. Pressure gage shall be minimum of 150 mm. Size of Bourdon shall not be less than 75% of nominal diameter of dial range. Gauge shall be of a good quality and in first class working condition.

Prior to the start of any test or periodically during the field test programmes, all test gauges shall be calibrated using a standard dead weight gauge tester or other suitable approved testing apparatus. Any gauge having an incorrect zero reading or error of more than ± 2% of full scale range shall be discarded. The Engineer-in-charge shall check the accuracy of master pressure gauge used for calibration.

5.4 Testing Pressure

5.4.1 Hydrostatic Test

All vents and other connections used as vents shall be kept open while filling the line with test fluid for complete removal of air. For pressurising and depressurising the system, temporary isolating valves shall be provided if valves, vents, drains do not exist in the system.

Pressure shall be applied only after the system/line is ready and approved by the Engineer-in-charge.

Pressure shall be applied by means of a suitable test pump or other pressure source which shall be isolated from the system as the desired test pressure is reached and stabilised in the system.

A pressure gauge shall be provided at the pump discharge for guiding the system to the required pressure.

The pump shall be attended constantly during the test by an authorised person. The pump shall be isolated from the system wherever the pump is to be left unattended.

Test pressure shall be maintained for a sufficient length of time to permit through inspection of all joints for leakage or signs of failure. Any joint found leaking during a pressure test, shall be re-tested to the specified pressure after repair. Test period shall be maintained for a minimum of four hours.

The pump and the piping system to be tested are to be provided with separate pressure indicating test gauges. There gauges are to be checked by the standard test gauge before each pressure test.

Care shall be taken to avoid increase in the pressure due to atmospheric variation during the test.

5.4.2 Air Test

When testing with air, pressure shall be supplied by means of a compressor. The compressor shall be portable type with a receiver after cooler & oil separator.

Piping to be tested by air shall have joints covered with a soap and water solution so that the joints can be examined for leaks.

All other activities shall be same as per hydrotesting procedure (specified above).

5.5 Completion of Testing

After the hydrostatic test has been completed, pressure shall be released in a manner and at a rate so as not to endanger personnel or damage equipments.

All vents and drains shall be opened before the system is to be drained and shall remain open till all draining is complete, so as to prevent formation of vacuum in the system. After draining lines/systems shall be dried by air.

After testing is completed the test blinds shall be removed and equipment/piping isolated during testing shall be connected using the specified gaskets, bolts and nuts. These connections shall be checked for tightness in subsequent pneumatic tests to be carried out by the contractor for complete loop/circuit including equipments (except rotary equipments).

Pressure tests shall be considered complete only after approved by the Engineer-in-charge. Defects, if any, noticed during testing shall be rectified immediately and retesting of the system/line shall be done by the contractor at his cost.

5.6 Test Records

Records in triplicate shall be prepared and submitted by the contractor for each piping system, for the pressure test done in the proforma provided / approved by the Engineer-in-charge.

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Edition : 1

SPECIFICATION
FOR
GASKETS, BOLTS & NUTS

SPECIFICATION NO.: MEC/S/05/21/19

(OIL & GAS SBU)
MECON LIMITED
DELHI 110 092

CONTENTS

SL.NO.	DESCRIPTION
1.0	GASKETS
2.0	NUTS AND BOLTS

TECHNICAL NOTES FOR GASKETS

1.0 All gaskets shall conform to the codes/standards and specifications given in the requisition. Vendor shall strictly comply with MR / PR stipulations and no deviations shall be permitted.

2.0 Process of manufacture, dimensions and tolerances not specified in requisition shall be in accordance with the requirements of the manufacturer's standards.

3.0 Test reports shall be supplied for all mandatory tests for gaskets as per the standards specified in the requisition.

4.0 Chemical composition and hardness of RTJ gaskets shall also be furnished in the form of test reports on samples.

5.0 For Spiral wound material following shall be furnished:

a. Manufacturer's test certificate for filler material and spiral material as per the relevant material specifications.

b. Manufacturer's test certificate for raw materials and tests for compressibility / seal-ability & recovery as per the relevant material specifications.

6.0 Full face gaskets shall have bolt holes punched out.

7.0 Filler material for spiral wound gaskets shall not have any colour or dye.

8.0 All spiral wound gaskets shall be supplied with Outer ring. Material of the outer ring shall be CS unless other wise specified in the MR.

9.0 For spiral wound gaskets, material of Inner Compression ring shall be same as Spiral Strip material. In addition to the requirements as per code and as specified in the MR, inner rings shall be provided for the following:

a. Sizes 26" and above.

b. Class 900 and above.

10.0 Hardness of metallic RTJ gaskets shall not exceed the values specified below unless otherwise specified in MR :

Ring Gasket Material	**Maximum Hardness (BHN)**
Soft Iron	90
Carbon steel	120
5 Cr. ½ Mo	130
Type 304, 316, 321, 347	140
Type 304L, 316L	120

11.0 Face finish of metallic RTJ gaskets shall be 32 to 63 AARH.

12.0 Gaskets of different types and sizes shall be placed in separate shipping containers and each container clearly marked with the size, rating, material specification and item code.

13.0 All items shall be inspected and approved by MECON Inspector or any other agency authorized by MECON.

14.0 Any additional requirements specified in the requisition, shall be fully complied with.

15.0 Non-metallic ring gaskets as per ASME B16.21 shall match flanges to ASME B16.5 upto 24" (except 22" size) and to ASME B16.47B above 24" unless specified otherwise. For 22" size, the matching flange standard shall be MSS-SP44 unless specified otherwise.

16.0 Spiral wound gasket as per ASME B16.20 shall match flanges to ASME B16.5 upto 24" (except 22" size) and to ASME B16.47B above 24" unless specifically mentioned otherwise. For 22" size, the matching flange standard shall be MSS-SP44 unless specified otherwise.

17.0 The following abbreviations have been used in the Material Requisition for Spiral Wound Gaskets :

(I)	:	Inner Ring
(O)	:	Outer Ring
CAF	:	Compressed Asbestos Fibre
GRAFIL	:	Grafoil Filler

TECHNICAL NOTES FOR BOLTS & NUTS

1.0 The process of manufacture, heat treatment, chemical & mechanical requirements and marking for all stud bolts, m/c bolts, jack screws & nuts shall be in accordance with the codes / standards and specification given in the requisition. The applicable identification symbol in accordance with the material specification shall be stamped on each bolt and nut. Vendor shall strictly comply with MR / PR stipulations and no deviations shall be permitted.

2.0 Test reports shall be supplied for all mandatory tests as per the relevant material specifications.

3.0 Material test certificate shall also be furnished. (Heat Analysis, Product Analysis and Mechanical Requirement)

4.0 Stress Rupture Test as detailed in ASTM A453 shall be carried out for all ASTM A453 bolting material irrespective of the temperature.

5.0 All bolting shall be as per ANSI B 18.2.1 for studs. M/c bolts and jackscrews and ANSI BI8.2.2 for nuts.

6.0 Threads shall be unified (UNC for 1" dia and BUN for> 1" dia) as per ANSI B.1.1 with class 2A fit for studs, M/c bolts and jackscrews and class 2B fit for nuts.

7.0 Stud bolts shall be threaded full length with two heavy hexagonal nuts. Length tolerance shall be in accordance with the requirement as per ANSI B 16.5.

8.0 The nuts shall be double chamfered, semi-finished, heavy hexagonal type and shall be made by the hot forged process and stamped as per respective material specification.

9.0 Heads of jackscrews and m/c bolts shall be heavy hexagonal type. Jackscrew end shall be rounded.

10.0 Each size of studs & m/c bolts with nuts and jackscrews shall be supplied in separate containers marked with size and material specifications. 'CRYO' shall be marked additionally in case 'CRYO' is specified in the requisition.

11.0 All items shall be inspected and approved (stagewise) by MECON inspector or any other agency authorized by MECON.

12.0 The heat treatment for stud bolts & nuts shall be as per code unless mentioned otherwise.

13.0 All austenitic stainless steel bolts, nuts, screws shall be supplied in solution annealed condition unless specified otherwise in the material specification.

14.0 Any additional requirements specified in the requisition shall be fully complied with.

15.0 Stud bolts, nuts & jackscrews shall be impact tested wherever specified in the material specification and also where the material specification is indicated as "CRYO". For" S.S. nuts and bolts minimum impact energy absorption shall be 27 Joules and test temperature shall be -196°C unless mentioned otherwise. For other materials impact energy and test shall be as per respective code.

16.0 Bolts / nuts of material of construction B7M / 2HM shall be 100% Hardness tested as per supplementary requirement S3 of ASTM A 193.

17.0 When specified as galvanized, the studs, m/c bolts and nuts shall be 'hot dip zinc coated' in accordance with requirements of 'class C' of 'ASTM A 153'. As an alternative, electro-galvanizing as per IS 1573, 'Service Grade Number 2' is also acceptable.

18.0 All Stud Bolts of Bolt diameter size 1" and above shall be provided with three nuts irrespective of whatever has been specified elsewhere in the MR.

Rev. : 0
Edition : 1

SPECIFICATION
FOR
PIPING FABRICATION AND ERECTION

SPECIFICATION NO.: MEC/S/05/21/06

(OIL & GAS SBU)
MECON LIMITED
DELHI 110 092

CONTENTS

SL.NO.	DESCRIPTION
1.0	GENERAL
2.0	SCOPE
3.0	BASIS FOR WORK
4.0	FABRICATION
5.0	ERECTION
6.0	WELDING
7.0	ERECTION
8.0	INSPECTION
9.0	PROTECTIVE COATING
10.0	FLUSHING
11.0	HYDROSTATIC TESTING

ANNEXURE-1 - WELDING SPECIFICATION

EXHIBIT-A - ELECTRODE QUALIFICATIONS TEST RECORD
EXHIBIT-B - STRESS RELIEF HEAT TREATMENT PROCEDURE SPECIFICATION
EXHIBIT-C - STANDARD PROCEDURE SPECIFICATION NO.
EXHIBIT-D - COUPON TEST RECORD
EXHIBIT-E - WELDER's IDENTIFICATION CARD
EXHIBIT-F - RADIOGRAPHIC PROCEDURE FOR PIPE WELDING
EXHIBIT-G - WELDING SPECIFICATION CHART

ANNEXURE-2 - DESTRUCTIVE TESTING OF WELDED JOINT - BUTT WELDS

ANNEXURE-3 - ULTRASONIC INSPECTION

ANNEXURE-4 - RADIOGRAPHY

1.0 GENERAL

This specification covers general requirements of fabrication and erection of aboveground and trench piping systems at site. The specification covers the scope of work of contractor, basis of work to be carried out by contractor and standards, specifications and normal practice to be followed during fabrication and erection by the contractor.

2.0 SCOPE

Generally the scope of work of contractor shall include the following :

2.1 Transportation of required piping materials, pipe support and all other necessary piping materials from Owner's storage point or contractor's storage point (in case of contractor's scope of supply) to work site / shop including raising store requisitions for issue of materials in the prescribed format & maintaining an account of the materials received from Owner's stores.

2.1.1 Piping materials include the following but not limited to the same.

a. Pipes (All sizes and schedule)

b. Flanges (All sizes, types & Pressure ratings).

c. Fittings (All sizes, types and schedule)

d. Valves (All sizes, types and Ratings)

e. Gaskets (All sizes, types & Ratings)

f. Bolts, Nuts or M/C Bolts (All types)

g. Expansion Joint / Bellows (All types)

h. Specialty items like online filters, ejectors, sample coolers, steam traps, strainers, air traps etc.

i. Online instruments like control valve, orifice flange, rotameter, safety valves etc.

2.2 Shop & field fabrication and erection of piping in accordance with documents listed under Cl. 3.0 i.e. 'BASIS OF WORK' including erection of all piping materials enumerated above.

2.3 Fabrication and erection of pipe supports like shoe, saddle, guide, stops, anchors, clips, cradles, hangers, turn buckles, supporting fixtures, bracket cantilevers, struts, teeposts including erection of spring supports and sway braces.

2.4 Fabrication

2.4.1 Fabrication of piping specials like special radius bends, reducers, mitres etc.

2.4.2 Fabrication of plain and threaded nipples from pipes as required during erection.

2.4.3 Fabrication of swage nipples as and when required.

2.4.4 Fabrication of odd angle elbow like 60°, 30° or any other angle from 90/45° elbows as and when required.

2.4.5 Fabrication of flange, reducing flange, blind flange, spectacle blinds as and when required.

2.4.6 Fabrication of stub-in connection with or without reinforcement.

2.4.7 Grinding of edges of pipes, fittings, flanges etc. to match mating edges of uneven / different thickness wherever required.

2.5 Modifications like providing additional cleats, extension of stem of valve, locking arrangement of valves etc. as and when required.

2.6 Preparation of Isometrics, bill of materials, supporting details of all NON-IBR lines upto 2-1/2" within the unit battery limit and get subsequent approval from Engineer-in-Charge as and when called for.

2.7 Obtaining approval for drawings prepared by contractor from statutory authority, if required.

2.8 Spun concrete lining of the inside of pipes 3" NB & above including fittings and flanges as required in accordance with specification.

2.9 Rubber lining inside pipes, fittings, flanges as and when required, in accordance with specification.

2.10 Radiography, stress relieving, dye penetration, magnetic particle test etc. as required in specification.

2.11 Performing PMI using alloy analysers as per 'Standard Specification for Positive Material Identification at Construction Sites, 6-82-0002'.

2.12 Casting of concrete pedestals and fabrication & erection of small structures for pipe supports including supply of necessary materials.

2.13 Providing insert plates from concrete structures and repair of platform gratings around pipe openings.

2.14 Making material reconciliation statement and return of Owner's supply left over materials to Owner's storage.

2.15 Flushing and testing of all piping systems as per standard specification for inspection, flushing and testing of piping systems (Specification No. MEC/S/05/21/11).

3.0 BASIS FOR WORK

3.1 The complete piping work shall be carried out in accordance with the following

3.1.1 "Approved for Construction" drawings and sketches issued by MECON to the Contractor - Plans and/or Isometrics.

3.1.2 "Approved for Construction" drawings and sketches issued by Turn-key bidders to the Contractor - Plans and/or Isometrics.

3.1.3 Approved Process licensor's standards and specifications.

3.1.4 Drawings, sketches and documents prepared by contractor duly approved by Engineer-in-Charge' (such as isometrics and offsite piping etc.)

3.1.5 Approved construction job procedures prepared by Contractor as stipulated in 2.16

3.1.6 MECON specifications/documents as below :

a. Process and Instrument Diagram.

b. Piping Materials Specification

c. Piping support standards.

d. Line list / Number

e. Piping support index.

f. Standard specification of NDT Requirement of Piping

g. Welding specification charts for piping classes.

h. Standard specification for Pressure Testing of Erected Piping System.

i. Welding specification for fabrication of piping

j. Any other MECON or OTHER specifications attached with Piping Material Specification or special condition of contract.

k. Procedure for storage, preservation and positive identification of materials Contractors works / stores.

3.1.7 Following codes, standards and regulations

a. ASME B 31.3 : Process Piping
b. ASME Sec. VIII : Code for unfired pressure vessel.
c. IBR Regulations

d.	IS:823	:	Code for procedure for Manual Metal Are Welding of Mild Steel (for structural steel).
e.	NACE Std.	:	Code for Sour Services material requirements MR.

Note : All codes referred shall be latest edition.

3.2 Deviations

Where a deviation from the "Basis of Work" and approved job procedure described above is required or where the basis of work does not cover a particular situation, the matter shall be brought to the notice of Engineer - in - Charge and the work carried out only after obtaining written approval from him in each case.

4.0 FABRICATION

4.1 Piping Material

Pipe, pipe fittings, flanges, valves, gaskets, studs bolts etc. used in a given piping system shall be strictly as per the "Piping Material Specification" for the "Pipe Class" specified for that system. To ensure the above requirement, all piping material supplied by the Owner / Contractor shall have proper identification marks as per relevant standards / MECON's specifications / Licensors specification. Contractor shall provide identification marks on left over pipe lengths wherever marked up pipe lengths have been fabricated / erected. Material traceability is to be maintained for AS., S.S., NACE, LTCS, material for Hydrogen service and other exotic materials by way of transferring heat number, etc. (hard punching) as per approved procedure. This shall be in addition to colour coding for all piping materials to avoid mix-up.

4.2 Fabrication

4.2.1 All fabrication shall be carried out in accordance with piping general arrangement drawings, (prepared by CONTRACTOR and approved by COMPANY) including this specification and codes as specified in section 2.0.

4.2.2 CONTRACTOR shall be responsible for working to the exact dimensions as per the approved drawings. Dimensional tolerances to be adopted during implementation of fabrication work shall be as per attached sketch "TOLERANCES FOR FABRICATION".

4.2.3 Flange bolt holes shall generally straddle the established centre lines unless other orientation is required and as called out in approved drawings.

4.2.4 Threading shall be NPT to ANSI B 1.20.1. Threading shall preferably be done after bending, forging or heat treatment operation. However if it is not possible, precaution shall be taken to protect threading against deformation. Thread shall be clean cut with no burrs or stripping. Dies shall be new, sharp and properly designed for piping material. Ends shall be reamed to remove burrs.

4.2.5 All threaded joints shall be aligned properly. The pipe entering unions shall be true to centrelines so as to avoid forcing of union coupling during make up. Damaged threads shall be cut from the end of run and the pipe shall be rethreaded.

4.2.6 Immediately before testing the piping, all threads of pipe and fittings shall be thoroughly cleared of cuttings, fuel oil or other foreign matter. The male threads shall be sealed with thread sealant and the piping made up sufficiently for the thread to seize. Sealant shall be teflon tape.

4.2.7 Seal welding of threaded connections when specified shall include the first block valve, cover all threads. The joint shall be cleaned of all cutting oil and other foreign material and made up dry to full thread engagement. Instrument threaded connections which are frequently subjected to testing and maintenance shall not be seal welded.

4.2.8 All threaded connections shall be protected from rusting by applying greases or oil when in operating condition.

4.2.9 When socket weld fittings or valves are used, pipe shall be spaced approximately 1/16" to avoid bottoming which could result in excessive weld stress.

4.2.10 Where the ends of the piping components being welded have an internal surface misalignment exceeding 1.6mm, the wall of the component extending internally shall be trimmed by machining so that the adjoining internal surface will approximately flush.

For the purpose of common understanding the construction job procedure, to be submitted by the contractor, shall include proposal for

- Maximizing prefabrication, inspection and testing at fabrication shop with minimum field joints.
- Positive material identification, handling, storage & preservation.

4.3 Dimensional Tolerances

Dimensional tolerances for piping fabrication shall be as per MECON Standard Specification. The Contractor shall be responsible for working to the dimensions shown on the drawings. However, the Contractor shall bear in mind that there may be variations between the dimensions shown in the drawing and those actually existing at site due to minor variations in the location of equipments, inserts, structures etc. To take care of these variations "Field Welds" shall be provided during piping fabrication. An extra pipe length of 100 mm over and above the dimensions indicated in the drawing may be left on one side of the pipe at each of the field welds. During erection, the pipe end with extra length at each field weld, shall be cut to obtain the actual dimension occurring at site. Isometrics, if supplied may have the field welds marked on them. However, it is the responsibility of the Contractor to provide adequate number of field welds. In any case no extra claims will be entertained from the Contractor on this account. Wherever errors / omissions occur in drawings and Bills of Materials it shall be the Contractor's responsibility to notify the Engineer-in-Charge prior to fabrication or erection.

4.4 IBR Piping

4.4.1 Contractor shall be supplied generally with all drawings for steam piping falling under the purview of Indian Boiler Regulations duly approved by Boiler Inspectorate. The Contractor shall carry out the fabrications, erection and testing of this piping as per requirements of Indian Boiler Regulations and to the entire satisfaction of the local Boiler Inspector. The Contractor shall also get the approval of IBR inspector for all fabrication and testing done by him at his own cost. All certificates of approval shall be in proper IBR forms. . .

4.4.2 Approval of boiler inspector on the drawings prepared by the contractor shall be obtained by the contractor at his own cost.

4.5 Pipe Joints

The piping class of each line specifies the type of pipe joints to be adopted. In general, joining of lines 2" and above in process and utility piping shall be accomplished by butt welds. Joining of lines 1-1/2" and below shall be by socket welding / butt welding / threaded joints as specified in "Piping Material Specifications". However, in piping 1-1/2" and below where socket welding/ threaded joints are specified butt - welds may be used with the approval of Engineer-in-Charge for pipe to pipe joining in long runs of piping. This is only applicable for non-galvanized piping without lining.

Flange joints shall be used at connections to Vessels, Equipment's, Valves and where required for ease of erection and maintenance as indicated in drawings.

4.6 Butt Welded and Socket Welded Piping

End preparation, alignment and fit-up of pipe pieces to be welded, welding, pre-heat, post-heating and heat treatment shall be as described in the welding specification and NDT specification.

4.7 Screwed Piping

In general, Galvanized piping shall have threads as per IS:554 or ANSI B 2.1 NPT as required to match threads on fittings, valves etc. All other piping shall have threads as per ANSI B 2.1, tapered unless specified otherwise.

Threads shall be clean cut, without any burrs or stripping and the ends shall be reamed. Threading of pipes shall be done preferably after bending, forging or heat treating operations. If this is not possible, threads shall be gauge checked and chased after welding heat treatment etc.

During assembly of threaded joints, all threads of pipes and fittings shall be thoroughly cleaned of cuttings, dirt, oil or any other foreign matter. The male threads shall be coated with thread sealant and the joint tightened sufficiently for the threads to seize and give a leakproof joint.

Threaded joints to be seal-welded shall be cleaned of all foreign matter, including sealant and made up to full thread engagement before seal welding.

4.8 Flange Connections

All flange facings shall be true and perpendicular to the axis of pipe to which they are attached. Flanged bolt holes shall straddle the normal centerlines unless different orientation is shown in the drawing.

Wherever a spectacle blind is to be provided, drilling and tapping for the jack screws in the flange, shall be done before welding it to the pipe.

4.9 Branch Connections

Branch connections shall be as indicated in the piping material specifications. For end preparation, alignment, spacing, fit-up and welding of branch connections refer welding specifications. Templates shall be used wherever required to ensure accurate cutting and proper fit-up.

For all branch connections accomplished either by pipe to pipe connections or by using forged tees the rates quoted for piping shall be inclusive of this work.

Reinforcement pads shall be provided wherever indicated in drawings/ specifications etc.

4.10 Bending

Bending shall be as per ASME B31.3 except that corrugated or creased bends shall not be used.

Cold bends for lines 1-1/2" and below, with a bend radius of 5 times the nominal diameter shall be used as required in place of elbows wherever allowed by piping specifications. Bending of pipes 2" and above may be required in some cases like that for headers around heaters, reactors etc.

The completed bend shall have a smooth surface, free from cracks, buckles, wrinkles, bulges, flat spots and other serious defects. They shall be true to dimensions. The flattening of a bend, as measured by the difference between the maximum and minimum diameters at any cross-section, shall not exceed 8% and 3% of the nominal outside diameter, for internal and external pressure respectively.

4.11 Forging and forming

Forging and forming of small bore fittings, like reducing nipples for piping 1-1/2" and below, shall be as per ASME B 31.3.

4.12 Mitre Bends and Fabricated Reducers

The specific application of welded mitre bends and fabrication reducers shall be governed by the Piping Material Specifications. Generally all 90 deg. mitres shall be 4-piece 3-weld type and 45 deg. mitres shall be 3-piece 2-weld type as per MECON Standard unless otherwise specified. Reducers shall be fabricated as per directions of Engineer-in-Charge. The radiographic requirements shall be as per Material Specifications for process and utility systems and NDT Specification for steam piping under IBR, radiographic requirements of IBR shall be complied with.

4.13 Cutting and Trimming of Standard Fittings & Pipes

Components like pipes, elbows, couplings, half-couplings etc. shall be cut / trimmed / edge prepared wherever required to meet fabrication and erection requirements, as per drawings and instructions of Engineer-in-Charge. Nipples as required shall be prepared from straight length piping.

4.14 Galvanised Piping

Galvanised carbon steel piping shall be completely cold worked, so as not to damage galvanised surfaces. This piping involves only threaded joints and additional external threading on pipes may be required to be done as per requirement.

4.15 Jacketed Piping

The Jacketing shall be done in accordance with MECON Specification or Licensors specification as suggested in material specification or special condition of contract.

Pre-assembly of jacketed elements to the maximum extent possible shall be accomplished at shop by Contractor. Position of jumpover and nozzles on the jacket pipes, fittings etc. shall be marked according to pipe disposition and those shall be prefabricated to avoid damaging of inner pipe and obstruction of jacket space. However, valves, flow glasses, in line instruments or even fittings shall be supplied as jacketed.

4.16 Shop Fabrication / Prefabrication

The purpose of shop fabrication or pre-fabrication is to minimise work during erection to the extent possible. Piping spool, after fabrication, shall be stacked with proper identification marks, so as facilitate their withdrawal at any time during erection. During this period all flange (gasket contact faces) and threads shall be adequately fabricated by coating with a removable rust preventive. Care shall also be taken to avoid any physical damage to flange faces and threads.

4.17 Miscellaneous

4.17.1 Contractor shall fabricate miscellaneous elements like flash pot, seal pot, sample cooler, supporting elements like turn buckles, extension of spindles and interlocking arrangement of valves, operating platforms as required by Engineer-in-Charge.

4.17.2 Spun Concrete Lining

The work of inside spun concrete lining of pipes and specials of diameter 3" and above shall be done as per material specifications and special condition contract.

4.17.3 Fabrication of pipes from plate

Pipes shall be fabricated at site as and when required as per the specifications attached and the actual Piping Material Specification.

5.0 ERECTION

5.1 Cleaning of Piping before Erection

Before erection all pre-fabricated spool pieces, pipes, fittings etc. shall be cleaned inside and outside by suitable means. The cleaning process shall include removal of all foreign matter such as scale, sand, weld spatter chips etc. by wire brushes, cleaning tools etc. and blowing with compressed air/or flushing out with water. Special cleaning requirements for some services, if any shall be as specified in the piping material specification or isometric or line list. S.S jacketed piping requiring pickling shall be pickled to remove oxidation and discolouring due to welding.

5.2 Piping Routing

No deviations from the piping route indicated in drawings shall be permitted without the consent of Engineer- in-Charge.

Pipe to pipe, pipe to structure / equipments distances / clearances as shown in the drawings shall be strictly followed as these clearances may be required for the free expansion of piping / equipment. No deviations from these clearances shall be permissible without the approval of Engineer-in-Charge.

In case of fouling of a line with other piping, structure, equipment etc. the matter shall be brought to the notice of Engineer-in-Charge and corrective action shall be taken as per his instructions.

5.3 Cold Pull

Wherever cold pull is specified, the Contractor shall maintain the necessary gap, as indicated in the drawing. Confirmation in writing shall be obtained by the Contractor from the Engineer-in-Charge, certifying that the gap between the pipes is as indicated in the drawing, before drawing the cold pull. Stress relieving shall be performed before removing the gadgets for cold pulling.

5.4 Slopes

Slopes specified for various lines in the drawings / P&ID shall be maintained by the Contractor. Corrective action shall be taken by the Contractor in consultation with Engineer-in-Charge wherever the Contractor is not able to maintain the specified slope.

5.5 Expansion Joints / Bellows

Installation of Expansion Joints/Bellows shall be as follows:

- All Expansion joints / Bellows shall be installed in accordance with the specification and installation drawings, supplied to the Contractor.
- Upon receipt, the Contractor shall remove the Expansion Joints/ Bellows from the case(s) and check for any damage occurred during transit.
- The Contractor shall bring to the notice of the Engineer-in-Charge any damage done to the bellows / corrugations, hinges, tie-rods, flanges / weld ends etc.
- Each Expansion Joint / Bellow shall be blown free of dust / foreign matter with compressed air or cleaned with a piece of cloth.
- For handling and installation of Expansion Joints, great care shall be taken while aligning. An Expansion Joints shall never be slinged from bellows corrugations / external shrouds, tie / rods, angles.
- An Expansion Joints / Bellow shall preferably be slinged from the end pipes / flanges or on the middle pipe.
- All Expansion Joints shall be delivered to the Contractor at "Installation length", maintained by means of shipping rods, angles welded to the flanges or weld ends or by wooden or metallic stops.
- Expansion Joints stop blocks shall be carefully removed after hydrostatic testing. Angles welded to the flanges or weld ends shall be trimmed by saw as per manufacturer's instructions and the flanges or weld ends shall be ground smooth.
- The pipe ends in which the Expansion Joint is to be installed shall be perfectly aligned or shall have specified lateral deflection as noted on the relevant drawings.
- The pipe ends / flanges shall be spaced at a distance specified in the drawings.
- The Expansion Joint shall be placed between the mating pipe ends / flanges and shall be tack welded/bolted. The mating pipes shall again be checked for correct alignment.
- Butt-welding shall be carried out at each end of the expansion joint. For flanged Expansion Joint, the mating flanges shall be bolted.

- After the Expansion Joint is installed the Contractor shall ensure that the mating pipes and Expansion Joints are in correct alignment and that the pipes are well supported and guided.

- The Expansion Joint shall not have any lateral deflection. The Contractor shall maintain parallelism of restraining rings or bellows convolutions.

- Precautions

  - For carrying out welding, earthing lead shall not be attached with the Expansion Joint.

  - The Expansion bellow shall be protected from arc weld spot and welding spatter.

  - Hydrostatic Testing of the system having Expansion Joint shall be performed with shipping lugs in position. These lugs shall be removed after testing and certification is over.

5.6 Flange Connections

While fitting up mating flanges, care shall be exercised to properly align the pipes and to check the flanges for trueness, so that faces of the flanges can be pulled together, without inducing any stresses in the pipes and the equipment nozzles. Extra care shall be taken for flange connections to pumps, turbines, compressors, cold boxes, air coolers etc. The flange connections to these equipments shall be checked for misalignment, excessive gap etc. after the final alignment of the equipment is over. The joint shall be made up after obtaining approval of Engineer-in-Charge.

Temporary protective covers shall be retained on all flange connections of pumps, turbines, compressors and other similar equipments, until the piping is finally connected, so as to avoid any foreign material from entering these equipments.

The assembly of a flange joint shall be done in such a way that the gasket between these flange faces is uniformly compressed. To achieve this the bolts shall be tightened in a proper sequence. All bolts shall extend completely through their nuts but not more than 1/4".

Steel to C.I. flange joints shall be made up with extreme care, tightening the bolts uniformly after bringing flange flush with gaskets with accurate pattern and lateral alignment.

5.7 Vents and Drains

High point vents and low point drains shall be provided as per the instructions of Engineer-in-Charge, even if these are not shown in the drawings. The details of vents and drains shall be as per piping material specifications / job standards.

5.8 Valves

Valves shall be installed with spindle / actuator orientation / position as shown in the layout drawings. In case of any difficulty in doing this or if the spindle orientation / position is not shown in the drawings, the Engineer-in-Charge shall be consulted and work done as per his instructions. Care shall be exercised to ensure that globe valves, check valves, and other uni-directional valves are installed with the "Flow direction arrow "on the valve body pointing in the correct direction. If the direction of the arrow is not marked on such valves, this shall be done in the presence of Engineer-in-Charge before installation.

Fabrication of stem extensions, locking arrangements and interlocking arrangements of valves (if called for), shall be carried out as per drawings / instructions of Engineer-in-Charge.

5.9 Instruments

Installation of in-line instruments such as restriction orifices, control valves, safety valves, relief valves, rotameters, orifice flange assembly, venturimeters, flowmeters etc. shall form a part of piping erection work.

Fabrication and erection of piping upto first block valve / nozzle / flange for installation of offline Instruments for measurement of level, pressure, temperature, flow etc. shall also form part of piping construction work. The limits of piping and instrumentation work will be shown in drawings / standards / specifications. Orientations / locations of take-offs for temperature, pressure, flow, level connections etc. shown in drawings shall be maintained.

Flushing and testing of piping systems which include instruments mentioned above and the precautions to be taken are covered in flushing, testing and inspection of piping. Care shall be exercised and adequate precautions taken to avoid damage and entry foreign matter into instruments during transportation, installation, testing etc.

5.10 Line Mounted Eqipments / Items

Installation of line mounted items like filters, strainers, steam traps, air traps, desuperheaters, ejectors, samples coolers, mixers, flame arrestors, sight glasses etc. including their supporting arrangements shall form part of piping erection work.

5.11 Bolts and Nuts

The Contractor shall apply molycoat grease mixed with graphite powder (unless otherwise specified in piping classes) all bolts and nuts during storage, after erection and wherever flange connections are broken and made-up for any purpose whatsoever. The grease and graphite powder shall be supplied by the Contractor within the rates for piping work.

5.12 Pipe Supports

Pipe supports are designed and located to effectively sustain the weight and thermal effects of the piping system and to prevent its vibrations. Location and design pipe supports will be shown in drawing for lines 2" NB. However, any extra supports desired by Engineer-in-Charge

shall also be installed.

No pipe shoe / cradle shall be offset unless specifically shown in the drawings.

Hanger rods shall be installed inclined in a direction opposite to the direction in which the pipe move during expansion.

Preset pins of all spring supports shall be removed only after hydrostatic testing and insulation is over. Springs shall be checked for the range of movement and adjusted if necessary to obtain the correct positioning in cold condition. These shall be subsequently adjusted to hot setting in operating condition. The following points shall be checked after installation, with the Engineer-in-Charge and necessary confirmation in writing obtained certifying that :

- All restraints have been installed correctly.
- Clearances have been maintained as per support drawings.
- Insulation does not restrict thermal expansion.
- All temporary tack welds provided during erection have been fully removed.
- All welded supports have been fully welded.

6.0 WELDING

Welding of pipelines shall be done as per applicable codes and **Annexure-1**

7.0 ERECTION

7.1 Pre-fabrication and Field Assembly

Extent of pre-fabrication shall be purely at the discretion of CONTRACTOR keeping in view the following :-

7.1.1 Field joint shall be decided by CONTRACTOR keeping in view the transportation of pre-fabricated pieces to site.

7.1.2 There can be some variations in the dimensions and level appearing in the arrangement drawings and those actually occurring at site due to minor variations in the location of equipments, structures, cut out etc. Adequate field joints shall be provided, permitting assembly and erection of pipe work without major modification.

7.2 Supporting

Location and design of pipe supports shown in approved drawings and support drawings shall be strictly followed.

7.2.1 Supports shall be installed in such a way that they do not contribute to over stressing of a line.

7.2.2 Fabrication and erection of additional supporting elements and structural fixtures which in COMPANY's view are required for proper supporting of the system, shall be carried out by CONTRACTOR at no extra cost.

7.2.3 All temporary supports, elements required for alignment, erection and assembly shall be removed after completion of work.

7.3 **Equipment hook-up**

7.3.1 Prior to hook-up, the alignment and trueness of flange faces shall be checked to ensure that no undue stresses shall be induced in the system while hooking up.

8.0 **INSPECTION**

8.1

8.2 CONTRACTOR shall provide all facilities/ assistance to COMPANY for proper execution of their inspection without any extra charge.

8.3 All piping work shall be subjected to inspection by COMPANY at any time during fabrication. CONTRACTOR shall furnish to COMPANY detailed work programme sufficiently in advance, in order to enable COMPANY to arrange for inspection.

9.0 **PROTECTIVE COATING**

9.1 All above ground piping system shall be applied with protective coating in accordance with specification for shop & field painting.

9.2 All under ground portion of piping system shall be coated with three layer P.E. coating. CONTRACTOR shall prepared procedure for epoxy painting of burried pipeline for approval of COMPANY. Procedure shall include surface preparation, brand and type of coating to be adopted. Coating of pipes shall not commence without approval of coating procedure. Total dry film thickness to be achieved shall not be less than 300 microns. Compatible primer and finish coat as recommended by coating manufacturer shall only be applied. Coating integrity shall be checked by "Holiday detector" over full length of coated pipe work. Coating to be supplied by CONTRACTOR shall be suitable for design temperature.

9.3 Once the coating has been accepted by COMPANY, backfiling operation can be started. In order to protect coated pipe from damage, the excavated trench shall be examined for stone, rock and any other hard substance detrimental to coating. All such substances shall be removed before lowering the pipe in the trench. COMPANY may ask for a 100mm padding of clear sand under and above pipeline in rocky or otherwise hard soil area. No additional payment on account of padding shall however be admissible.

10.0 **FLUSHING**

Completed piping systems shall be flushed by CONTRACTOR with fresh water, to clean the pipe of all dirt, debris, and foreign material. CONTRACTOR shall prepare a procedure for flushing of the system for approval of COMPANY. Flushing shall not be commenced without approval of flushing procedure.

10.1 CONTRACTOR shall perform all activities like dismantling and reinstalling of all strainers, in line instruments etc. before and after completion of flushing.

10.2 Flushing shall be considered as complete only after inspection and approval by COMPANY.

10.3 Disposal of muck and flushing media shall be arranged by CONTRACTOR as directed by COMPANY, in such a manner that it does not spoil the adjacent installation. CONTRACTOR shall obtain COMPANY approval regarding the place and method to be adopted for disposal of debris.

10.4 Record of flushing giving following details shall be submitted by CONTRACTOR to COMPANY for its approval and records :

a) Date of flushing

b) Identification of line : flushed-line number

11.0 **HYDROSTATIC TESTING**

11.1 Completed piping system as approved by COMPANY shall be hydrostatically tested in the presence of COMPANY. The general requirements of hydrostatic testing shall be in accordance with codes specified in section 2.0.

11.2 CONTRACTOR shall prepare hydrostatic test procedure based on specified codes. The hydrostatic test shall commence only after approval of procedure by COMPANY.

11.3 Piping system shall be hydrostatically tested to a pressure corresponding to 1.4 times the design pressure.

11.4 Fresh water shall be used as test media. CONTRACTOR shall locate the source of water supply and arrange for transportation of water to test site. CONTRACTOR shall arrange at his own cost the water analysis and confirm that water is suitable for testing. In case any corrosion inhibitor is to added, the same shall be done after approval of COMPANY.

11.5 Lines repaired subsequent to hydrostatic test shall be retested using the same procedure as originally adopted. However COMPANY may waive such retest in case of minor repairs by taking precautionary measures to ensure sound construction.

11.6 All equipment and instruments used for hydrostatic test shall be approved by COMPANY before start of tests.

11.7 Pressure gauges shall be installed on line to measure test pressures. In case of longer lines two or more pressure gauges shall be installed as directed by COMPANY. One gauge shall be installed at the discharge of the pressurising pump. Pressure gauge used for hydrostatic testing shall be calibrated with dead weight tester in the presence of Engineer-in-charge. Range of pressure gauge shall generally be 1.5 times the test pressure.

11.8 Orifice plates and restriction orifices shall not be installed until hydrostatic testing is completed. Temporary gaskets shall be used during testing.

11.9 First block valve of pressure instruments shall be half open & plugged at the time of hydrostatic testing. Temperature connections shall be blanked off during testing.

11.10 All equipments, in line instruments, relief valves shall be disconnected from piping system by means of blinds during testing. Control valves shall be replaced by spool pieces during testing.

11.11 High point vents and low point drain required for testing in addition to those marked in the drawings shall be provided by CONTRACTOR at his own cost.

11.12 All welded and screwed joints shall be kept clean for detecting leaks during testing.

11.13 Test pressure shall be maintained long enough to facilitate complete inspection of the system. Minimum duration of test shall be 6 hours unless other wise specified. Pressurising equipment shall be isolated immediately after test pressure is attained.

11.14 After successful completion of hydrostatic testing, the piping system shall be dewatered. All lines shall be completely dried using compressed air. CONTRACTOR shall make his own arrangement for supply of compressed air. Drying of lines shall be considered complete on approval by COMPANY.

11.15 **Test Records**

The records in duplicate shall be prepared and submitted by CONTRACTOR as below :

a) Date of test
b) Identification of pipe tested - line number
c) Test pressure
d) Test results
e) Signature of CONTRACTOR
f) Approval signature by COMPANY.

ANNEXURE-1

WELDING SPECIFICATION

1.0 GENERAL

This specification shall be followed for the fabrication of all types of welded joints of carbon steel above ground natural gas service piping systems.

The welded pipe joints shall include the following :

a) All line pipe joints of the longitudinal and circumferential butt welded.

b) Attachments of castings, forgings, flanges.

c) Welded manifold headers and other sub-assemblies

d) Welded branch connections with or without reinforcing pads.

e) Joints in welded/ fabrication piping components.

f) The attachments of smaller connections for vents drain drips and other instrument tappings.

Any approval granted by the Engineer-in-charge or owner's inspectors shall not relieve the contractor of his responsibilities & guarantees.

1.1 Applicable Codes & Standards

All welding work, equipments for welding, heat treatment, other auxiliary functions and the welding personnel shall be as per the requirements of the latest editions of the following approved standards and procedures :-

i) Code for gas transmission and distribution piping systems. ANSI B31.8.
ii) Code for petroleum refinery piping, ANSI B31.3.

In addition, the following codes/ specifications referred to in the relevant code of fabrication shall be followed for the welding/ brazing qualifications, consumable qualifications and non destructive test procedures.

i) Standard for welding of pipelines and related facilities API-1104.
ii) Material Specifications - Welding rods, electrodes and filler materials - ASME Sec. - IIC.
iii) Code for non destructive examination ASME Sec-V.
iv) Qualification standard for welding and brazing procedure and welders, brazers, welding and brazing operators - ASME Sec-I

In the event of any difference due to the additional requirements mentioned in this specification, over and above those obligation as per codes, this specification shall be binding.

1.2 **Base Material**

a) In general carbon steel is used in this plant. The details of material specifications are given in the welding Specification Chart.

b) The contractor shall provide the Manufacturer's test certificates for every heat of the materials supplied by him.

1.3A **Filler Materials**

a) The Contractor shall provide all the necessary welding electrodes, filler materials, etc. required for the execution of the work.

b) The welding electrodes/ filler wires supplied by the Contractor shall conform to the class specified in the welding specification chart. The materials shall be of the make approved by the Engineer-in-charge.

c) The electrode shall be suitable for the welding process recommended and base metal used. Unless otherwise specified physical properties of the welds produced by a electrode recommended for the welding of a particular base metal shall not be lower than the minimum valves specified for the base metal and shall correspond to the physical properties of the class of electrode adopted. The choice of electrode shall be made after conducting the required tests on the electrodes as per relevant standards, and shall be the sole prerogative of the Engineer-in-charge.

d) Tungsten electrodes used shall conform to ASME Sec. II C SFA 5.12 specification. Thoriated Tungsten electrodes shall not be permitted due to possible radiation hazard. Instead, ceriated Tungsten Electrodes (EWCe-2 or equivalent) shall be used for GTA Welding.

e) Electrode qualification test records should be submitted as per the **Exhibit-A** (attached) in respect of the electrodes tested by the contractor, for obtaining the approval of the Engineer-in-charge.

f) The Contractor shall submit batch test certificate from the electrode Manufacturers giving details of physical and chemical tests carried out by them, for each batch of electrodes to be used.

g) All electrodes shall be purchased in sealed containers and stored properly to prevent deterioration. The electrodes removed from the containers shall be kept in holding ovens at temperature recommended by the electrode Manufacture. Out-of-the oven time of electrodes before they are consumed shall not exceed the limits recommended by the electrodes manufacturer. The electrodes shall be handled with care to avoid any damage to flux covering.

h) All low hydrogen type of electrodes shall be rebaked at 350°C for 1 hour minimum and stored in ovens kept at 80-100°C before use. Recommendations of the electrode Manufacturer shall be followed if available.

i) The electrodes, filler wires and flux used shall be free from rust, oil, greases, earth and other foreign matter which can affect the quality of welding.

1.3B **SHIELDING & PURGING GAS**

a) Argon gas used in GTA welding for shielding purposes shall be 99.995% pure. The purity of the gas shall be certified by the manufacturer. The rate of flow for shielding purposes shall be established through procedure qualification tests. Normally this rate may be 12-20 CFH.

b) Argon gas with a purity level of 99.995% shall be used for purging.

c) When GTAW process alone or a combination of GTA Wand SMAW processes is recommended for the production of a particular joint, the purging shall be maintained during the root pass and for the first filling pass to minimize oxidation on the inner side of the pipe, unless otherwise specified in Welding Specification Chart.

d) Initial purging shall be maintained for sufficient period of time so that at least 4-5 times the volume between the dams is displaced, in order to completely remove the entrapped air. In no case should the initial purging period be less than 10 minutes. High gas pressure should be avoided.

e) After initial purging, the flow of the backing gas should be reduced to a point where only a slight positive pressure prevails. For systems, which have a small volume (up to 1/2 cubic foot) to be purged, a gas flow rate of 6-CFH is usually adequate. Systems of larger volume may require higher flow rates and these should be established during procedure qualification tests.

f) Gas backing (purging) is not required for socket type of welded joints.

g) Dams, used for conserving inert gas during purging, shall be removed after completion of the welding, and shall be accounted for. Wherever, removal of dams is not possible after welding, use of water-soluble dams should be made.

1.4 **Welding Consumables**

The Contractor shall provide at this own expense all the welding consumables necessary for the execution of the job such as electrodes filler wires, oxygen, acetylene, etc. and these should bear the approval of the COMPANY.

1.5 **Equipment & Accessories**

1.5.1 The Contractor should have the arrangement of sufficient number of welding and cutting equipments, auxiliaries and accessories of sufficient capacities so as to meet the target schedule.

1.5.2 All the equipment for performing the heat treatment, including transformers, thermocouples, flow meters, automatic temperature recorders with suitable calibration arrangement etc. shall be provided by the Contractor, at his own expense and these should bear the approval of the COMPANY.

1.5.3 Contractor shall make necessary arrangements at his own expense for providing the radiographic equipment, radiographic films, and all the equipment/ materials required for carrying out the dye penetrant/ magnetic particle test for satisfactory and timely completion of the job.

1.5.4 Redoing of any work necessitated by faulty equipments or operation used by the Contractor, will be done at his own expense.

1.6 **Welding Processes**

1.6.1 Welding of various materials under this specification shall be carried out using Shielded Metal Arc Welding (SMAW) Process with the approval of the Engineer-in-charge.

1.6.2 The welding processes to be employed are given in the welding specification chart. Any deviation desired by the Contractor shall be obtained through the express consent of the Engineer-in-charge.

1.6.3 Automatic and semi-automatic welding processes shall be employed only with the express approval of the Engineer-in-charge. The welding procedure adopted and consumables used shall be specifically approved.

1.6.4 A combination of different welding processes or a could be employed for a particular joint only after duly qualifying the welding procedure as per the requirements of code of fabrication to be adopted and obtaining the approval of the Engineer-in-charge.

1.7 **End Preparation**

1.7.1 **End Preparation**

The edges to be welded shall be prepared to meet the joint design requirements by gas cutting, machining or grinding method. After gas cutting, oxides shall be removed by chipping or grinding.

1.7.2 **Cleaning**

a) The ends to be welded shall be properly cleaned to remove paint, oil, greases, rust, oxides, sand, earth and other foreign matter. The ends shall be

completely dry before the welding commences.

b) On completion of each run, craters, welding irregularities, slag etc., shall be removed by grinding and chiseling. Wire brushes used for cleaning stainless steel joints shall have stainless steel wires and the grinding wheels used for grinding stainless steel shall be of a suitable type. Separate grinding wheels and wire brushes should be used for carbon steels and stainless steels.

1.8 **Alignment and Spacing**

a) Prior to alignment, the contractor shall inspect the pipe ends inside and outside for damage, dents, laminations etc. Pipe for welding shall be set up correctly spaced. Temporary attachment of any kind shall not be welded. Every effort shall be made to reduce misalignment by the use of clamp and rotation of pipes to the best fit. For pipes of same nominal wall thickness, the off set should not exceed 1.6mm. Any branch connections sleeve shall be at least 150mm from any other weld. The welds for fitting shall be so located that top of the weld shall not come within 50mm of any other weld. The use of internal line up clamps is mandatory for diameters 10" and above. However, in case where it is impossible to use internal line up clamp, external line up clamp may be used.

b) Tack welds, for maintaining the alignment, of pipe joints shall be made only by qualified welders using approved WPS. Since the tack welds become part of the final weldment they shall be executed carefully and shall be free from defects. Defective tack welds must be removed prior to the actual welding of the joints.

1.9 **Weather Conditions**

1.9.1 The parts being welded and the welding personnel should be protected from rain and strong winds. In the absence of such a protection no welding shall be carried out.

1.9.2 During field welding using GTAW process, particular care shall be exercised to prevent any air current affecting the welding process.

1.10 **Welding**

1.10.1 **Root Pass**

a) Root pass shall be made with electrodes/ filler wires recommended in the welding specification chart. The preferable size of the electrode is 2.5mm diameter (12 SWG) but in no case greater than 3.25mm (10 SWG).

b) Uphill welding shall be adopted for welding pipes weld fixed with its axis horizontal. Downward technique of welding shall not be used for welding of pipes in horizontal position, unless specifically permitted by Engineer-in-charge for a particular case.

c) The root pass of but joints should be executed properly so as to achieve full penetration with complete fusion of the root edges. Weld projection inside the pipe shall not exceed .4mm wherever not specified by the applicable code.

d) Any deviations desired from the recommended welding technique and electrodes indicated in the welding specification chart should be adopted only after obtaining express approval of the Engineer-in-charge.

e) Welding shall be continuous & uninterrupted during a pass.

f) On completion of each run, craters, welding irregularities, slag etc., shall be removed by grinding and chiselling.

g) While the welding is in progress care should be taken to avoid any kind of movement of components, to prevent occurrence of weld cracks.

h) Fillet welds shall be made by shielded metal arc/ GTAW welding process irrespective of the thickness and class of piping.

i) Peening shall not be used unless specified in the welding specification chart.

1.10.2 **Joint Completion**

a) Joint shall be completed using the class of filler wires/ electrodes, recommended in the welding specification chart. Size of the electrode shall not exceed 4 mm in diameter for stainless steels and alloy steels used for low temperature applications.

b) Two weld beads shall not be started at the same point in different layers.

b) Butt joints shall be completed with a cover layer that would effect good cover at the joint edge and a gradual notch free surface.

d) Each weld joints should have a workman like finish.

e) Weld identification mark shall be stamped clearly at each joint, just adjacent to the weld. Metal stamping shall not be used on the thin wall pipe. Suitable paint shall be used on thin wall pipes for identification.

f) No painting shall be done until the weld joint has been hydrostatically tested.

1.10.3 **Dissimilar Welds**

Where welds are to be produced between carbon steels and alloy steels, preheat and post weld heat treatment requirements shall be those specified for corresponding alloy steels and filler wire / electrodes shall correspond to ER 70 S-G or AWS E-7016/7018 type. For welds between two dissimilar Cr-Mo low alloy steels, preheat and post weld

heat treatments shall be those specified for higher alloy steel and electrodes used shall correspond to those specified for steel of lower alloy content. For carbon steel or alloy steel to stainless welds, use of filler wire / electrodes E/ER-309/E-310/E NiCr Fe-3 shall be made. The welding procedure, electrodes / filler wires to be used shall be approved by the Engineer-in-Charge.

1.11 Heat Treatment

1.11.1 Preheating

a) Preheating requirements for the various materials shall be as per the welding specification chart attached. No welding shall be carried out without preheating the joint to 10°C (50°F) when the ambient temperature is below 10 degree.

b) Preheating shall be performed using resistance or induction heating methods. Preheating by gas burners, utilising any acetylene or oxy-propane gas mixtures, with neutral flame may also be carried out when permitted by the Engineer-in-charge.

c) Preheating shall extend uniformly to atleast three times the thickness of the joint, but not less than 50mm, on both sides of the weld.

d) Preheating temperature shall be maintained over the whole length of the joint during welding. Temperature indicating crayons or other temperature indicating devices shall be provided by the contractor to check the temperature.

e) Preheating temperature shall be maintained over the whole length of the joint during welding. Temperature recorders shall be provided by the Contractor to record the temperature.

1.11.2 Post Heating

In case of alloy steel materials such as Cr-Mo steels, if the post weld heat treatment is not performed immediately after welding, the weld joint and adjacent portion of pipe, at least 50 mm on either side of weld, shall be uniformly heated to 300°c. This temperature shall be maintained for half an hour minimum, and then wrapped with mineral wool before allowing it to cool to room temperature. If the Post Heating temperature specified in the Welding Specification Charts exceeds 300°C, the same shall be followed. Similarly, if the welding specification chart specifies post-heat time, the same shall be applicable. Post weld heat treatment as specified in the Welding Specification Chart shall be carried out later on.

1.11.3 Postweld Heat Treatment

a) Post weld heat treatment, wherever required for joints between pipes, pipes an fittings, pipe body and supports shall be carried out as per the relevant specifications, applicable standards and the instructions of the Engineer-in-charge. In this regard procedure qualification to be done before carrying out

PWHT in production welds.

b) The heat treatment of welded joints shall be carried out as per the requirements laid down in ANSI B31.8 and welding specification chart.

c) The contractor shall submit for the approval of the Engineer-in-charge, the details of the post weld heat treatment procedure, as per **Exhibit `B'** attached, that the propose to adopt for each of the materials/ assembly/ part involved, well before carrying out actual heat treatment.

d) Post weld heat treatment shall be done by using an electric resistance or induction heating equipment as decided by the Engineer-in-charge.

e) While carrying out local post weld heat treatment, technique of application of heat must ensure uniform temperature attainment at all points of the portion being heat treated. Care shall be taken to ensure that width of treated band over which specified post weld heat treatment is carried out, the temperature attained is atleast as that specified in the relevant applicable standards/ codes.

f) Throughout the cycle of heat treatment, the portion outside the heated band shall be suitably wrapped under insulation so as to avoid any harmful temperature gradient at the exposed surface of pipe. For this purpose temperature at the exposed surface of the pipes should not be allowed to exceed 400°C.

g) The temperature attained by the portion under heat treatment shall be recorded by means of thermocouple pyrometers. Adequate number of thermocouples should be attached to the pipe directly at the equally spaced location along the periphery of the pipe joint. The minimum number of thermocouples attached per joint shall be 1 upto 6" dia, 2 upto 10" dia and 3 upto 12" and above. However the Engineer-in-charge can increase the required minimum number of thermocouples to be attached if found necessary.

h) Automatic temperature recorders which have been duly calibrated should be employed. The calibration chart of each recorder should be submitted to the Engineer-in-charge prior to starting the heat treatment operation and his approval should be obtained.

i) Immediately on completion of the heat treatment, the post weld heat treatment charts/ records alongwith the hardness test results on the weld joints (whenever required as per the welding specification chart), shall be submitted to Engineer-in-charge for his approval.

j) Each joint shall bear an identification number which shall be maintained in the piping sketch to be prepared by the contractor. The joint identification number should appear on the corresponding post weld heat treatment charts. The same identification numbers shall also be followed for identification for corresponding radiographic films. The chart containing the identification

numbers and piping sketch shall be submitted to the Engineer-in-charge in suitable folders.

k) The hardness of the heat affected zone as well as of the weld metal, after heat treatment, shall be measured using suitable hardness tester and shall not exceed the maximum hardness specified in the welding specification chart. The weld joint shall be subjected to re-heat treatment when hardness measured exceeds the specified limit, at the contractor's own expenses.

l) The contractor shall arrange for the hardness testing and shall maintain the records of all joints tested. These records shall be checked by the plant Owner's inspector.

1.12 Cleaning of the Weld Joints

All weld joints shall be free from adherent weld spatter, slag, dirt or foreign matter. This can be achieved by brushing.

1.13 Inspection & Testing

1.13.1 General

a) The owner's inspector shall have free access to all concerned areas, where the actual work is being performed. The contractor shall also offer the Owner's inspector all means and facilities necessary for carrying out inspection.

b) The owner is entitled to depute his own inspector to the shop or field where pre-fabrication and erection of pipelines are being done with (but not limited to) the following objectives :-

i. To check the conformance to relevant standards and suitability of various welding equipments and the welding performance.
ii. To supervise the welding procedure qualification.
iii. To supervise the welder performance qualifications.

c) Contractor shall intimate sufficiently in advance the commencement of qualification tests welding works and acceptance tests, to enable the plant owner's inspector to be present to supervise them.

1.13.2 Welding Procedure Qualifications

a) Welding Procedure Qualification shall be carried out in accordance with the relevant requirements of API 1104/ ASME Sec-IX or other applicable codes and other job requirements by the contractor at his expense. The contractor shall submit the welding procedure specifications in format as per **Exhibit-C** (attached) immediately after the receipt of the order.

b) COMPANY's inspector will review, check and approve the welding procedure submitted and shall release the procedure for procedure qualification tests. The procedure qualification test shall be carried out by the Contractor under field conditions at this own expense. A complete set of test results in format as per **Exhibit-D** (attached) shall be submitted to the COMPANY's inspector for approval immediately after completing the procedure qualification test and atleast 2 weeks before the commencement of actual work. Standard tests as specified in the code shall be carried out in all cases. In addition to these tests, other tests like radiography, macro/ micro examination, hardness testers, dye penetrant examination, Charpy V-notch etc. shall be carried out on specimens. It shall be the responsibility of the contractor to carry out all the tests required to the satisfaction of the COMPANY's Inspector. The destructive testing of welded joints shall be as per **Annexure-2** and ASME Sec-IX.

1.13.3 **Welder's Qualification**

a) Welders shall be qualified in accordance with the API 1104/ ASME IX and other applicable codes by the contractor at his expense. The butt weld test pieces of the qualification test shall meet the radiographic tests requirements as mentioned in this specification. The COMPANY's inspector shall witness the test and certify the qualification of each welder separately. Only those welders who have been approved by the COMPANY's inspector shall be employed for welding. Contractor shall submit the welder qualification test reports in the standard format and obtain express approval, before commencement of the work. No welder shall be permitted to work without the possession of the identify card. It shall be the responsibility of contractor to carry out Qualification tests of welders.

b) The welders shall always have in their possession the identification card as shown in **Exhibit-E** and shall produce it on demand by the COMPANY's Inspector. It shall be the responsibility, of the Contractor to issue the identify cards after it has been duly certified by the COMPANY. If a welder is found to perform a type of welding for which he is not qualified, he shall be debarred from doing any further work. All welds performed by an unqualified welder shall be cut and redone by a qualified welder at the expense of the Contractor.

1.13.4 **Visual Inspection**

Inspection of all welds shall be carried out by COMPANY as per the latest editions of the applicable codes and specifications. All finished welds shall be visually inspected for parallel and axial alignment of the work, excessive reinforcement, concavity of welds, shrinkage, cracks, under cuts, dimensions of the weld, surface porosity and other surface defects. Under-cutting adjacent to the completed weld shall not exceed the limits specified in the applicable standard/ code.

1.13.5 **Non-destructive Examination**

The non destructive examination shall mainly consist of examination using x-ray radiography as detailed in **Annexure-4.**

Radiographic examination of one hundred percent (100%) girth welds will be required by the COMPANY. Welds shall meet the standards of acceptability as set forth in API 1104 and as per the requirements laid in subsequent paragraphs.

The CONTRACTOR shall make all the arrangements for the radiographic examination of work covered by this specification at his expense.

The COMPANY will review all the radiographs of welds and inform the CONTRACTOR regarding unacceptable welds. The decision of the COMPANY shall be final and binding in this regard.

All requirements mentioned in the specification shall be arranged and executed by the CONTRACTOR through his own resources. In addition, for pipes with wall thickness 9.5mm and above, ultrasonic inspection is required in the following cases as per **Annexure-3** of this specification.

a) On the first 100 welded joints corresponding to each automatic (GTAW/ GMAW) welding procedure used.

b) When 20mm or more are cut from the pipe end as supplied, the ends shall be ultrasonically inspected for an additional length of 20mm to ensure no lamination exist.

c) When welds are repaired.

d) When in the opinion of COMPANY, ultrasonic inspection is required to confirm or clarify defects indicated by radiography.

e) When automatic procedure is used at least 10cm on each weld shall be ultrasonically inspected at COMPANY's discretion.

In addition, ultrasonic inspection may be required for certain critical weldings of the pipeline (i.e. tie-ins, welding of valves, flanges) randomly selected at COMPANY's discretion. All fillet and groove welds other than that radiographed shall be subjected to dye pentrant/ MP inspection. The non destructive test system used for inspecting welds must be approved by the COMPANY.

Weld quality is judged on the basis of the acceptability criteria mentioned below :

Any weld which as a result of radiographic and / or ultrasonic examination in the opinion of COMPANY **exhibits** imperfections greater than the limits stated in API-1104 latest edition or as superseded in this article shall be considered defective and shall so be marked with an identification paint marker.

In addition to the API-1104 requirements, the welds containing cracks including crater cracks regardless of size of location are unacceptable.

i. Any amount of inadequate penetration of the root bead as defined by API-1104 is unacceptable.

ii. Any amount of incomplete fusion between the root and bevel as defined by API-1104 is unacceptable.

iii. Unrepaired burn through areas are unacceptable.

Contractor shall appoint agency for carrying out the radiography works at site from the list of agency (ies) enclosed in the bid document.

- The Radiographic Examination procedures to be adopted shall be submitted by the contractor as per **Exhibit-F** and shall be got approved from the Owner's Inspector prior to employment. A person qualified to ASNT Level-II or ASNT Level-III in Radiographic testing shall prepare the procedure. The Radiography Procedure shall be established to demonstrate that the required sensitivity can be consistently achieved under the most unfavorable parameters (e.g. source to film distance, geometric unsharpness, thickness etc.). The radiographic technique and procedure adopted shall conform of the requirements mentioned in Article 2 as well as Article 22 of ASME Sec.V. The IQI sensitivity obtained shall be equal to or better than the requirements mentioned in Article 2 of ASME Sec.V. Source side penetrameter shall be used in establishing radiographic procedure / technique. The acceptance criteria shall be as per the relevant codes of Fabrication and over riding requirements if mentioned else where in the technical specifications of the contract. The Contractor shall be responsible for carrying out Radiography; rectification of defects and re-radiography of welds repaired/rectified at his cost.

- The extent of Radiography shall be as per specifications to be supplied to the Contractor. For welds between dissimilar materials, the extent of Radiographic Examination shall be the more stringent of the two recommended for the materials being welded. Wherever random Radiography is called for, in a particular piping class, the dissimilar materials weld joints shall essentially be included.

- Type of Radiation source and film to be used shall be as per **Exhibit-H** for carrying out radiographic examination. However if specifications (as given else where in the contract) for some critical material require usage of X-Radiation, then Radiography shall be done using X-Rays only.

- The Contractor shall fulfill all the statutory and owner's safety requirements while handling X-ray and Gamma-ray equipments.

- In case of random radiography, the joints for Radiography shall be selected by the Owner's Inspector and the Radiography shall be performed in his presence, if he instructs the contractor to do so. The contractor shall furnish all the radiographs, to the Owner's Inspector immediately after processing along with evaluation by a person qualified to ASNT Level-II in Radiographic testing, inline with Article 2 of ASME Sec.V. The certificate of ASNT / ISNT Level II qualification of the NDT personnel shall be submitted to owner's inspector for his approval prior to start of job.

- The Contractor shall provide the Owner's Inspector, all the necessary facilities at site such as a dark room with controlled temperature, illuminator (viewer) suitable for varying densities, a duly calibrated electronic densitometer with batteries, magnifying glass, tracing papers, ruler, marking pencils etc. to enable him to review the radiographs.

- Where random radiography is specified, the first weld of each welder shall be completely radiographed. In the case of pipe of size 6" and below, the first two welds shall be completely radiographed.

- For each weld performed by a welder found unacceptable, two additional checks shall be carried out on welds performed by the same welder. This operation is iterative and the of two additional welds for each weld deemed unsatisfactory shall be continued till such time that two consecutive welds of satisfactory quality are found for every defective weld.

- The Contractor shall carry out these additional radiographic testing at his own expense. To avoid the possibility of too many defective welds by a single welder remaining undetected for a long period to time, the Contractor shall promptly arrange for Radiographic Examination so that there is no accumulation of defective joints.

- Contractor shall quote rates for X-ray as well as Gamma Ray for joints indicated to be radiographed by X-ray in Table of **Exhibit-H.**

1.13.6 **Check shots**

(a) Owner / Engineer- in- charge or his representative shall select 5% of the total joints radiographed on a day for check shots. Contractor shall carry out check shots as directed.

(b) Weld profiles of check shots shall be compared with weld profile observed in the earlier Radiographs. In the event of anyone variation in the check shots and earlier Radiographs, contractor shall re-shoot the entire lot of joints radiographed by particular Radiography agency on the particular date. All the re-shot films shall be compared with the originally submitted films.

1.13.7 **Magnetic Particle & Liquid Penetrant Examination**

a) Whenever such tests are specified, the tests shall be carried out on joints chosen by the Owner's inspector, as per ASME Section V article 6 and 7 respectively. The tests are to be performed by a person possessing a valid ASNT / ISNT Level-II qualification in the method being used.

(b) For austenitic stainless steels and other nonmagnetic materials, liquid (dye) penetrant test shall be carried out. For carrying out this test, the materials shall be brought within a temperature limit of 15° to 50°C.

1.13.8 **Hardness Test**

Hardness requirements for welds shall be as per the Welding Specification Chart / Non Destructive Examination Specification attached elsewhere in the contract. Hardness testing shall be carried out by Vickers Hardness Tester during welding procedure qualification and shall be cross sectional. For production welds, hardness testing shall be carried out by portable digital hardness testers. Poldi hardness tester shall not be permitted. Contractor shall produce documentary evidence/calibration certificate to the Owner's Inspector and obtain approval of the hardness testing equipment.

1.13.9 **Proof Tests**

Hydrostatic and pneumatic tests shall be performed as per the requirements laid down in the respective flushing & testing specification/ applicable codes to demonstrate the soundness of the welds. The tests shall be conducted only after fulfilling the requirements of visual examination, radiography etc. and after the entire work has been certified by the Owner's inspector, as fit for subjecting to such test.

1.14 **Repairs of Welds**

a) Defects ascertained, through the inspection methods, which are beyond acceptable limits shall be removed from the joint completely by the process of chipping and grinding.

b) When an entire joint is judged unacceptable, the welding shall be completely cut and the edges be suitably prepared as per required alignment tolerances. The welded joint shall again be examined following standard practices.

c) No repair shall be carried out without prior permission of the Owner's inspector.

d) Where random radiography is specified, the test welds of each welder shall be completely radiographed. In the case of pipes of sizes 6" and below, the first two welds shall be completely radiographed.

e) For each weld found unacceptable due to a welder's fault, two additional checks should be carried out on welds performed by the same welder. This operation is interactive and the procedure of radiographing two additional

welds for each weld deemed unsatisfactory shall be continued till such time that the two consecutive welds of satisfactory quality are found for every defective weld.

The contractor shall carry out these additional radiographic testing.

To avoid the possibility of too many defective welds by a single welder remaining undetected for a long period of time, the Contractor shall promptly arrange for radiographic examination so that there is no accumulation of defective joints.

1.15 **Limitations on Repairs**

Only one attempt at repair of any region is permitted. Repairs are limited to a maximum 30% of the weld length. For internal or external repairs which open the weld root, only 20% of the weld length may be repaired. Repairs opening the root must only be carried out in the presence of COMPANY. The minimum length of a repaired area shall be 100mm as measured over the recapped length. Welds containing cracks shall be cut out and rebevelled to make a joint, COMPANY shall authorise all repairs.

1.16 **Weld Rejected by Accumulation of Defects**

Where a weld is rejected by the accumulation of defect clause, as defined by API-1104 and this specification, repairs within these limitations are permitted. Defects in the filling and capping passes shall be repaired preferentially.

1.17 **DOCUMENTS TO BE SUBMITTED BY CONTRACTOR (4 COPIES EACH)**

a) Electrode and Welding Consumable Qualification Records as per **Exhibit-A, f**or the Welding Consumables tested and approved for the work.
b) Batch Test Certificates, for the Electrodes used, obtained from the Electrode Manufacturers.
c) Proposed Heat Treatment Procedure as per **Exhibit-B.**
d) Heat Treatment Charts.
e) Weld joint hardness test results.
f) Welding Procedure Specifications as per **Exhibit-C** immediately after receipt of the order.
g) Welding Procedure Qualification records as per **Exhibit-D.**
h) Welder Performance Qualification records as per **Exhibit-E** immediately after conducting Welder Qualification Tests.
i) Radiography Procedure as per **Exhibit-F** and other NDT procedures.
j) Radiographic test Report along with Radiographs and other NDT reports.
k) Piping Sketch (Isometric) giving all the details regarding the pipe specifications, welded joints, joints radiographed magnetic particle, tested, ultrasonic tested, penetrant tested, joints heat treated, WPS used, welders identification number, etc.

EXHIBIT-A

Sheet 1 of 4

ELECTRODE QUALIFICATIONS TEST RECORD

A : Tested at (Site Name) Date :

Test Period :

Manufacturer's Name :

Brand Name :

Batch Number & size Tested :

Classification & Code :

Intended for Welding in positions :

In combination with (if any) :

Code of Reference (used for testing) :

Special requirements (if any) :

B : **All - Weld Tensile Test**

Base Material used :

Pre-heat temperature :

Postweld Heat Treatment Details :

Visual Examination :

Radiographic Examination Results :

Tensile Test Results :

Sl. No.	Identification Number	U.T.S.	Yield Point	Elongation	Remarks

C : **Impact Test Results**

Test Temperature : Notch in :

Type of Specimens (Impd, Charpy : Size of Specimens :

Specimen No.	Impact Value	Average
1.		
2.		
3.		
4.		
5.		

D : **Chemical Analysis Result**

Electrode size used :

Batch No.

%C	%S	%P	%Si	%Mn	%Cr	%Ni	%Mo

E : **Fillet Weld Test Results**

Welding Positions :

Base Materials :

Size of electrode used :

Visual Inspection Results : 1)
2)
3)

Micro Test Results

Fracture Test Results :

Remarks :

F : **Other Test Results**

i) Transverse Tensile Test :

In Combination with :

Base Material used :

Position of Welding :

Preheat Temperature :

Postweld Heat Treatment :

Radiography :

Identification No.	U.T.S.	Fracture in	Remarks

2. **Guide Bend Test**

Position	ID No.	Root, Face or Side Bend	Remarks
	1		
	2		
	3		
	4		
	5		

3. **Any other tests**

Conclusions

Approved By :

EXHIBIT-B
Sheet 1 of 2

STRESS RELIEF HEAT TREATMENT PROCEDURE SPECIFICATION

Name of the Heat - Treatment :.....
Name of the Project :.....Specification
Reference No. .....

1. **General Details**

Name of the Equipment : .....

Name of the Assembly/ Part : .....

Assembly/ Part Drawing No. : .....

Material : .....

2. **Furnace Details**

Type of Heating : Gas/ Oil/ Elec. Res./ Induction (Tick Mark)

Capacity (size) : .....
Maximum Temp. (°C)

Method of temp. measurement : .....

Atmosphere Control : .....

3. **Heat Treatment Cycle Details**

Charging Temp. °C : .....

Rate of Heating, °C/Hr : .....

Soaking Temp., °C : .....

Soaking Time, Hrs. : .....

Rate of Cooling, °C/Hr : .....

Mode of Cooling : .....

4. Other Details, if any : .....

5. The following documents are to be furnished :
along with these specification :

   i) Material Test Certificates

   ii) Assembly/ Part Details

EXHIBIT-C
Sheet 1 of 2

STANDARD PROCEDURE SPECIFICATION NO.

for ..... Welding of ..... Pipe and Fittings

- Process & type ..... (Details of special machines).
- Material ..... (Pipes to which the procedure applied, grade of steel, type of pipe, Reference Specification).
- Diameter and wall thickness ..... (Series of dia and thickness to which procedure is applicable)
- Joint Design .....
- Filler Metal and Number of Beads .....
- Electrical or Flame Characteristics .....
- Position .....
- Direction of Weldings ..... (Uphill, Downhill, Mixed)
- Number of Welders .....
- Time Lapse between passes .....
- Type of Line-up Clamp .....
- Removal of Line-up Clamp ..... (Minimum percentage of welding carried out before removal of clamps)
- Cleaning .....
- Preheat, Stress Relief .....
- Shielding Flux .....
- Speed of Travel .....
- Sketches and Tabulations (to be attached) .....
- Wire Speed (rate of wire speed and variation range) .....
- Minimum No. of passes which must be completed before discontinuing weld.

- Minimum No. of welders required for the first pass and second pass :

  Tested : ..... Welder .....

  Approved : ..... Welding Supt. .....

  Accepted : ..... Chief Engineer .....

EXHIBIT-D
Sheet 1 of 2

COUPON TEST RECORD

Location .....
Date ..... State ..... Roll Weld ..... Fixed position weld ..... welder ..... Mark
..... Welding Time ..... Time of day
..... M. Temperature ..... F. Weather Condition
..... Wing break used ..... Voltage
..... Amperage ..... Type of welding machine
..... Size ..... Filler Metal
..... Size of reinforcement
..... Pipe kind and Grade
..... Wall thickness
..... Dia O.D. .....

---

1 2 3 4 5 6 7

Bead No. ..... Size of electrode
..... No. of electrode
.....

---

1 2 3 4 5 6 7

Coupon Stenciled ..... Original Dimension of Plate ..... Original area of plate (inch^2) ..... Maximum Load
..... Tensile S/ in. plate area
..... Fracture Location
.....

Procedure	Qualifying Test	Qualified
Welder	Line Test	Disqualified

Max. tensile strength ..... min. tensile strength .....

Avg. tensile strength ..... Remarks on tensile strength .....

1. .....

2. .....

3. .....

4. .....

Remarks on Bend Tests

1. .....
2. .....
3. .....
4. .....

Remarks on Nick Tests

1. .....
2. .....
3. .....
4. .....

Other Tests .....

(Use back for additional remarks)

EXHIBIT-E

WELDER's IDENTIFICATION CARD

Name :

Identification :

Date of Testing :

Valid Unit :

Approval of Welding :

Welding Position :

Material :

Diameter :

Wall Thickness :

Type of Welding Consumable :

Approved By :

Employer's Signature
with Seal

EXHIBIT-F
Sheet 1 of 1

RADIOGRAPHIC PROCEDURE FOR PIPE WELDING

1. Location
2. Date of Testing
3. Name of Supervised Contractor
4. Material
5. Dia. & Thickness
6. Type of Weld Joint
7. Radiation Source (X-ray, gamma ray)
8. Type of equipment (external/ internal)
9. Intensifying screens and material
10. Filter type and placement mask, diaphragm lead screen etc. adjacent to radiation sources or specimen.
11. Geometric relationship (source local spot size, max and min source strength, object to film distance, radiation angle with respect to weld and film).
12. Limit of film coverage
13. Film type and make
14. Exposure Time
15. Processing (time temperature for development stop bath or rinse, fixation, washing, drying etc.)
16. Density
17. Sensitivity
18. Type of penetrameter

Approval of the COMPANY

Signature of CONTRACTOR
with seal

WELDING SPECIFICATION CHART

EXHIBIT-G
Sheet 1 of 2

Class :

Material Specification :

Pipes : API 5L Gr. X 60, API 5L Gr. B API 5L Gr. X 42

Fittings : A 105, A234 Gr. WPB. MSS-SP-75, Gr. WPHY42, MSS-S

Flanges : A 105, MSS-SP-44 Gr. F42, MSS-SP as Gr. WPH 60

Other : _____ 44 Gr. F6C

Base Metal of NCL :

Welding Processes : Groove Joints : Butt

Root Pass SMAW Filler Pass SMAW Root Pass SMAW Filler Pass SMAW Filler Joints/ Socket Joints : SMAW

Welding Materials : Groove Joints : Butt

Root Pass E6010G/ E7010G Filler Pass F7010G/ E8010G/ E8818G
Root Pass E7010/ E7018G/ E8018G Filler Pass F7016/ E7018G/ E80118G

Filler Joints/ Socket Joints : E7016/ E7018/ E7018G/ E8018G

Backing Page _____ Consumable :

Gases : Purging _____ Sheilding

Gas Composition : Purging _____ Sheilding

Preheating : 10 min for all welds, 100°C Post heating

Post weld heat treatment :

Holding temp. : 595-650 C Holding Time : 1 Hr. per inch thk
Rate of heating : 200 C/hr max. Min holding time : 1 hr.
Method of cooling : Controlled Rate of cooling : 200°C/hr max.

Mechanical property requirements :

Charpy `V' notch impact test valve :

Normal	:	22 J
Average	:	27 J
At temperature	:	0 °C
Hardness	:	300 HV10 (for weld & HAZ)

Code of fabrication : ANSI B31.8; API 1104 and welding specifications.

TECHNICAL NOTES

1. Welding, heat treatment and non destructive testing shall be carried out in accordance with the requirement of ANSI B31.8/ API-1104 and additional requirement specified in the specification. In case of conflict between code and specification more stringent conditions shall be applicable.

2. No welding shall be carried out without preheating the joint to 10°C (50 °F) when the ambient temperature is below 10°C (50 °F).

3. Preheat shall be applied while welding the following material as detailed below :

API 5L Gr. B	:	Thickness upto and inclusive of 12mm	100 °F min.
A 105	:		
MSS-SP-44 Gr. F60	:	Thickness beyond	200 °F
A 234 Gr. WPB	:	12 mm	
MSS-SP-75-WPHY60			

4. For fillet welds complete welding may be carried out using the electrodes recommended for filler passes.

5. All weldments & HAZ shall meet the hardness requirements of 300 HV10 during procedure qualification. If the hardness exceeds 300 HV10 the joints shall be heat treated at temp. 1100-1250 °F for one hour. The heating and cooling rates shall be decided during procedure qualification subject to a maximum of 200 °C/Hr. Hardness testing shall be carried out by Vickers hardness tester during welding procedure qualification test only. No hardness test is required for production welds.

6. The electrodes used shall meet the following additional requirement :

Specification	UTS (Min.) (As welded)	Impact (As welded)
E7018-G	52.7 kg/mm^2	20 ft. lb. at 0°C
E7018-I	52.7 kg/mm^2	-
E6010	-	-
E6018	-	20 ft. lb. at 0°C

7. All the weldments & HAZ shall meet the impact test requirement of 20 ft. lb at 0°C.

ANNEXURE-2

1.0 DESTRUCTIVE TESTING OF WELDED JOINT - BUTT WELDS

1.1 Preparation

Having passed the visual and the non destructive inspection, the test weld shall be subjected to mechanical test.

After satisfactory completion of all visual and non destructive testing the procedure test weld shall be set aside for a period not less than 24 hours. No further work on the test weld and no cutting of test specimens from the weld be performed till a period of at least 24 hours has expired.

Weld specimens, for pipe diameter greater than or equal to 12.3/4" shall be taken from the positions indicated in Fig. 1 of this specification from areas as free from defects as possible. For this reason it is necessary to take the previous non destructive tests into account. The minimum no. of tests to be carried out is given in Table-I of this specification.

The test shall be carried out at laboratories approved by COMPANY. The specimens shall be prepared in accordance with the figure given in the paragraphs which refer to the individual test.

Table-I

TYPE AND NUMBER OF TEST SPECIMENS FOR PROCEDURE QUALIFICATION TEST

Pipe Size, Out-side diameter Inches	Number of Specimens									
	Tensile API	Tensile ISO	Nick Break	Root Bend	Face Bend	Side Bend	Macro	Hard-ness	Impact	Total
Wall Thickness > ½ inch (12.7mm) and under										
Under 2 3/8	0	0	2	2	0	0	0	0	0	4
2 3/8 to 4½ incl.	0	0	2	2	0	0	0	0	0	4
Over 4½ less than 12 3/4	2	0	2	2	2	0	2	2	12	24
12 3/4 and over	2	2	4	4	4	0	2	2	24	44
Wall Thickness > ½ inch (12.7mm)										
4½ and smaller	0	2	0	0	0	2	0	0	0	4
Over 4½ less than 12 3/4	2	0	2	2	2	0	2	2	12	24
12 3/4 and over	2	2	4	0	0	8	2	2	24	44

1.2 **Tensile Strength**

Specimens for pipe diameter over 12 3/4" shall be taken from the position indicated in Fig. 1 of this specification. Two API type specimen shall be taken for pipe diameter greater than or equal to 12 3/4".

1.3 **Nick-Break Test**

1.3.1 **Preparation**

Specimens for nick-break test with notches thus worked can break in the base metal, instead of in the fusion zone; therefore an alternative test piece may be used after authorisation by the COMPANY with a notch cut in the reinforcement of outside weld bead to a maximum depth of 1.5mm measured from the surface of the weld bead.

1.4 **Macroscopic Inspection**

1.4.1 **Preparation**

Specimens shall be taken from the positions indicated in Fig. 1 of this specification and shall be prepared in accordance with ASTM E2 and E3.

The width of the macrosection has to be at least three times the width of the weld. The section is to be prepared by grinding or polishing and etching to clearly reveal the weld metal and heat effected zone.

1.4.2 **Method**

Specimens shall be carefully examined under the microscope with a magnification of at least 25 times. The COMPANY may ask for a macrograph with 5 times magnification for documentation purposes.

1.4.3 **Requirements**

Under macroscopic examination, the welded joints shall show good penetration and fusion, without any defect exceeding the limits stated in the evaluation criteria of the nick break test.

1.5 **Hardness Test**

1.5.1 **Preparation**

The prepared macrosection is to be used for hardness testing using the Vickers method with 100 N (10 kg) load. Indentations are to be made along traverses each approximately 1mm below the surface at both side of the weld.

In the weld metal a minimum of 6 indentations equally spaced along the traverses are to be made. The HAZ indentations are to be made along the traverses for approximately 0.5mm each into unaffected material, and starting as close to the fusion line as possible.

One indentation at each side of the weld along each traverse has to be made on parent metal. Reference is made to fig. 3 of this specification. The indentation are to be made in the adjacent region as well as on the opposite side of the macrosection along the specified traverses.

1.5.2 **Method**

The test shall be carried out in accordance with Recommendation ISO R81, Vickers hardness, using laboratory type machine controlled as per-recommendation of ISO R 146 and using a diamond pyramid penetrator set at 2.37 rad. (136) with a load of 100 N (10 kg).

1.5.3 **Requirements**

Hardness value shall not exceed 300 H VI0 . In case of a single reading slightly (+10 HV) higher than the specified limit, further indentations should be made to check if the high value was an isolated case.

All the hardness values obtained from the heat effected zone shall not exceed 100 HV with respect to the average hardness of the values obtained for the base metal.

If these additional tests mentioned above give a hardness within the specification limit, the slightly higher value may be accepted.

1.6 **Charpy-V-notch Impact Test**

1.6.1 Specimens shall be taken from the position indicated in Fig. 1 of this specification. The test specimens will be prepared in accordance with ISO R 148. Charpy V-notch specimens shall have dimensions as given in Fig. 3 of the specification.

Three test specimens shall be taken from each sample and they shall be cut and worked so that their length is transversal and perpendicular to the weld bead with the notch position as shown in Fig. 4 of this specification. The notch shall be perpendicular to the roller surface. The test specimens width shall depend upon the pipe wall nominal thickness as following :

Nominal wall thickness in mm	Test Specimens width in mm
> 12	12
> 9.5 and ≤ 12	7.5

≥ 7 and ≤ 9.5	5
< 7	2.5

1.6.2 **Test Method**

The test shall be carried out as indicated in ISO R 148 "Beam Impact Test V-notch.

Test pieces shall be immersed in a thermostatic bath and maintained at the test temperature for at least 15 minutes. They shall than be placed in the testing machine and broken within 5 seconds of their removal from the batch.

1.6.3 **Requirements**

The impact energy shall be greater or equal to :-

Test Specimens in mm	Average of Three specimens Joule (min) (Note-2)	Minimum Single Value Joules (Note 1)
10	27	22
7.5	21.5	17.5
5	18.5	15.0
2.5	10.0	8.0

Note:
1) Only one value is permitted to be lower than average upto the value specified.

1.7 **Bend Test Requirements**

The bend test specimens shall be made and tested as per the requirements of API-1104 sixteenth edition - May, 1983 except that the dimensions of Jig for guided bend test fig. 5 para 2.6 API-1104 shall be modified as follows :

Radius of the plunger	°A'	= 2 t
Radius of the die	°B'	= 3 t + 1.6mm
Width of the die	°C'	= 50.8

The acceptance criteria shall however be as per para 2.643 and 2.653 of API-1104 sixteenth edition - May, 1983.

Note t = Thickness of Specimen (nominal)

ANNEXURE-3

1.0 ULTRASONIC INSPECTION

In addition to the radiographic inspection ultrasonic inspection is required as per conditions mentioned in **Annexure-1** of this specification.

This section concerns manual ultrasonic inspection. However ultrasonic inspection by automatic equipment may be used if approved by the COMPANY.

1.1 Equipment and Operators

The CONTRACTOR who carries out the ultrasonic inspection shall have sufficient qualified personnel, equipment and instrument at his disposal to be able to effect the tests without hindering or delaying the pipeline assembly operations.

- Calibrate the equipment;
- Perform an operational test under production conditions;
- Interpret the screen picture;
- Evaluate the size and location of reflectors
- Interpret the type of defects detected.

The COMPANY has the option of checking the ability of personnel employed for ultrasonic testing by means of qualification tests.

The CONTRACTOR appointed to carry out UT inspection shall supply the instruments necessary for their execution on site.

1.2 Specification for Ultrasonic Testing Procedure

Qualification

Before work begins the CONTRACTOR shall present a specification describing the proposed U.T. procedure qualification.

This specification shall be state, as an indication only but not limited to the following information :

- Type of U.T. equipment used
- Type and dimensions of transducers
- Frequency range
- Details for calibration
- Coupling medium
- Inspection technique
- Record details
- Reference to the welding procedure where it is intended to adopt the specification.
- Temperature range of the joints to be inspected.

1.3 **Qualification of Ultrasonic Inspection Procedure**

The ultrasonic inspection procedure shall be approved by the COMPANY. Before inspection begins, the COMPANY may require the qualification test of the ultrasonic inspection procedure. This specification test consists in testing (under normal operating conditions) some CONTRACTOR welds made according to the same production procedure, when there are typical defects the test intends to detect.

1.4 **Test Procedure**

Circumferential weld shall be inspected from both sides using angled. Probes.

The surface with which the probe comes into contact shall be free of metal spatter, dirt, iron oxide and scales of any type: therefore it shall be necessary to clean a strip at least 50mm wide on both sides of the weld with steel - wire brushes and anyhow the cleaned strip must be atleast wide enough to allow full skip examination.

If during the test, echoes of doubtful origin appear, it shall be necessary to inspect a convenient area on the pipe surface, close to the weld, with a straight beam transducer in order to check whether any manufacturing defects are present which could have interfered with the ultrasonic beam.

By way of an example, the equipment shall include but not be limited to the following :

- Ultrasonic equipment and coupling medium
- Sample sections for calibration of instruments.
- Equipment for cleaning of surface to be examined.
- Rulers calibrated in centimeters for exact location of the position of defects.

The characteristics of the above-listed instruments and equipment shall guarantee:

a) that the required standards of the inspection procedure, as previously established and approved by the COMPANY, are satisfied.

b) continuous operation

All the instruments and equipment shall be approved by the COMPANY before being used. The COMPANY has the authority to reject any item which is considered unsuitable. The decision of the COMPANY is final. The CONTRACTOR appointed to carry out ultrasonic inspection shall also ensure the operational efficiency and maintenance of the instruments and equipment, and shall immediately substitute any item rejected by the COMPANY.

All the instrument and equipment necessary for carrying out ultrasonic inspection on site shall satisfy the requirements laid down by the public board of institutions which regulate "safety at work".

1.5 **Ultrasonic Instruments**

The ultrasonic instruments :

- Shall be each pulse type, able to generate, receive and display, on the screen a cathode ray tube (CRT) pulse, at frequencies between 1 and 6 mhz. The useful part of the CRT screen shall be at least 70m wide and at least 50mm high.
- Shall have various amplification, with steps of 1 or 2 dB over a range of a least 60 dB.
- The regulation control shall be accurate to within 1 dB and this accuracy shall be certified by the instrument manufacturer.
- May be powered by a battery or an electric generator. In the first case, the autonomy of operation (endurance) of the instrument shall be sufficient to carry on working without frequent interruptions, and the instrument shall be equipped with an automatic switch which switches it off when the battery runs down, in the second case, there must be a voltage stabilising device with a tolerance of 2 volts.

1.6 **Probes**

The probes used shall have dimensions, frequencies, and a refraction angle suited to the type of steel, the diameter the thickness of the pipeline and to the joint design.

1.7 **Reference Sample Pieces**

The efficiency of the equipment used, the effective refraction angle of the probe, and the beam output points, shall be checked using a V_1 and V_2 sample block, IIW type or the calibration block ASTM E-428.

For the calibration of runs and the regulation of detection sensitivity during the test, a calibration piece be used. This piece shall be taken from the production material, and will be at least 150mm long (measured in the direction of the axis), and at least 50mm wide (measured in the direction of the circumference), (see Fig. 4 of this specification).

In the middle of the inside and the outside surface of the calibration piece a groove shall be made. The groove will have a rectangular cross-section, a flat bottom and the following dimensions :-

- Depth : 1 +/- 0.1mm
- Breadth (measured parallel to the 150mm side) : 1 +/- 0.1mm
- Length (measured parallel to the 50mm side) not less than 30mm.

In addition, the calibration piece shall have a hole, 2mm in diameter, passing through its thickness and positioned so that during calibration the echoes returning from the two grooves do not interfere with those returning from the hole.

1.6 **Calibration**

For a precise check of the sound paths necessary for a full inspection of the weld joint, the probe shall be moved (half skip and full skip distance) until internal and external notches on the test piece are detected (see Fig. 5 of this specification).

The relevant defect limits the path lengths on the time base. The calibration of reference sensitivity is obtained by utilising the through drilled test hole in the thickness of the reference block to draw the distance amplitude correction curve relevant to the test probe.

Calibration shall be carried out according to the following procedure : place its internal vertex until the maximum height of echo is displayed on the screen; this echo is adjusted to 80% of full screen height by means of the sensitivity adjuster set in dB. Without varying the amplification, the probe placed at full skip distance from the hole is moved to detect the external vertex the hole until the maximum height of echo is obtained. The straight line connecting the peaks of the two echoes obtained by the above procedure, represents the 100% reference level, while the one connecting the two points at half height of the same echoes represents "50% reference level".

The two straight lines shall be marked on the screen with a pen. Calibration shallbe repeated each time tests are re-started at intervals not longer than 30 minutes during normal operations; each time the conditions fixed in advance are altered. This calibration is applicable provided that the crystal of the probe is 8 x 9mm size. Should this size of the crystal be different, the value of the sensitivity obtained from the calibration by a crystal of a different size shall be brought to the value of sensitivity obtained from the calibration by a 8 x 9mm crystal. The sensitivities of the two different size probes shall be compared through the echoes obtained on the notch of the test piece with the probe position at half skip of the distance.

1.9 **Regulation of Amplification during Production Testing**

The amplification during production testing shall be obtained by adding 2-6 dB (according to the surface condition of the pipe and its cleanness) to the reference amplification.

1.10 **Qualification of Ultrasonic Testing Operators**

Before the inspection begins or during the same inspection, the COMPANY may require a qualification test for the ultrasonic equipment operators.

1.11 **Evaluation of Indications given by Ultrasonic Tests**

Each time that echoes from the weld bead appear during production testing, the instrument amplification shall be altered to coincide with the reference amplifications and the probe shall be moved until maximum respond is obtained paying attention all the time to the probetube coupling.

If, under these conditions, the height of the defer echo is equal to or greater than that of the reference echo, the defect shall be evaluated. If the defect has also been detected by the radiographic and or visual examination, the dimensions shall be judged according to the type of examination which detects the greater defects. Returns which are less than 50% of the reference echo, will not be considered. It returns are above 50% but lower than 100% of the reference echo, and if the operator has good reasons to suspect that the returns are caused by unfavorably oriented cracks, he shall inform the COMPANY. Moreover, when there is a defect to be repaired such defect shall be removed for a length corresponding to the one where no more return echo is given.

1.12 **Other Equipment**

The use of rules calibrated in centimeters, attached if possible to the probe, for the precise location of the position of welding defects, it recommended. Defect location is effected by measuring the projection distance between the probe output and the reflecting surface.

The operators carrying out the tests shall have besides the probing instrument, tools for cleaning the pipe surface (files, brushes, etc.) as well as the coupling liquid or paste appropriate for the temperature of the section to be examined.

ANNEXURE-4

RADIOGRAPHY

1.0 **SCOPE**

This annexure covers the radiographic inspection of all types of welded joints of the main pipeline. The welded joints shall include the following :

i) Full girth welds on the mainline construction including double jointing of pipe, if adopted.

ii) Welds for installation of block valves, insulating joints and other appurtenances and tie-ins.

iii) Welds at scraper launching and receiving barrels

iv) Terminal Piping.

2.0 **APPLICABLE STANDARDS**

This specification shall apply in conjunction with the following (all latest edition) :

i) API 1104, Standard for welding pipelines and related facilities.

ii) ANSI B31.8, code for Gas Transmission and Distribution Piping Systems.

iii) ANSI B31.4, Code for Liquid Petroleum Transportation Piping System.

iv) ASTM E94, Recommended practice for Radiographic Testing.

v) ASTM, E 142, Standard Method for Controlling Quality of Radiographic Testing.

vi) The American Society for non-destructive Testing. Recommended Practice No. SNT-TC-1A Supplement-A.

3.0 **PROCEDURE**

3.1 The radiographic examination procedure to be adopted shall be submitted by the CONTRACTOR as per **Exhibit-F.**

3.2 The procedure of radiographic examination shall be qualified to the entire satisfaction of COMPANY prior to use. It shall include but not be limited to the following requirements.

i) Lead foil intensifying screens, at the rear of the film shall be used in all exposures.

ii) Type 2 and 3 films as per ASTM E-94 shall be used.

iii) A densitometer shall be used to determine film density. The transmitted film density shall be 2.0 and 3.5 through out the weld. The unexposed base density of the film shall not exceed 0.30.

iv) Radiographic identification system and documentation for radiographic interpretation reports and their recording system.

3.3 The CONTRACTOR shall qualify each procedure in the presence of the COMPANY prior to use.

3.4 The procedure of radiographic examination shall produce radiographs of sufficient density, clarity and contrast so that defects in the weld or in the pipe adjacent to the weld, and the outline and holes of the pentrameter are clearly discernible.

3.5 All the girth welds of mainline shall be subjected to 100% radiographic examination. The CONTRACTOR shall furnish all the radiographs to the COMPANY, immediately after processing them, together with the corresponding interpretation reports on approved format. The details of the radiographs alongwith the joint identification number shall be duly entered in a register and signed by the CONTRACTOR and submitted to the COMPANY for approval.

3.6 When the radiation source and the film are both on the outside of the weld and located diametrically opposite each other, the maximum acceptable length of film for each exposure shall not exceed the values given in Table 4 of API 1104. The minimum film overlap, in such cases, shall be 40mm. The ellipse exposure technique may be used on nominal pipe sizes of 2 inch and smaller provided that the source to film distance used is a minimum of 12 inches.

3.7 Three copies of each acceptable radiographic procedure (as outlined in Specification no. MEC/S/O5/62/02) and three copies of radiographic qualification records, shall be supplied to COMPANY. One set of the qualifying radiographs on the job shall be kept by the CONTRACTOR's authorised representative to be used as a standard for the quality of production radiographs during the job. The other two sets shall be retained by COMPANY for its permanent record.

3.8 Three copies of the exposure charts relating to material thickness, kilo voltage, source to film distance and exposure time shall also be made available to aCOMPANY by the CONTRACTOR.

3.9 The CONTRACTOR shall, on a daily basis, record for each radiograph (1) radiography number (2) approximate chainage of weld location, (3) whether or not the welds meet the specified acceptance standards and (4) the nature and approximate location of unacceptable defects observed. It must be possible to relate to a particular butt weld and welder on piping drawing and pipeline alignment drawing.

3.10 Each day's production of processed radiographs shall be properly packaged separately, identified by at least the (1) date, (2) radiographic unit, (3) job locations, (4) starting and ending progress survey stations and (5) shall include original and three copies of the daily radiographic record. The package shall be submitted to the COMPANY daily when possible, but in no event later than noon of the following day.

3.11 The CONTRACTOR shall provide all the necessary facilities at site, such as a dark room with controlled temperature, film viewer etc. to enable the COMPANY to examine the radiographs.

3.12 The CONTRACTOR, if found necessary, may modify the procedure of radiographic examination suiting the local conditions prevailing. This shall, however, be subject to the approval of the COMPANY.

3.13 COMPANY shall have free access to all the CONTRACTOR's work facilities in the field.

3.14 Any approval granted by the COMPANY shall not relieve the CONTRACTOR of his responsibilities and guarantees.

4.0 RADIATION SOURCE

4.1 Radiographic examination shall be carried out using x-radiations. Radiographic examination by Gamma rays may be allowed, at the discretion of the COMPANY, in case of inaccessible joints.

4.2 Whenever possible, pipeline welds will be inspected by placing the radiation source inside the pipe, on the pipeline axis, with a radiation of 6.28 rad. (360°).

If it is impossible to place the radiation source inside the pipe, the weld will be inspected with the source on the outside. An overlap of at least 40mm at the ends of each film shall be required to ensure that the first and last location increment numbers are common to successive films and to establish that no part of a weld has been omitted.

5.0 LEVEL OF QUALITY

The quality level of radiographic sensitivity required for radiographic inspection shall be at least equivalent to the values in Figure-6.

6.0 PENETRAMETERS

6.1 The image quality indicator (abbreviation : IQI) shall be used for the qualification of the welding procedure and during normal line production. Radiographic sensitivity shall be measured with the wire image quality indicator (Penetrameter). The penetrameter shall be selected according to DIN 54109 or ISO 1027. For radiographs made with the source on the outside, a penetrameter shall be placed on each side of the film with the smaller wire of the penetrameter turned towards the end of the film itself. When a complete weld is radiographed in a single exposure using a source inside the piping,

four penetrameters approximately equally spaced around the circumference shall be used. During the procedure qualification, IQI shall be placed both on the source side and on the film side. The sensitivity obtained with IQI on the source side shall not be less than the values shown in Fig. 6 of this specification.

The sensitivity limit may be considered to have been reached when the outline of the IQI, its identification number and the wire of the required diameter show up clearly on the radiographs.

The COMPANY may authorise use of types of IQI other than those planned, provided that they conform with recognised standards and only if the CONTRACTOR is able to demonstrate that the minimum sensitivity level required is obtained. For this demonstration, a test shall be carried out comparing the IQI specified and the CONTRACTOR's to show up the identification number and other details of the proposed IQI, which must be visible in the test radiograph.

7.0 FILM IDENTIFICATION MARKERS

All films shall be clearly identified by lead numbers, letters, and/ or markers. The image of the markers shall appear on the films, without interfering with the interpretation. These markers positions shall also be marked on the part to be radiographed and shall be maintained during radiography.

8.0 PROTECTION AND CARE OF FILM

8.1 All unexposed films shall protected and stored properly as per the requirements of API 1104 standard and ASTM E 94.

8.2 The exposed and unexposed film shall be protected from heat, light, dust and moisture. Sufficient shielding shall be supplied to prevent exposure of film to damaging radiation prior to and following the use of the film for radiographic exposure.

9.0 RE-RADIOGRAPHY

9.1 The weld joints shall be re-radiographed in case of unsatisfactory quality of the radiographs, at the expense of the CONTRACTOR.

9.2 All the repaired weld joints shall be re-radiographed at no extra cost to the COMPANY in the same manner as that followed for the original welds. In addition, the repaired weld area shall be identified with the original identification number plus the letter `R' to indicate the repair.

9.3 When evaluating repair film, radiographers shall compare each section (exposure) of the weld with the original film to assure repair was correctly marked and original defect removed.

9.4 The COMPANY will review prior to any repair of welds, all the radiographs of welds which contain, according to the CONTRACTOR's interpretation, unacceptable defects.

The final disposition of all unacceptable welds shall be decided by the COMPANY.

10.0 QUALIFICATION OF RADIOGRAPHERS

10.1 Pipeline radiographers shall be qualified in according with the requirement of API 1104 and to the full satisfaction of COMPANY.

10.2 Certification of all the radiographers, qualified as per 10.1 above, shall be furnished by the CONTRACTOR to the COMPANY before a radiographer will be permitted to perform production radiography. The certificate record shall include :

i) Background and experience record
ii) Training course record
iii) Technical examination record
iv) Doctor's report on radiographer's Oaecuer 0-1 acquity eye test.
v) Date of qualification.

10.3 The radiographers shall be required to qualify with each radiographic procedure they use, prior to performing the work assigned to him in accordance with the specification.

11.0 PRESERVATION OF RADIOGRAPHS

11.1 The radiographs shall be processed to allow storage of films without any discoloration for at least three years. All the radiographers shall be presented in suitable folders for preservation alongwith necessary documentation.

11.2 All radiographs shall become property of the COMPANY.

12.0 EQUIPMENT AND ACCESSORIES

12.1 CONTRACTOR shall make necessary arrangement at his own expense, for providing the radiographic equipment, radiographic films and the accessories for carrying out the radiographic examination for satisfactory and timely completion of the job.

12.2 For carrying out the mainline radiographic examination the CONTRACTOR shall be equipped with suitable mobile/ stationary type with rooms. These shall have all the required facilities for film processing. Film viewer used shall be equipped with the film illuminator that has a light source of sufficient intensity and can be suitably controlled to allow viewing film densities upto 4.0 without damaging the film.

13.0 RADIATION PROTECTION

13.1 CONTRACTOR shall be responsible for the protection and personal monitoring of every man with or near radiation sources.

13.2 The protection and monitoring shall comply with local regulations.

13.3 In view of visual hazards in the handling of radioactive source of material, CONTRACTOR shall be solely responsible for complying with all rules and regulations set forth by Atomic Energy Commission or any other Government agencies of India in this regard and COMPANY shall not be responsible and shall be kept indemnified by the CONTRACTOR for default(s) of whatever nature by the Contractor. Safety equipment as considered adequate by the COMPANY for all necessary personnel shall be made available for use and maintained for immediate and proper use by the CONTRACTOR.

14.0 DISPLAY OF SAFETY INSTRUCTIONS

14.1 The safety provisions shall be brought to the notice of all concerned by display on a notice board at prominent place at the work spot. The person responsible for the "safety" shall be named by the CONTRACTOR.

15.0 ENFORCEMENT FOR SAFETY REGULATIONS

15.1 To ensure effective enforcement of the rules and regulations relating to safety precautions, the arrangement made by the CONTRACTOR shall be open to inspection by COMPANY or its representatives.

16.0 FIRST AID INDUSTRIAL INJURIES

16.1 CONTRACTOR shall maintain first aid facilities for its employees and those of its sub-contractors.

16.2 CONTRACTOR shall make outside arrangements for ambulance service and for treatment of industrial injuries. Names of those providing these services shall be furnished to COMPANY prior to start of work and their telephone no. shall be posted prominently in CONTRACTOR's field office.

16.3 All critical industrial injuries shall be reported promptly to the COMPANY and a copy of CONTRACTOR's report covering each personal injury requiring the attention of physician shall be furnished to the COMPANY.

17.0 NO EXEMPTION

17.1 Not withstanding the above there is nothing in these clauses to exempt the CONTRACTOR from the operation of any other act or rules in force.

Rev. : 0
Edition : 1

SPECIFICATION
FOR
SHOP & FIELD PAINTING

SPECIFICATION NO.: MEC/S/05/21/07

(OIL & GAS SBU)
MECON LIMITED
DELHI 110 092

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ANNEXURE-II- LIST OF RECOMMENDED MANUFACTURE'S PRODUCTS.

PREPARED BY:	CHECKED BY:	APPROVED BY:	ISSUE DATE :
(Shalini Singh)	(Sunil Kumar)	(A.K. Johri)	Dec. 2008

1.0 **GENERAL**

1.1 These technical specifications shall be applicable for the work covered by the contract, and without prejudice to the various codes of practice, standard specifications etc. it is understood that contractor shall complete the work in all respects with the best quality of materials and workmanship and in accordance with the best engineering practice and instructions of Engineer-in-charge.

1.2 Wherever it is stated in the specification that a specific material is to be supplied or a specific work is to be done it shall be deemed that the same shall be supplied or carried out by the contractor.

Any deviation from this standard without within deviation permit from appropriate authority will result in rejection to job.

2.0 **SCOPE**

Scope of work covered in the specification shall include, but not limited to the following.

2.1 This specification defines the requirements for surface preparation, selection and application of paint on external surfaces of equipment, vessels, machinery, piping, ducts, steels structures, external & internal protection of storage tanks for all services RCC Chimney & MS Chimney with or without refractory lining and flare lines etc.

2.2 **Extent of Works**

2.2.1 The following surface and materials shall require shop, pre-erection and field painting.

a. All uninsulated C. S. & A.S. equipment like columns, vessels, drums, storage tanks, heat exchangers, pumps, compressors, electrical panels and motors etc.

b. All uninsulated carbon and low alloy piping fitting and valves (including painting of identification marks), furnace, ducts and stacks.

c. All items contained in a package unit as necessary.

d. All structural steel work, pipe, structural steel supports, walkways, handrails, ladders, platforms etc.

e. RCC/ MS chimneys with or without refractory lining & Flare lines.

f. Identification colour bands on all piping as required including insulated aluminium clad, galvanised, SS and non-ferrous piping.

g. Identification lettering/ numbering on all painted surface of equipment/ piping insulated aluminium clad, galvanised, SS and non-ferrous piping.

h. Marking/ identification signs on painted surfaces of equipment/ piping for hazardous service.

i. Supply of all primers, paints and all other materials required for painting other than owner's supply.

j. Over insulation surface of equipments and pipes wherever required.

k. Painting under insulation for carbon steel and stainless steel as specified.

l. Repair work of damaged/ preerection/ fabrication shop primer and weld joints at field.

2.2.2 The following surface and materials shall not be painted unless otherwise specified:

a. Uninsulated austentic stainless steel.

b. Plastic and/ or plastic coated materials.

c. Non ferrous materials like aluminium, galvanised "piping", "gratings" and "handrails" etc. except G. I. Towers.

2.3 Documents

2.3.1 The contractor shall perform the work in accordance with the following documents issued to him for executions of work.

a. Bill of quantities for piping, equipment, machinery and structure etc.

b. Piping line list.

c. Painting specifications including special civil defence requirement.

2.4 Unless otherwise instructed final painting on pre-erection/ shop primed pipes and equipments shall be painted in the field, only after mechanical completion and testing on system are completed as well as, after completion of steam purging wherever required.

2.5 Changes and deviations required for any specific job due to clients requirement or otherwise shall be referred to MECON for deviation permit.

3.0 CODES & STANDARDS

3.1 Without prejudice to the provision of clause 1.1 above and the detailed specifications of the contract, the following codes and standards shall be followed for the work covered by this contract.

IS:5	:	Colour coding
IS-101	:	Methods of test for ready mixed paint and enamels.
IS-2379:1990	:	Indian standard for pipe line Identification –Colour code.
ASTM Vol. 6.01 and 6.03	:	American standard test methods for Paints and coatings.
ANSI A 13.1-1981	:	Scheme for Identification of piping systems : American National Standard Institution.

3.2 Surface Preparation Standards:

Following standards shall be followed for surface preparations:

3.2.1 Swedish Standard : SIS-05 5900-1967/ ISO-8501-1-1998
(Surface preparation standards for painting steel surfaces).

This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-Charge.

3.2.2 Steel structure painting Council, U.S.A (surface preparations specifications (SSPC-SP).

3.2.3 British standard (surface finish or Blast-cleaned for painting) BS:4232

3.2.4 National Associations of Corrosion Engineers, U.S.A. (NACE)

3.2.5 Various International Standards equivalent to swedish Standard for surface preparation are given in Table-I.

3.3 The contractor shall arrange, at his own cost, to keep a set of latest edition of any one of the above standards and codes at site.

3.4 The paint manufacturer's instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

a. Instructions for storage to avoid exposure as well as extremes of temperature.

b. Surface preparations prior to painting.

c. Mixing and thinning.

d. Application of paints and the recommended limit on time intervals between coats.

4.0 EQUIPMENT

4.1 All tools, brushes, rollers, spray guns, abrasive materials hand/ power tools for leaning and all equipments, scaffolding materials, shot/ wet abrassive blasting, water blasting equipments & air compressors etc. required to be used shall be suitable for the work and all in good order and shall be arranged by the contractor at site and in sufficient quantity.

Mechanical mixing shall be used for paint mixing operations in case of two pack systems except that the Engineer-in-Charge may allow the hand mixing of small quantities at his discretion.

5.0 SURFACE PREPARATION, SHOP COAT, COATING APPLICATION & REPAIR AND DOCUMENTATION

5.1 General

5.1.1 In order to achieve the maximum durability, one or more of following methods of surface preparation shall be followed, depending on condition of steel surface and as instructed by Engineer-in-Charge. Adhesion of the paint film to surface depends largely on the degree of cleanliness of the metal surface. Proper surface preparation contributes more to the success of the paint protective system:

a. Manual or hand tools cleaning.
b. Mechanical or power tool cleaning.
c. Blast cleaning.

5.1.2 Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. The minimum acceptable standard in case of manual or hand tool cleaning shall be St. 2 or equivalent, in case of mechanical or power tool cleaning it shall be St. 3 or equivalent, in case of blast cleaning it shall be Sa 2½ or equivalent as per Swedish Standard SIS-055900-1967/ ISO-8501-1-1988. Where highly corrosive condition exits, then blast cleaning shall be Sa3 as per Swedish Standard.

Remove all other contaminants, oil, grease etc. by use of an aromatic solvent prior to surface cleaning.

5.1.3 Blast cleaning shall not be performed where dust can contaminate surfaces undergoing such cleaning or during humid weather conditions having humidity exceeding 85%.

5.1.4 Irrespective of the method of surface preparation, the first coat of primer must be applied on dry surface. This should be done immediately and in any case within 4 hours of cleaning of surface. However, at times of unfavourable weather conditions, the Engineer-in-Charge shall have the liberty to control the time period, at his sole discretion and / or to insist on recleaning, as may be required, before primer application is taken up. In general, during unfavourable weather conditions, blasting and painting shall be avoided as far as practicable.

5.1.5 The external surface of R.C.C. chimney to be painted be dry and clean. Any loose particle of stand, cement, aggregate etc. shall be removed by rubbing with soft wire brush if necessary, acid etching with 10-15% HCL solution about 15 minutes shall be carried out and surface must be thoroughly washed with water to remove acid & loose particles then dry completely before application of paint.

5.2 Procedure of Surface Preparation.

5.2.1 Blast Cleaning

5.2.1.1 Air Blast Cleaning

The surface shall be blast cleaned using one of the abrasives: AL_20_2 particles chilled casts iron or malleable iron and steel at pressure of 7kg. Cm^2 at appropriate distance and angle depending on nozzle size maintaining constant velocity and pressure. Chilled cast iron, malleable iron and steel shall be in the form of shot or grit of size not greater than 0.055" maximum in case of steel and malleable iron and 0.04" maximum in case of chilled iron. Compressed air shall be free form moisture and oil. The blasting nozzles should be venturei style with tungsten carbide or boron carbide as the material for liners. Nozzles orifice may vary from 3/16" to ¾". On completion of blasting operation, the blasted surface shall be clean and free from any scale or rust and must show a grey white metallic lusture. Primer or first coat of paint shall be applied within 4 hours of surface preparation. Blast cleaning shall bot be done outdoors in bad weather without adequate protection or when there is dew on the metal which is to be cleaned, surface profile shall be uniform to provide good key to the paint adhesion (i.e.35to 50μ). If possible vacuum collector shall be installed for collecting the abrasive and recycling.

5.2.1.2 Water Blast cleaning

Environmental, health and safety problems associated with abrassive blast cleaning limit the application of air blast cleaning in many installations. In such case water blast cleaning is resorted to.

Water blast cleaning can be applied with or without abrassive and high-pressure water blasting. The water used shall be inhibited with sodium chromate/ phosphate. The blast cleaned surface shall be washed thoroughly with detergents and wiped solvent and dried with compressed Air. For effective cleaning abrassives are used. The most commonly used pressure for high pressure water blast cleaning for maintenance surface preparation is 3000 to 6000 psi at 35-45 liters/ minute water volume and pressure upto 10000 psi and water volume of 45 liters/ minute provide maximum cleaning.

The wate blast cleaned surface shall be comparable to SSPC-SP-12/ NACE No. 5. The operation shall be carried out as per SSPC guidelines for water blast cleaning. The indicative values for sand injection is

Air : 300 to 400 Cu.ft/ min.

Water	:	5-10 liter/ min. with corrosion inhibitor
Sand	:	200-400 lbs/ hr.
Nozzle	:	0.5 to 1" dia

Special equipments for water blast cleaning with abrasives now available shall be used.

5.2.2 Mechanical of Power tool cleaning

Power tool cleaning shall be done mechanical striking tools, chipping hammers, griding wheels or rotating steels wire-brushes. Excessive burnish of surface shall be avoided as it can reduce paint adhesion. On completion of cleaning, the detached rust mill scale etc. shall be removed by clean rags and/ or washed by water or stream and thoroughly dried with compressed air jet before application of paint.

5.2.3 Manual or hand tool cleaning

Manual or hand tool cleaning is used only where safety problems limit the application of other surface preparation procedure and hence dones not appear in the specifications of paint systems.

Hand tool cleaning normally consists of the following:

a. Hand descaling and/ or hammering
b. Hand scraping
c. Hand wire brushing

Rust, mill scale spatters, old coating and other foreign matter, shall be removed by hammering, scrapping tools, emery paper cleaning, wire brushing or combination of the above methods. On completion of cleaning, loose materials shall be removed from the surface by clean rags and the surface shall be brushed, swept, deducted and blown off with compressed air/ steam to remove all loose matter. Finally the surface may be washed with water and dried for effective cleaning.

5.3 **Non compatible shop coat primer**

The compatibility of finishing coat should be confirmed from the paint manufacturer. In the event of use of primer such as zinc rich epoxy, inorganic zinc silicate etc. as shop coat the pant system shall depend on condition of shop coat, if shop coat is in satisfactory condition showing no major defects, the shop

coat shall not be removed. The touch up primer and finishing coat(s) shall be identified for application by Engineer-in-Charge.

5.4 Shop coated (coated with primer & finishing coat) equipment should not be repainted unless paint is damaged.

5.5 Shop primed equipment and surface will only be 'spot cleaned' in damaged areas by means of power tool brush cleaning and then spot primed before applying one coat of filed primer unless otherwise specified. If shop primer is not compatible with field primer then shop coated primer should be completely removed before applications of selected paints system for particular environment.

5.6 For packaged units/ equipment, shop primer should be as per the paint system given in this specification. However, manufacturer's standard can be followed after review.

5.7 **Coating Procedure and Application:**

5.7.1 Surface shall not be coated in rain, wind or in environment where injurious airbone elements exists, when the steel surface temperature is less than 5° F above dew point when the relative humidity is greater then 85% or when the temperature is below 40° F.

5.7.2 Blast cleaned surface shall be coated with one complete application of primer as soon as practicable but in no case later than 4 hrs. the same day.

5.7.3 To the maximum extent practicable, each coat of material shall be applied as a continuous film uniform thickness free of probes. Any spots or areas missed in application shall be recoated and permitted to dry before the next coat is applied. Applied paint should have the desired wet film thickness.

5.7.4 Each coat shall be proper state of cure or dryness before the application of succeeding coat. Material shall be considered dry for recoating when an additional coat can applied without the development of any detrimental film irregularities such as lifting or loose of adhesion of the under coat. Manufacturer instruction shall be followed for intercoat interval.

5.7.5 When the successive coat of the same colour have been specified, alternate coat shall be tinted, when practical, sufficiently to produce enough contrast to indicate complete coverage of the surface. The tinting material shall be compatible with the material and not detrimental to its service life.

5.7.6 Air spray application shall be in accordance with the following:

a. The equipment used shall be suitable for the intended purpose, shall be capable of properly atomizing the paint to be applied, and shall be equipped with suitable pressure regulators and gauges. The air caps, nozzles, and needles shall be those recommended by the manufacturer of the equipment for the material beign sprayed. The equipment shall be kept in satisfactory condition to permit proper paint application.

b. Traps or separators shall be provided to remove oil and condensed water from the air. These traps or separators must be of adequate size and must be drained periodically during operations. The air from the spray gun impinging against the surface shall show condensed water or oil.

c. Ingredients shall be kept properly mixed in the spray pots or containers during application by continuous mechanical agitation.

d. The pressure on the material in the pot and of the air at the gun shall be adjusted for optimum spraying effectiveness. The pressure on the material in the pot shall be adjusted when necessary for change in elevation of the gun above the pot. The atomizing air pressure at the gun shall be high enough to properly atomize the paint but not so high as to cause excessive fogging of paint, excessive evaporation of solvent, or less by overspray.

e. Spray equipment shall be kept sufficiently clean so that dirt, dried paint, and other foreign materials are not deposited in the paint film.

Any solvents left in the equipment shall be completely removed before applying paint to the surface begin painted.

f. Paint shall be applied in a uniform layer, with overlapping at the edge of the spray pattern. The spray patterns shall be adjusted so that the paint is deposited uniformly. During application the gun shall be held perpendicular to the surface and at a distance which will ensure that a wet layer of paint is deposited on the surface. The trigger of the gun should be released at the end of each stroke.

g. All runs and sags shall be brushed out immediately or the paint shall be removed and the surface repainted.

h. Areas inaccessible to the spray gun shall be painted by brush: if not accessible by brush, daubers or sheepking shall be used.

i. All nameplates, manufacturer's identification tags, machined surface instrument glass, finished flange faces, control valve items and similar items shall be masked to prohibit coating disposition. If these surface are coated, the component shall be cleaned and restored to its original condition.

j. Edges of structural shapes and irregular coated surface shall be coated first and an extra pass made later.

k. If spray gun shown choking, immediately dechoking procedure shall be followed.

5.7.7 Airless spray application shall be in accordance with the following procedure: as per steel structure paint manual vol. 1 & vol. 2. By SSPC, U.S.A., Air less spray relies on hydraulic pressure rather than air atomization to produce the desired spray. An air compressor or electric motor is used to operate a pump to produce pressures of 1,000 to 6.000 psi. Paint is delivered to the spray gun at this pressure through a single hose within the gun, a single paint stream is divided into separate streams, which are forced through a small orifice resulting in atomization of paint without the use of air. This result in more repaid coverage with less overspray. Airless spray usually is faster, cleaner, more economical and easier to use than conventional airspray.

Airless spray equipment is mounted on wheels, and paint is aspirated in a hose that sucks paint from any container, including drums. The unit shall have in built agitator that keep the paint uniformly mixed during the spraying. The unit shall consists of in built strainer. Usually very small quantities of thinning is required before spray. Incase of High Build epoxy coating (two pack), 30:1 pump ratios and 0.020-0.023" tip size will provide a good spray pattern. Ideally fluid hoses should no be less than 3/8" ID and not longer than 50ft to obtain optimum results.

In case of gun choking, decoking steps shall be followed immediately.

5.7.8 Brush application of paint shall be in accordance with the following:

a. Brushes shall be of a style and quality that will enable proper application of paint

b. Round or oval brushes are most suitable for rivets, bolts, irregular surfaces and rough or pitted steel. Wide flat brushes are suitable for large flat areas, but they shall not have width over five inches.

c. Paints shall be applied into all corners.

d. Any runs or sags shall be brushed out.

e. There shall be minimum of brush marks left in the applied paint

f. Surface not accessible to brushes shall be painted by spray, duubers, or sheepkin.

5.7.9 Manual application by sling (where 6 O' clock position of pipe is not approachable)

A canvas strip (alternatively a tinplate strip) about 450mm wide and 1.5m longs is hold under the pipe by two men. Liquid coating poured on the sling at each side of the pipe. The men holding this sling move it up and down and walk slowly forward while fresh coating is poured on the pipe and they manipulate the sling so that an even coating is ontained all round the bottom. This work shall be done vey carefully and by experienced personnel. There shall bot be any formation of "Whiskers" and holes in the coating. The coating film shall be inspected by mirror.

5.7.10 For each coat the painter should know the WFT corresponding to the specified DFT and standardise the paint application technique to achieve the desired WFT. This is to be ensured in the qualification trial.

5.8 **Drying of Coated Surface**

5.8.1 No coat shall be applied unit the preceding coat has dried. The material shall be considered dry for re-coating when another coat can be applied without the development of any film irregularities such as lifting or loss of adhesion of undercoats. Drying time of the applied coat should not exced maximum specified for it as a first coat; if it exceeds the paint material has possible deteriorated or mixing is faulty.

5.8.2 No paint shall be force dried under condition which will cause checking, wrinkling blistering formation of pores, or detrimentally after the condition of the paint.

No drier shall be added to a paint on the job unless specifically called for in the manufacturer's specification for the paint.

Paint shall be protected from rain, condensation, contamination snow and freezing until dry to the fullest extent practicable.

5.9 **Repair of damaged paint surface.**

5.9.1. Where paint has been damaged in handling and in transportation, the repair of damaged coating of pre-creation/ fabrication shall be as given below.

5.9.2. Repair of damaged inorganic zinc silicate primer after erection/ weldding:

Quickly remove the primer from damaged area by mechanical scraping and emery paper to expose the white metal. Blasts clean the surfaces possible. Feather the primer over the intact adjacent surface surrounding the damaged area by emery paper.

5.9.3 Repair of damaged pre-erection and shop priming in the design temperature of 90° C to 500° C.

- Surface preparation shall be done as per procedure 5.9.2

- One coat of F-9 shall be applied wherever damaged was observed on pre-erection/ pre-fabrication/ shop primer of inorganic zinc silicate coating (F-9) shall not be applied if damaged area is not more than 5 x 5 cm.

5.10 **PAINT APPLICATION**

5.10.1 Shop priming/ pre-erection priming with F9 of F12 shall be done only on blasted surface.

5.10.2 Shop priming/ pre-erection priming with F-9 or F-12 shall be done only with airless spray.

5.10.3 For large flat surface field painting shall be done by airless spray otherwise brush can be used.

5.11 **Assessment of Painting Requirement**

The paint system to be applied for a specific job shall be arrived as sequentially as given below :

- Identify the environment from area classification details and chose the appropriate table.

- Identify the design temperature from the technical documents.

- Identify the specific field paint system and surface preparation requirement from the above identified table and temperature range.

- Identify the shop priming requirement from Table 7.1 based on compatibility of the above paint system.

- Identify the need of repair of shop primer and execute as per Table 7.2.

5.12 **Documentation.**

A written quality plan with procedure for qualification trials and for the actual work.
Daily progress report with dedtails of weather condition, particular of application no of coats and type of materials applied, anomolies, progress of work versus programme.
Result of measurement of temperature relative humidity, surface profile, film thickness, holiday detection, adhesion tests with signature of appropriate authority.
Particular of surface preparation and paint application during trials and during the work.
Details of non-compliance, rejects and repairs.
Type of testing equipments and calibration.
Code and batch numbers of paint material used.

TABLE-I (for clause 5.0)
SURFACE PREPARATION STANDARDS

S. NO.	DESCRIPTION	VARIOUS INTERNATIONAL STANDARDS (EQUIVALENT)				REMARK
		SWEDISH STANDARD SIS-05-5900 1967	SSPC-SP USA	NACE USA	BRITISH STANDARD BS-4232: 1967	
1.	MANUAL OR HAND TOOL CLEANING REMOVAL OF LOOSE RUST LOOSE MILL SCALE AND LOOSE PAINT, CHIPPING, SCRAPING, SANDING AND WIRE BRUSHING, SURFACE SHOULD HAVE A FAINT METALLIC SHEEN.	ST.2	SSPC-SP-2	-	-	THIS METHOD IS APPLIED WHEN THE SURFACE IS EXPOSED TO NORMAL ATMOSPHERIC CONDITION WHEN OTHER METHODS CANNOT BE ADOPTED AND ALSO FOR SPOT CLEANING DURING MAINTENANCE PAINTING.
2.	MECHANICAL OR POWER TOOL CLEANING REMOVAL OF LOOSE RUST, LOOSE MILL SCALE AND LOOSE PAINT TO DEGREE SPECIFIED BY POWER TOOL CHIPPING, DESCALING, SANDING, WIRE BRUSHING AND GRINDIN, AFTER REMOVAL OF DUST, SURFACE SHOULD HAVE A PRONOUNCED METALLIC SHEEN.	ST.3	SSPC-SP-3	-	-	-DO-

TABLE-I (for clause 5.0)
SURFACE PREPARATION STANDARDS

S. NO.	DESCRIPTION	VARIOUS INTERNATIONAL STANDARDS (EQUIVALENT)				REMARKS
		SWEDISH STANDARD SIS-05-5900 1967	SSPC-SP USA	NACE USA	BRITISH STANDARD BS-4232: 1967	
3.	BLAST CLEANING (AIR & WATER) THERE ARE FOUR COMMON GRADES OF BLAST CLEANING					
3.1	WHITE METAL BLAST CLEANING TO WHITE METAL CLEANLINESS REMOVAL OF ALL VISIBLE RUST, MILL SCALE PAINT & FOREIGN MATTER 100% CLEANLINESS WITH DESIRED SURFACE PROFILE.	SA-3	SSPC-SP-5	NACE#1	FIRST QUALITY	WHERE EXTREMELY CLEAN SURFACE CAN BE EXPECTED FOR PROLONG LIFE OF PAINT SYSTEMS.
3.2	NEAR WHITE METAL BLAST CLEANING TO NEAR WHITE METAL CLEANLINESS, UNIT AT LEAST 95% OF EACH ELEMENTS OF SURFACE AREA IS FREE OF ALL VISIBLE RESIDUES WITH DESIRED SURFACE PROFILE.	SA 2 ½	SSPC-SP-10	NACE #2	SECOND QUALITY	THE MINIMUM REQUIREMENT FOR CHEMICALLY RESISTANT PAINT SYSTEM SUCH AS EPOXY, VINYL, POLYURETHANE BASED AND INORGANIC ZINC SILICATE PAINTS, ALSO FOR CONVENTIONAL PAINT SYSTEM USED UNDER FAIRLY CORROSIVE CONDITIONS TO OBTAIN DESIRED LIFE OF PAINT SYSTEM.

TABLE-I (for clause 5.0)
SURFACE PREPARATION STANDARDS

S. NO.	DESCRIPTION	VARIOUS INTERNATIONAL STANDARDS (EQUIVALENT)				REMARKS
		SWEDISH STANDARD SIS-05-5900 1967	SSPC-SP USA	NACE USA	BRITISH STANDARD BS-4232: 1967	
3.3	COMMERCIAL BLAST BLAST CLEANING UNIT AT LEAST TWO—THIRD OF EACH ELEMENT OF SURFACE AREA IS FREE OF ALL VISIBLE RESIDUES WITH DESIRED SURFACE PROFILE.	SA-2	SSPC-SP-6	No. 3	THIRD QUALITY	FOR STEEL REQUIRED TO BE PAINTED WITH CONVENTIONAL PAINTS FOR EXPOSURE TO MILDLY CORROSIVE ATMOSPHERE FOR LONGER LIFE OF THE PAINT SYSTEMS.
3.4	BRUSH-OFF BLAST BLAST CLEANING TO WHITE METAL CLEANLINESS, REMOVAL OF ALL VISIBLE RUST, MILL SCALE , PAINT & FOREIGN MATTER, SURFACE PROFILE IS NOT SO IMPORTANT.	SA-1	SSPC-SP-7	No. 4		

6.0 PAINT MATERIALS

Paint manufacturers shall furnish all the characteristics of paint material on printed literature, alongwith the test certificate for all the specified characteristics given in this specifications. All the paint materials shall be of first quality and conform to the following general characteristics as per the table 6.1, 6.2 and 6.3.

PAINT MATERIALS
TABLE NO.: 6.1 PRIMERS

S. No.	DESCRIPTION	P-2	P-4	P-6
1.	Technical Name	Chlorinated rubber Zinc Phosphpate primer	Etch primer/ wash primer	Epoxy zinc phosphate primer
2.	Type and composition	Single pack, air drying chlorinated rubber based medium plasticised with unsaponlfiable plasticizer, plgmented with Zic phosphate.	Two pack polyvinyl butyral resin medium cured with phosphoric acid solution pogmented with zic tetroxy choromate.	Tow component polyamide cured epoxy resin medium, pigmented with zinc phosphate.
3.	Volume solids (approx)	40%	7-8%	40%
4.	DFT (Dry dilm thickness) per coat (approx)	40-50μ	8-10μ	40-50μ
5.	Theoretical covering capacity in M2/ coat/ litre (approx)	8-10	8-10	8-10
6.	Welght per litre in kgs/ litre (approx)	1.3	1.2	1.4
7.	Touch dry at 30° C (approx)	30 minutes	2 hrs.	After 30 mins.
8.	Hard dry at 30° C (approx)	Min.: 8 hrs. Max.: no limitation	Min.: 2 hrs. Max.: 24 hrs.	Min.: 8 hrs. Max.: 3-6 months
9.	Over Coating Interval (approx.)	Min : 8 hrs Max : No limitation	Min : 4.6 hrs Max : 24 hrs	Min : 8 hrs Max : 3-6 months
10.	Pot life (approx) at 30° C for two component paints (approx).	Not applicable	Not applicable	8 hrs.
11.	Temperature Resistance	60°C	Not applicable	80°C

PAINT MATERIALS
TABLE NO.: 6.2FINISH PAINT

S. No	DESCRIPTION	F-2	F-3	F-6	F-7
1.	Technical Name	Acrylic polyurethane finish paint	Chlorinated rubber based finish paint	Epoxy-High build finish paint	High build coaltar epoxy coating.
2.	Type and composition	Two-pack aliphatic isocynate cured acrylic finish paint	Single pack plasticised chlorinated rubber based medium with chemical and weather resistant pigments.	Tow- pack polyamide/ ployamine cured epoxy resin medium suitable pigmented.	Tow pack polyamide cured epoxy resin blended with coal/ tar medium, suitably pigmented.
3.	Volume solids (approx)	40%	40%	62%	65%
4.	DFT (Dry film thickness) per coat (approx)	30-40μ	40-50μ	100-125μ	100-125μ
5.	Theoretical covering capacity in M2/ coat/ litre (approx)	10-13	8-10	5-6	5-2-6.5
6.	Welght per litre in kgs/ litre (approx)	1.3	1.2	1.4	1.5
7.	Touch dry at 30° C (approx)	1 hrs.	30 minutes	3 hrs.	4 hrs.
8.	Hard dry at 30° C (approx)	Overnight	8 hrs.	Overnight	48 hrs.
9.	Overcoating interval (approx)	Min.: Overnight (12) hrs. Max.: Unlimited	Min.: Overnight Max.: Unlimited	Min.: Overnight Max.: 5 day	Min.: 24 hrs. Max.: 5 day
10.	Pot life at 30° C for two component paints (approx).	6-8 hrs.	Not applicable	4-6 hrs.	4-6 hrs.
11.	Temperature Resistance	80°C	60°C	80°C	125°C

PAINT MATERIALS
TABLE NO.: 6.3 FINISH PAINTS

S. No	DESCRIPTION	F-8	F-9	F-11	F-12
1.	Technical Name	Self priming type surface tolerant high build epoxy coating (Complete rust control coating)	Inorganic Zinc Slicate coating	Heat resistant synthetic medium based two pack aluminum paint suitable upto 250°C dry temperature	Heat resistant silicone aluminum paint suitable upto 500° C temperature
2.	Type and composition	Two-pack epoxy resin based suitable pigmented and capable pigmented and capable of adhering to manually prepared surface and old coating	A two-pack air drying self-curing solvent based inorganic zinc silicate coating.	Heat resistant synthetic medium based two pack aluminum paint suitable upto 250°C	Single pack silicone resin based medium with aluminum flakes.
3.	Volume solids (approx)	72%	60%	25%	20%
4.	DFT (Dry film thickness) per coat (approx)	100-125μ	65-75μ	20-25μ	20-25μ
5.	Theoretical covering capacity in M2/ coat/ litre	6.0-7.2	8-9	10-12	8-10
6.	Welght per litre in kgs/ litre (approx)	1.4	2.3	1.2	1.1
7.	Touch dry at 30° C (approx)	3 hrs.	30 min.	3 hrs.	30 min.
8.	Hard dry at 30° C (approx)	24 hrs.	12 hrs.	12 hrs.	24 hrs.
9.	Overcoating interval (approx)	Min.: 10 hrs. Max.: 6 months	Min.: 8 hrs. at 20°C and 50% RH. Max.: Unlimited	Min.: 16 hrs. Max.: Unlimited	Min.: 16 hrs. Max.: Unlimited

S. No	DESCRIPTION	F-8	F-9	F-11	F-12
10.	Pot life (approx) at 30° C for two component paints (approx).	90 min.	4-6 hrs.	Not applicable	Not applicable
11.	Temperature resistance	80°C	400°C	250° C	500° C

F-14: Specially for mulated polyamine cured coal tal epoxy suitable for-45°C to 125°C for application under insulation
F-15: Two pack cold curved epoxy phenolic coating suitable for 45°C to 125°C for application under insulation
F-16: Eoxy siloxane anser coat 738

PAINT MATERIALS
TABLE NO. 6.4 FINISH PAINTS

Sl. No.	Description	F-14	F-15	F-16	F-17
1.	Technical name	Polyamine cured coal tar epoxy	Two-component Epoxy phenolic coating cured with polyamine adduct hardner system (primer + intermediate coat + finish paint)	Ambient temperature curing Poly Siloxane coating / High build cold applied inorganic copolymer based aluminum coating suitable for under insulation coating of CS and SS piping for high temperature service.	Two component solvent free type high build epoxy phenolic / novalac epoxy phenolic coating cured with Polyamine adduct hardner system.
2.	Type & composition	Specially formulated polyamine cured coal tar epoxy suitable for application under insulation	Two pack ambient temperature curing epoxy phenolic coating system suitable for application under insulation of CS / SS piping.	Amercoat 738 from Ameron Products, USA / Berger 938 from Berger Paints Ltd., or Intertherm 751 CSA from Akzo Nobel coating. Note : 6	Two component solvent free type high build epoxy phenolic / novalac epoxy phenolic coating cured with Polyamine adduct hardner system.
3.	Volume Solids (minimum)	70%	65%	60%	98-100%
4.	DFT (Dry Film thickness) per coat (minimum)	125 μm	75 - 100 μm	75 - 100 μm	125- 150 μm
5.	Theoretical covering capacity in M^2 / coat / litre (minimum)	5.5	6.5-8.5	6.0-8.0	6.5-8.0
6.	Weight per liter in kgs/litre (max paint) (minimum)	1.5	1.7	1.3	1.7
7.	Touch dry at 30°C (maximum)	4 hrs.	2 hrs.	1 hr.	2 hrs.

Sl. No.	Description	F-14	F-15	F-16	F-17
8.	Hard dry at 30°C (maximum) Full cure 30°C (for immersion / high temp. service)	24 hrs. 168 hrs.(7 days)	24 hrs. 168 hrs.(7 days)	16 hrs. -	24 hrs. 168 hrs.(7 days)
9.	Over-coating interval	Min. 6 hrs. Max. 5 days	Min. 36 hrs. Max. 21 days	Min. 16 hrs. Max. Not applicable	Min. 16 hrs. Max. 21 days.
10.	Pot life at 30°C for two component paints (minimum)	4 hrs.	1.5 hrs.	1 hr.	1 hr.
11.	Temperature Resistance (min.)	-45°C to 125°C under insulation	-45°C to 125°C under insulation (Note : 5)	Up to 400°C for CS & SS under insulation	-45°C to 150°C for immersion service

Notes:

1. Covering capacity and DFT depends on method of application. Covering capacity specified above are theoretical. Allowing the loose during the application, minimum specified DFT should be maintained.

2. All primers and finish coats should be cold cured and air drying unless otherwise specified.

3. All paints shall be applied in accordance with manufacturer's instruction for surface preparation, intervals, curing and application. The surface preparation, quality and workmanship should be ensured.

4. Technical data sheets for all paints shall be supplied at the time of submission of quotations.

6.4 List of recommended manufacturers

The paint shall conform to the specifications given above and the best quality in their products range of the manufacturers listed in Annexure-I.

7.0 PAINT SYSTEM

The paint system should vary with type of environment envisaged in and around the plants. Three types of environment as given below are considered for selection of paint system. The paint system is also given for specific requirements.

Primers & finish coats covered in table nos. 7.0 to 15.0

PRIMERS

P-2	:	Chlorinated Rubber Zinc Phosphate Primer
P-4	:	Etch Primer/ Wash Primer
P-6	:	Epoxy Zic Phosphate Primer

FINISH COATS/ PAINTS

F-2	:	Acrylic- Polyurethane finish paint
F-3	:	Chlorinated Rubber Finish Paint
F-6	:	High Build Epoxy finish coating
F-7	:	High Build Coal Tar epoxy coating
F-8	:	Self-priming surface tolerant high build epoxy coating
F-9	:	Inorganic Zinc Silicate Coating.
F-11	:	Heat resistant Synthetic medium based Aluminum paint.
F-12	:	Heat resistant Silicone Aluminum paint.
F-14	:	Specially formulated polyamine-cured coal for Epoxy coating
F-15	:	Epoxy phenolic coating
F-16	:	Epoxy Siloxane Coating : Amercoat 738
F-17	:	Two component solvent free type high built epoxy phenolic / novalac epoxy phenolic coating cured with polyamine.

TABLE 7.1: PRE-ERECTION/ PRE-FABRICATION AND SHOP PRIMING FOR CARBON STEEL, LOW TEMPERATURE CARBON STEEL & LOW ALLOY STEEL, STEEL STRUCTURE, PIPING AND EQUIPMENT ETC.

S. No.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM	TOTAL DFT IN MICRONS (MIN.)	REMARKS
7.1.1	-90 TO 400	SSPC-SP-10	1 COAT OF F-9	65-75	No overcoating is to be done
7.1.2	401 To 500	SSPC-SP-10	1 COAT OF F-12	40-50	Finish Coat at Site
7.1.3	-40 to 150 for Structures, hand rails and Grating only	SSPC-SP-3	1 COAT OF F-9 OR 2 COATS OF P-7 @ 40μ DFT / COAT	65-75 OF F-9 OR 80 (P-7)	For Damaged Area of more than 5 x 5 Cm2.

TABLE 7.2: REPAIR OF PRE-ERECTION/ PRE- FABRICATION AND SHOP PRIMING AFTER ERECTION/ WELDING FOR CARBON STEEL LOW TEMPERATURE CARBON STEEL & LOW ALLOY STEEL, ITEMS IN ALL ENVIRONMENT.

S. No.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM	TOTAL DFT IN MICRONS (MIN.)	REMARKS
7.2.1	-90 TO 400	SSPC-SP-3 (FOR REPAIR ONLY) SSPC-SP-10	1 COAT OF F-9	65-75	FOR DAMAGED AREA OF MORE THAN 5X5 CM.
7.2.2	401 TO 550	SSPC-SP-3	1 COAT OF F-12	20	FOR DAMAGED AREA OF MORE THAN 5X5 CM.

TABLE 8.0: FIELD PAINT SYSTEM FOR NORMAL CORROSIVE ENVIRONMENT (FOR CARBON STEEL, LOW TEMPERATURE CARBON STEEL & LOW ALLOY STEEL)

ALL NORMAL CORROSIVE AREAS SUCH AS OFF SITES EXTERNAL SURFACE OF UNINSULATED COLUMNS, VESSELS, HEAT EXCHANGERS, BLOWERS, PIPING, PUMPS, TOWERS, COMPRESSORS, STRUCTURAL STEEL WORKS, RCC CHIMNEY WITH OR WITHOUT REFRACTORY LINE INSIDE CHIMNEY (ALL ENVIRONMENTS), EXCLUDING TANK TOPS, FLARE LINES, D.M. PLANTS, INTERIOR OF TANKS ETC. FLARE LINES FOR NORMAL CORROSIVE ENVIRONMENT ALSO TO NE PAINTED AS PER TABLE 9.0

S. NO.	DESIGN TEMPERATURE IN C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			FIELD PRIMER	FINISH PAINT		
8.1	-90 TO –15	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 @65-75μ DFT/ COAT	NONE	65-75	No over coating to be done follow repair procedure only on damaged areas of pre-erection/ pre-fabrication primer/ coating F-9
8.2	-14 TO 60	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 @ 65-75μ DFT/ COAT + 2 COATS OF P-2 @ 40μ DFT/ COAT 2 X 40 = 80	2 COATS OF F-3 @ 40 μ DFT/ COAT 2 X 40 = 80	225	
8.3	61 TO 80	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 @ 65-75μ DFT/ COAT + 2 COATS OF P-6 @ 40μ DFT/ COAT 2 X 40 = 80	1 COATS OF F-6 @ 100 μ DFT/ COAT	245	

S. NO.	DESIGN TEMPERATURE IN C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			FIELD PRIMER	FINISH PAINT		
8.4	81 TO 250	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 @ 65-75μ DFT/ COAT	3 COATS OF F-11 @ 20 μ DFT/ COAT 3 X 20 = 60	125	
8.5	251 TO 400	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 @ 65-75μ DFT/ COAT	2 COATS OF F-12 @ 20 μ DFT/ COAT 2 X 20 = 40	105	
8.6	401 TO 500	SSPC-SP-10	REPAIR AS PER 7.2.2	2 COATS OF F-12 @ 20 μ DFT/ COAT 2 X 20 = 40	80	

NOTE 1 : FOR MS CHIMNEY OR WITHOUT REFRACTORY LINING 8.3, 8.4 AND 8.5 SHALL BE FOLOWED.

NOTE 2 : FOR EXTENAL SURFACE OF RCC CHMNEY: 2 COATS OF F-6 @ 100 μ DFT/ COAT TO OBBTAIN 2 X 100=200μ SHALL BE APPLIED AFTER MAKING SURFACE PREPARATION AS PER GUIDELINES IN 1.5

NOTE 3 : WHEREVER REQUIRED S.NO. 8.3 SHALL BE USED FOR 14°C TO 80°C AND S.NO. 8.2 WILL BE DELETED.

TABLE 9.0: FIELD PAINT SYSTEM FOR CORROSIVE ENVIRONMENT (FOR CARBON STEEL, LOW TEMPERATURE CARBON STEEL & LOW ALLOY STEEL)

FOR ALL CORROSIVE AREAS ABOVE GROUND WHERE H_2S, SO_2 FUMES OR SPILLAGE'S OF ACID/ ALKALI/ SALT ARE LIKELY TO COME IN CONTACT WITH SURFACE SUCH AS EXTERNAL SURFACE OF UNINSULATED COLUMNS, VESSELS, HEAT EXCHANGERS, BLOWERS, PIPING, PUMPS, TOWERS, COMPRESSORS, FLARE LINES, STRUCTURAL STEEL ETC.

S. NO.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			FIELD PRIMER	FINISH PAINT		
9.1	-90 TO –15	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 @ 65-75μ DFT/ COAT	NONE	65-75	Repair of pre-erection/ pre fabrication primer shall be done wherever damage is observed.
9.2	-14 TO 80	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 @ 65-75μ DFT/ COAT + 1 COATS OF P-6 @40 μ DFT/ COAT	1 COATS OF F-6 @ 100μ DFT/ COAT + 1 COAT OF F-2 @ 40μ DFT/ COAT	225	Surface preparation is required only for repairing of damaged pre-erection/ fabrication primer
9.3	81 TO 400	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 @ 65-75μ DFT/ COAT	2 COATS OF F-12 @ 20 μ DFT/ COAT 2 X 20 = 40	105	
9.4	401 TO 500	SSPC-SP-10	REPAIR 2S PER 7.2.2	2 COATS OF F-12 @ 20 μ DFT/ COAT	80	

TABLE 10.0: FIELD PAINT SYSTEM FOR HIGHLY CORROSIVE (FOR CARBON STEEL, LOW TEMPERATURE CARBON STEEL & LOW A LLOY STEEL) EXTERNA L SURFACES OF UNINSULA TED COLUMNS, VESSELS, HEAT EXCHANGERS, BLOWERS, PIPING PUMPS, TOWERS, COMPRESSORS, FLARE LINES, STRUCTURE STEEL ETC.

EXPOSED TO SPILLAGE OR FUMES OF HCL H_2S0_4, SALTY WATER IMPINGEMENT, CHLORIDE ETC.

S. NO.	DESIGN TEMPERATUR E IN °C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			FIELD PRIMER	FINISH PAINT		
10.1	-90 TO –15	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 65-75μ DFT/ COAT	NONE	65-75	Repair of pre-erection/ fabrication primer shall be followed. No over coating is allowed
10.2	-14 TO 80	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 @ 65-75μ DFT/ COAT + 1 COATS OF P-6 @40 μ DFT/ COAT	2 COATS OF F-6 @ 100μ DFT/ COAT = 2 X 100= 200 + 1 COAT OF F-2 @ 40μ DFT/ COAT	345	Surface preparation is required only for repairing of damaged pre-erection/ fabrication primer.
10.3	81 TO 400	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER 1 COAT OF F-9 @ 65-75μ DFT/ COAT	2 COATS OF F-12 @ 20 μ DFT/ COAT 2 X 20 = 40	105	
10.4	401 TO 500	SSPC-SP-10	REPAIR AS PER 7.2.2	3 COATS OF F-12 @ 20 μ DFT/ COAT 2 X 20 = 40	80	

TABLE 11.0 : FIELD PAINT SYSTEM FOR CARBON STEEL STORAGE TANKS (EXTERNAL) FOR ALL ENVIRONMENTS.

S. NO.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			FILED PRIMER	FINISH PAINT		
1.1 EXTERNAL SHELL. WIND GIRDERS APPARATUSES, ROOF TOPS OF ALL GROUND TANK INCLUDING TOP SIDE OF FLOATING ROOF OF OPEN TANK AS WELL AS COVERED FLOATING ROOF AND ASSOCIATED STRUCTURAL WORK ROLLING AND STATIONARY LADDERS, SPIRAL STAIRWAYS, HAND TAILS FOR ALL ENVIRONMENTS FOR GRUDE OIL, LDO, HSD, ATF KEROSENE, GASOLINE, MOTOR SPIRIT, DM WATER, FIREWATER, RAW WATER, POTABLE WATER, ACIDS, ALKALIS SOLVENTS AND CHEMICALS ETC.						
11.1.1	-14 TO 80	SSPC-SP-10	1 COAT OF F-9 @ 65-75μ DFT/ COAT + 1 COATS OF P-6 @40 μ DFT/ COAT 65 X 40 = 105	1 COATS OF F-6 @ 100μ DFT/ COAT + 2 COATS OF F-2 @ 40μ DFT/ COAT 2 X 40 = 80	285	F-6 should be suitable for occasional water immersion
11.1.2	81 TO 500	SSPC-SP-10	1 COAT OF F-9 @ 65-75μ DFT/ COAT	2 COATS OF F-12 @ 20 μ DFT/ COAT 2 X 20 = 40	105	
11.2 EXTERNAL SURFACE OF BOTTOM PLATE (SOIL SIDE) FOR ALL STORAGE TANKS.						
11.2	-14 TO 80	SSPC-SP-10	1 COAT OF F-9 @ 65-75μ DFT/ COAT	3 COATS OF F - 7 @ 100 μ DFT/ COAT 3 X 100 = 300	365	F7 should be suitable for immersion service of the products given.

TABLE 12.0 : FIELD PAINT SYSTEM FOR CARBON STEEL AND ALLOY STORAGE TANK: (INTERNAL)

S. NO.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			FILED PRIMER	FINISH PAINT		
INTERNAL SURFACE OF UNDERSIDE OF FLOATING ROOF, INTERNAL STRUCTURAL OF CONE ROOF, BOTTOM PLATE, ROOF STRUCTURE, STEEL, LADDERS SUPPORTS FOR STORING GRUIDE OIL, LDO AND HSD (EXCLUDING WHITE OIL PRODUCTS)						
12.1	-14 TO 80	SSPC-SP-10	1 COAT OF F-9 @ 65-75µ DFT/ COAT	3 COATS OF F-7 @ 100µ DFT/ COAT 3 X 100 = 300	365	F7 should be suitable for immersion service of the products given.
12.2	BARE SHEEL OF INSIDE FLOATING ROOF TANK AND CONE ROOF TANK FOR PRODUCTS MENTIONED IN 12.1					
12.2.1	-14 TO 80	SSPC-SP-10	PHOSPHATING TREATMENT WITH PHOSPHATING CHEMICALS (2 COATS)	2 COATS OF @10 µ 2 X 10 = 20	20	
12.3	FLOATING CONE ROOF TANKS FOR PETROLEUM PRODUCTS SUCH AS ATF, GASOLINE, NAPHTHA, KEROSENE, MOTOR SPIRIT, INSIDE OF BOTTOM PLATE, UNDERSIDE OF FLOATING ROOF AND SHELL ABOVE MAXIMUM LIQUID LEVEL AND STRUCTURAL STEEL , LADDERS ETC.					
12.3.1	-14 TO 80	SSPC-SP-10	1 COAT OF F-9 @ 65-75µ DFT/ COAT	3 COATS OF F-6 @ 100µ DFT/ COAT 3 X 100 = 300	365	F-6 should be suitable for immersion service of petroleum produce like ATF, Kerosene, petrol etc.
12.4	BARE SHELL OF INSIDE OF FLOATING CONE ROOF TANKS FOR PRODUCTS MENTIONED IN 12.3					
12.4.1	-14 TO 80	SSPC-SP-10	1 COAT OF F-9 @ 65-75µ DFT/ COAT	NONE	65-75	No over coating is allowed same as per pre-erection primer, if any
12.5	INTERNAL PROTECTION IF FIXED ROOF TYPE STORAGE TANKS FOR POTABLE WATER: INSIDE OF SHELL, UNDER SIDE OF ROOF AND ROOF STRUCTURE INSIDE SURFACE BOTTOM PLATE AND STRURAL STEEL WORKS, LADDERS, WALKWAYS, PLATFORMS ETC.					
12.5.1	-14 TO 80	SSPC-SP-10	2 COAT OF F-6 @ 40µ DFT/ COAT 2 X 40 = 80	2 COATS OF F-6 @ 100µ DFT/ COAT 2 X 100 = 200	280	F-6 shall be suitable for immersion service.
12.6	D. M. (DEMINERALISED WATER) AND HYDROCHLORIC ACID (HCL): INTERNAL SHELL, BOTTOM PLATE AND ALL ACCESSORIES					
12.6.1	-14 TO 80	SSPC-SP-10	EBONITE RUBBER LINING AS PER SMMS SPECIFICATION 6-06-204			
12.7	EG TANKS (INTERNAL SHELL, BOTTOM PLATE ROOF AND ALL ACCESSORIES)					
12.7.1	ALL	SSPC-SP-10	3 COATS VINYL CHLORIDE CO-POLYMER AMERCOAT 23 @ 75µ / COAT		225	

S. NO.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			FILED PRIMER	FINISH PAINT		
12.8	INSIDE PONTOON AND INSIDE OF DOUBLE DECK OF ALL FLOATING ROOFS.					
12.8.1	-14 TO 80	SSPC-SP-3	1 COAT OF F-8 @ 100µ DFT/ COAT	1 COATS OF F-6 @ 100µ DFT/ COAT 1 X 100 = 100	200	
12.9	INTERNAL SURFACE OF AMINE & SOUR WATER STORAGE TANKS					
12.9.1	-14 TO 80	SSPC-SP-10	1 COAT OF F-9 @ 65-75µ DFT/ COAT 2 X 40 = 80	2 COATS OF F-15 @ 75µ DFT/ COAT 2 X 75 = 150	215-225	

TABLE 13.0 : COATING SYSTEM FOR EXTERNAL SIDE OF UNDERGROUND CA RBON STEEL PLANT PIPING AND TANKS

S. NO.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			PRIMER	FINISH PAINT		
13.1	CARBON STEEL PLANT PIPING (UNDERGROUND)					
13.1.1	YARD COATING					
13.1.1.1	25 TO 60	SSPC-SP-10	1 COAT OF SYNTHETIC FAST DRYING PRIMER TYPE-B AS PER AWWA-C-203 (1991)	4mm THICK COALTAR COATING WRAPPING AS PER AWWA-C-203 IN 2 LAYER OF EACH 2mm THICKNESS	4mm	CTE coating shall confirm to 120/ 5 as per BS: 4164
13.1.2	OVER THE DITCH COATING					
13.1.2.1	25 Tto 60	SSPC-SP-10	1 COAT OF SYNTHETIC FAST DRYING PRIMER TYPE-B AS PER AWWA-C-203 (1991)	2 LAYERS OF COALTAR BASED TAPE COATING AS PER AWWA-C-203.	4 mm	
13.2	CARBON STEEL PLANT PIPING (UNDERGROUND)					
13.2.1	61 TO 400	SSPC-SP-10	1 COAT OF F-9 @ 65-75μ DFT/ COAT	NONE	65-75	
13.3	EXTERNAL SIDE OF UNINSULATED UNDERGROUND STORAGE TANKS:					
13.3.1	40 TO 80	SSPC-SP-10	1 COAT OF F-9 @ 65-75μ DFT/ COAT	3 COATS OF F-7 @ 100μ DFT/ COAT 3 X 100 = 300	365	
13.3.2	-90 TO –41 81 TO 400° c	SSPC-SP-10	1 COAT OF F-9 @ 65-75μ DFT/ COAT 1 COAT OF AMERCOAT 738 @ 250μ DFT/ COAT	NONE NONE	65-75 250	

TABLE 14.0 : PAINTING UNDER INSULATION FOR INSULATED (HOT COLD SAFETY CARBON STEEL, LOW ALLOY STEEL, LOW TEMPERATURE CARBON STEEL & STAINLESS STEEL PIPING, STORAGE TANKS EQUIPMENTS IN ALL ENVIRONMENT

S. NO.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			PRIMER	FINISH PINTS		
14.1	INSULATED CARBON STEEL, LOW ALLOY STEEL AND LTCS PIPING AND EQUIPMENT & TANKS					
14.1.1	-4 TO 125	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER F-9 @ 65-75μ DFT	2 COATS OF F-14 @ 125μ DFT/ COAT 2 X 125 = 250 OR 3 COATS OF F-15= 3 X 80=240	315	For other temprature ranges no painting is required under insulation.
14.1.2	OPERATING TEMPERATURE –45 TO 125° C BUT DESIGN TEMPERATURE 126-400° C	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER F-9 @ 65-75μ DFT	3 COATS OF F-12 @ 20μ DFT/ COAT 3 X 20 = 60	105-115	
14.2	INSULATED STAINLESS STEEL INCLUDING ALLOY-20- PIPING					
14.2.1	BELOW 0° C TO ALL MINUS TEMPRATURE	ALUMINUM SHEETING WITH ALUMINUM FOIL AND CHLORIDE FREE MINERAL SEALANT CONTAINING BARIUM CHROMATE SHALL BE APPLIED				If the piping & equipments are already erected then surface shall be prepared by cleaning with emery paper and wash/ flush with chloride free DM water followed by wiping with organic solvent
14.2.2	0 TO 120	SSPC-SP-10 (15-25μ SURFACE PROFILE)	NONE	2 COATS OF F-14 @ 125μ DFT/ COAT 2 X 125 = 250 OR 3 COATS OF F-15= 3 X 80 = 240	250	

S. NO.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			PRIMER	FINISH PINTS		
14.2.3	121 TO 500	SSPC-SP-10	NONE	3 COATS OF F-12 @ 20μ DFT/ COAT 3 X 20 = 60	60	No pre erection primer to be applied
14.2.4	501 TO 1000	SSPC-SP-10	NONE	1 COAT OF AMERCOAT 738 @ 150μ DFT/ COAT	150	Only Amorcoat 738 from Amoron is available for this temperature range.
14.2.5	CYCLIC SERVICE-196 TO 480 EXCEPTING –45 TO 120	SSPC-SP-10	NONE	1 COAT OF AMERCOAT 738 @ 150μ DFT/ COAT	150	
14.3	NO PAINTING REQUIRED FOR INSULATED MONEL, IN COLOY AND NICKEL LINES					

TABLE 15.0 : INTERNAL PROTECTION OF CARBON STEEL WATER BOXES AND TUBE SHEETS OF COOLERS/ CONDENSERS WATER BOXES, CHANNELS, PARTITION PLATES, END COVERS AND TUBE SHEETS ETC.

S. NO.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			PRIMER	FINISH PAINT		
15.1	Upto 65	SSPC-SP-10	1 COATS OF F-6 @ 40μ DFT/ COAT	2 COATS OF F-7 @ 125μ DFT/ COAT 2 x 125 = 250	290	For C. S.
15.2	Upto 65 NON FERROUS AND BRASS TUBE SHEETS	SSPC-SP-10	1 COATS OF P-4 @ 8μ DFT/ COAT 1 COATS OF P-6 @ 40μ DFT/ COAT	2 COATS OF F-7 @ 125μ DFT/ COAT 2 x 125 = 250	300	FOR NON FERROUS SURFACE

TABLE 16.0 FIELD PAINTING SYSTEM FOR GI TOWERS/ NON-FERROUS TUBE SHEET

S. NO.	DESIGN TEMPERATURE IN °C	SURFACE PREPARATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			FILED PAINT	FINISH PAINT		
16.1	Upto 65	SSPC-SP-10	1 COATS OF P-4 @ 8-10μ DFT/ COAT + 1 COAT OF P-6 @ 4μ DFT/ COAT	2 COATS OF F-2 @ 40μ DFT/ COAT 2 x 40 = 250	130	SHADE AS PER DEFENCE REQUIREMENTS
16.2	Upto 65 NON FERROUS AND BRASS TUBE SHEETS	SSPC-SP-10	1 COATS OF P-4 @ 8μ DFT/ COAT 1 COATS OF P-6 @ 40μ DFT/ COAT	2 COATS OF F-7 @ 125μ DFT/ COAT 2 x 125 = 250	300	

17.0 STORAGE

17.1 All paints and painting materials shall be stored only in rooms to be arranged by contractor and approved by Engineer-in-Charge for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent building. A signboard bearing the words " PAINT STORAGE NO NAKED LIGHT-HIGHLY INFLAMMABLE" shall be clearly displayed outside.

18.0 COLOUR CODE FOR PIPING

For identification of pipeline, the colour code as per Table 18.1 shall be used. Paint material for color-coding shall be as specified in this standard in clause- 6.0.

18.1 Colour coding scheme for pipe, equipment, machinery & structure:

SR. NO.	DESCRIPTION	GROUND COLOUR	FIRST COLOUR BAND	SECOND COLOUR BAND
18.1.1	ALL KINDS OF WATER			
	DRINKING WATER	Sea Gree	French Blue	Signal Red
	DE-MINERALISED WATER	-do-	Gulf Red	-
	COOLING WATER	-do-	French Blue	-
	BOILER FEED WATER	-do-	Gulf Red	-
	CONDENSATE	-do-	Light Brown	Signal Red
	QUENCH WATER	-do-	Dark Grey	-
	WASH WATER	-do-	Ganary Yellow	-
	PROCESS WATER	-do-	Oxide Red	-
	PROCESS WATER	-do-	Crimson Red	-
	FIRE WATER	Fire red	White	-
	SEA WATER	Sea Green		-
18.1.2	STEAM			
	VERY HIGH PRESSURE STEAM (VHP)	Aluminiumto IS2339	Signal Red	-
	HIGH PRESSURE STEAM (SH)	-do-	French Blue	-
	MEDIUM PRESSURE STEAM (SH)	-do-	Gulf Red	
	LOW PRESSURE STEAM (SL)	-do-	Canary Yellow	Canary Yellow
	DILUTION STEAM/ PURGE STEAM	-do-	Grey	

SR. NO.	DESCRIPTION	GROUND COLOUR	FIRST COLOUR BAND	SECOND COLOUR BAND
18.1.3	COMPRESSED AIR PLANT AIR INSTRUMENT AIR NITROGEN OXYGEN CO_2	Sky Blue -do- -do- Canary Yello -do- -do-	Signal Red Silver Grey French Blue Black White Light Grey	- - - - - -
18.1.4	GASES FUEL GAS AND SOUR GAS CHARGE GAS RESIDUE GAS, LPG ACETYLENE SWEET GAS	 Canary Yellow -do- -do- -do- -do-	 Grey Signal Red Oxide Red Service Brown Grey	 Dark Violet French Blue White - -
18.1.5	ACIDS AND CHEMICALS SULFURIC ACID NITRIC ACID HYDROCHLORIC ACID ACETIC ACID CAUSTIC CHLORINE	 DARK Violet -do- -do- -do- smoke Grey Canary Yellow	 Briliant Green French Blue Signal Red Silver Grey Light Orange Dark Violet	 Light Orange -do- -do- -do- - -do-
18.1.6	HYDRO CARBONS NAPTHAS PROPYLENE PROPYLENE C.G. (LIQ) ETHYLENE GLYCOL ETHYLENE DICHLORIDE BENZENE BUTADIENE ETHANE(LIQ) PROPYLENE(LIQ) ETHYLENE(LIQ) TAR AROMATIC GASOLINE METHANOL (LIQ) PYROLYSIS GASOLINE MIXED C4(LIQ) LPG(LIQ) KEROSENE DIESEL OIL (WHITE) DIESEL OIL (BLACK)	 Dark Admiralty Grey -do- -do- -do- -do- -do- -do- Dark Admiralty Grey -do- -do- -do- -do- -do- -do- -do- -do- -do- Light Brown -do- -do-	 Brilliant Green -do- -do- -do- Gulf Red Canary Yellow Black Light Grey Signal Red Light Grey Signal Grey Brilliant Green White Brilliant Green Signal Green Brilliant Gren -do- -do- -	 Black Smoke Grey Gulf Red - - - French Blue Black Black Brilliant Green Canary Yellow Gulf Red Black Light Brown Dark Violet - -

18.2 The colour code scheme is intended for identification of the individual group of the pipeline. The system of colour coding of a ground colour and colour bands superimposed on it.

18.3 Ground colours as given in Table 18.1 shall be applied throughout the entire length for uninsulated pipes, on the metal cladding & on surfaces covered by Clause 2.2.2, ground colour coating of minimum 2m length or of adequate length not to be mistaken as colour band shall be applied at places requiring colour bands. Colour band(s) shall be applied at the following location.

a. At battery limit points

b. Intersection points & change of direction points in piping ways.

c. Other points, such as midway of each piping way, near valves, junction joints of services appliances, walls, on either side of pipe culverts.

d. For zong stretch/ xard piping at 50M interval.

e. At start and terminating points.

18.4 **Identification Sign**

18.4.1 Flow direction shall be indicated by an arrow in the location stated in Para a,b,c & d and as directed by Engineer-in-charge.

18.4.2 Colours of arrows shall be black or white and in contrast to the colour on which they are superimposed.

18.4.3 Product names shall be marked at pump inlet, outlet and battery limit in a suitable size as approved by Engineer-in-charge.

18.4.4 Size of arrow shall be either of those given in 18.5.

18.5 **Colour Bands**

18.5.1 As a rule minimum width of colour band shall conform to the following table:

Nominal Pipe Size	Width : L(mm)
3" NB and below	25mm
Above 3" NB upto 6" NB	50mm
Above 8" NB upto 12" OD	75mm
Above 12" OD	100mm

Note: For insulated pipes, nominal pipe size means the outside diameter of insulation.
Nominal pipe size figures are to be inches.

18.5.2 Colour band(s) shall be arranged in the sequence shown in Table 18.1 and the sequence follows the direction of flow. The relative proportional width of the first colour band to the subsequent bands shall be 4:1, minimum width of any band shall be as per Clause 18.5.1.

18.5.3 Whenever it is required by the Engineer-in-charge to indicate that a pipeline carries a hazardous material, a hazard marking of diagonal strips of black and golden yellow as epr IS:2379 shall be painted on the ground colour.

18.6 Wherever it is required by the Engineer-in-charge to indicate that a pipeline carries a hazardous material, a hazard marking of diagonal strips of black and golden yellow as per IS:2379 shall be painted on the ground colour.

19.0 IDENTIFICATION OF VESSELS, PIPING ETC.

19.1 Equipment number shall be stencilled in black or white on each vessel, column, equipment & machinery (insulated or uninsulated) after painting. Line number n black or white shall be stencilled on all the pipelines of more than one location as directed by Engineer-in-charge, size of letters printed shall be as below :

Column & Vessels	-	150mm(high)
Pump, Compressor and other machinery	-	50mm (high)
Piping	-	40-150mm

19.2 **Identification of storage tanks**

The storage tanks shall be marked as detailed in the drawing.

20.0 **PAINTING FOR CIVIL DEFENCE REQUIREMENTS**

20.1 Following items shall be painted for camouflaging if required by the client.

a. All columns
b. All tanks in offsites
c. Large vessels
d. Spheres

20.2 Two coats of selected finishing paint as per defence requirement shall be applied in a particular pattern as per 20.3 and as per the instructions of Engineer-in-charge.

20.3 **Method of Camouflaging**

20.3.1 Disruptive painting for camouflaging shall be done in three colours in the ratio of 5:3:2 (all matt finish).

Dark Green	Light Green	Dark Medium Brown
5:	3:	2

20.3.2 The patches should be asymmetrical and irregular.

20.3.3 The patches should be inclined at 30 degree to 60 degree to the horizontal.

20.3.4 The patches should be continuous where two surfaces meet at an angle.

20.3.5 The patches should not coincide with corners.

20.3.6 Slits and holes shall be painted and dark shades.

20.3.7 Width of patches should be 1 to 2 meters.

21.0 INSPECTION AND TESTING

21.1 All painting materials including primers and thinners brought to site by contractor for application shall be procured directly from manufacturers as per specifications and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates are not acceptable.

21.2 Engineer-in-Charge at his discretion, may call for tests for paint formulations. Contractor shall arrange to have such tests performed including batchwise test of wet paints for physical & chemical analysis. All costs there shall be borne by the contractor.

21.3 The painting work shall be subject to inspection by Engineer-in-Charge at all times. In particular, following stagewise inspection will be performed and contractor shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall ne maintained in the registers. Stages of inspection are as follows:

a. Surface preparation
b. Primer application
c. Each coat of paint

In addition to above, record should inculde type of shop primer already applied on equipment e. g. Redd oxide zinc chromate or zinc chromate or Red lead primer etc.

Any defect noticed during the various stages of inspection shall be rectified by the contractor to the entire satisfaction of Engineer-in-Charge before proceeding further. Irrespective of the inspection, repair and approval at intermidiate stages of work. Contractor shall be responsible for making good any defects found during final inspection/ guarantee period/ defect liability period as defined in general condition of contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra coat of paint should be applied to make-up the DFT specified without any extra cost to owner, the extra cost should have prior approval of Engineer-in-Charge.

21.4 **Primer Application**

After surface preparation the primer should be applied to cover the crevices, corners, sharp edges etc. in the presence of inspector nominated by Engineer-in-Charge.

21.5 The shades of successive coats should be slightly different in colour in order to ensure application of individual coats, the thickness of each coat and complete coverage should be checked as per provision of this specification. This should be approved by Engineer-in-Charge before application of successive coats.

21.6 The contractor shall provide standard thickness measurement instrument with appropriate ranges(s) for measuring.

Dry film thickness of each coat, surface profile guage for checking of surface profile in case of blast cleaning. Holiday directors and pinhole detector and positector whenever required for checking in case of immersion conditions.

21.7 Prior to application of paints on surface of chimneys the thickness of the individual coat shall be checked by application of each coat of same paint on M. S test panel. The thickness of paint on test panel shall be determined by using guage such as 'Elkomere'. This thickness of each coat shall be checked as per provision of this specification. This shall be approved by Engineer-in-Charge before application of paints on surface of chimney.

21.8 At the discretion of Engineer-in-Charge, the paint manufacturer must provide the expert technical service at site as and when required. This service should be free of cost and without any obligation to the owner, as it would be in the interest of the manufacturer to ensure that both surface preparation and application are carried out as per their recommendations.

21.9 Final inspection shall include measurement of paint dry film thickness. Adhesion Holiday detection check of finish and workmanship. The thickness should be measured at as many points/ locations as decided by Engineer-in-Charge and shall be within + 10% of the dry thickness, specified in the specifications.

21.10 The contractor shall arrange for spot checking of paint materials for Sp. Gr., flow time (ford cup) and spreading rate.

22.0 GUARANTEE

22.1 The contractor shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein/ to be provided during execution of work.

22.2 The contractor shall produce test report from manufacturer regarding the quality of the particular batch of paint supplied. The Engineer-in-Charge shall have the right the test wet samples of paint at random, for quality of same as stipulated in clause 11 above. Batch test report of manufacturer's for each batch paint supplied shall be made available by the contractor.

23.0 QUALIFICATION CRITERIA OF PAINTING CONTRACTOR

Painting contractor who is awarded any job for MECON, projects under this standard must have necessary equipments, machinery, tool and tackles for surface preparation, paint application and inspection. The contractor must have qualified trained and experienced surface preparation, paint applicator, inspector, and supervisors. The contractor supervisor, inspector surface perpetrator and paint applicator must be conversant with the standards referred in this specification the contractors capacity, capability and competency requirements for the job shall be quantified in the tender document and shall be assessed by an MECON team before awarding any job.

24.0 PROCEDURE FOR APPROVAL OF NEW COATING MATERIALS AND MANUFACTURER'S

Following procedure is recommended to be followed for approval of new manufacturers.

24.1 The manufacturer should arrange testing of the inorganic zinc silicate coating materials as per the list of tests given in para 24.5 below from one of the reputed Government laboratories.

24.2 Samples of coating should be submitted to the Govt. laboratory in sealed containers with batch no. and test certificate on regular format of manufacturer's testing laboratory. The sampling shall be certificate and sealed by a citifying agency.

24.3 All test panels should be prepared by govt. testing agency coloured photographs of test panels should be taken before and after the test should be enclosed alongwith test report.

Sample batch. No. and manufacturer's test certificate should ne enclosed alongwith the report. Test reports contain details of observation and rusting if any, as per the testing code. Suggested government laboratories are:

RRL, Hayderabad
HBTI, Kanpur
DMSRDE, Kanpur
IIT, Mumbai
BIS Laboratory
UDCT, Mumbai
RITES, Calcutta
PDIL

24.4 Manufacturers should intimate the company, details of sample submitted for testing name of Govt. testing agency, date, contact personnel of the Govt. testing agency. At the end of the test the manufacturer should submit the test report to the company for approval. The manufacturer(s) shall be qualified based on the result of these tests and other assessment and the Company's decision in this regard shall be final and binding on the manufacturer.

24.5 Tests required for evaluation of acceptance of coating materials for offshore application.

Test	ASTM Test Method
Density	D 1475
Dipping properties	D 823
Film Characteristics	
Drying time	D 1640
Flexibility	D 1737/ D 522
Hardness	D 3363
Adhesion	D 2197
Abrasion resistance	D 968/ D 1044
DFT/ Coat	AS PER SSPC GUIDELINES
Storage Stability	D 1849
Resistance to	
Humidity for 2000 hrs.	D 2247
Salt Spray for 2000 hrs.	B 117
Accelerated Weathering	D 822
% Zn in DFT	G 53

24.6 Coating system for panel test shall be decided after discussion with MECON.

ANNEXURE-I

LIST OF RECOMMENDED MANUFACTURERS

Indian Vendors

1.0 Asian Paints(I) Ltd.
2.0 Berger Paints Ltd.
3.0 Goodlass Nerlolac Paints Ltd.
4.0 Jenson And Nicholson Paint Ltd & chokuGu Jenson & Nicholson Ltd.
5.0 Shalimar Paints Ltd.
6.0 Sigma Coating, Mumabai
7.0 CDC Carboline Ltd.
8.0 Premier Products Ltd.
9.0 Coromandel Paints & Chemicals Ltd.
10.0 Anupam Enterprises
11.0 Grand Polycoats
12.0 Bombay Paints Ltd.
13.0 Vanaprabha Esters & Glycer, Mumbai
14.0 Sunil Paints and Varnishes Pvt. Ltd.
15.0 Courtaulds Coating & Sealants India (Pvt.) Ltd.
16.0 Mark-chem Incorporated, Mumbai (for phosphating chemicals only)
17.0 VCM Polyurethane Paint (for polyurethane Paint only)

FOREIGN VENDORS FOR OVERSEAS PRODUCTS

1.0 Sigma Coating, Singapore
2.0 Ameron, USA
3.0 Kansai Paint, Japan
4.0 Hempel Paint, USA
5.0 Valspar Corporation, USA
6.0 Courtaulds Coating, UK.

Note: This list subjected to revision based fresh approval which will be intimated to PDD/ Vendor Cell.

ANNEXURE-II

LIST OF RECOMMENDED MANUFACTURER'S PRODUCTS

S. No.	MANUFACTURER NAME	P2 CHLORINATED RUBBER Zp PRIMER	P4 ETCH PRIMER/ WASH PRIMER	P6 EPOXY ZINC PH. PRIMER	F9 INORGANIC ZINC SILICATE PRIMER/ COATING
1.	ASIAN PAINTS (I) LTD.	ASIOCHL OR HB. ZN.PH PRIMER RO PC 168	APCONYL WP 636 (PC 335)	APCODUR HB. RO.ZP-PC433	APCOCIL 605
2.	BARGER PAINT LTD.	LINSOL HIGH BUILD ZP PRIMER	BISON WASH PRIMER	EPILUX 610	ZINC ANODE 304
3.	AMERON/ GODDLASS NEROLAC PAINTS LTD.	-	AMERCOAT 187	AMERCOAT 71	DIMET COTE-9
4.	JENSON & NICHOSON PAINTS LTD. AND CHOKUGU JENSON NICHOLSON	JENSOLAC CHLORINATED RUBBER HB ZN.PH. PRIMER	J & N ETCH PRIMER	EPILAC ZINC PHOSPHATE PRIMER	-
5.	SHALIMAR PAINTS LTD.	CHIOROKOTE ZINC PHOSPHATE PRIMER GREY	TUFFKOTE ETC PRIMER	EPIGUARD 4 ZINC PHOSPHATE PRIMER GREY	TUFFKOTE ZILICATE TL
6.	SIGMA COATING	SIGMA NUCOL UNICOAT 7321	SIGMA COVER PRIMER (7413)	COLTURE CM PRIMER 7412	SIGMASIL MC (7568)
7.	CDC CARBOLINE LTD.	-	-	CARBOLINE 893	CARBOZINC 11
8.	PRIMER PRODUCTS LTD.	-	-	P-15/3A U-16/92	U17/ 92 ETHYL SILICATE INORGANIC ZINC
9.	CORAMANDEL PAINTS CHEMICALS LTD.	COROCLORE CR HB. ZN. PH. PRIMER	CPC WASH PRIMER	COROPEX EPOXY ZH. PH. HIGH BILD PRIMER	-

S. No.	MANUFACTURER NAME	P2 CHLORINATED RUBBER Zp PRIMER	P4 ETCH PRIMER/ WASH PRIMER	P6 EPOXY ZINC PH. PRIMER	F9 INORGANIC ZINC SILICATE PRIMER/ COATING
10.	ANUPAM ENTERPRISES	ANUCHLOR ZP PRIMER	ANUPRIME 291	ANUPAM ANILICOR A-EZP-500	-
11.	GRAND POLYCOATS	GP CHILOROPRIME 601	GP PPRIME 401	-	-
12.	BOMBAY PAINTS LTD. THEMPEL MAKINE PAINTS	HEMPA TEX HIGHBUILD 4633	PENTOLITE WASH PRIMER 8520	HEMPEL'S SHOP PRIMER E-1530	GALVASOL 1570
13.	VANAPRABHA ESTERS & GLYCERIDES,	VEGCHLOR HB PRIMER 1143	VEG WASH PRIMER 1181	VEGPOX 1241 Z/ P	-
14.	SUNIL PAINTS AND VARNISHED PVT. LTD.	SUNCHLOR HB ZINC PHOSPHATE PRIMER	SUN WASH	SUNPOXY ZINC PHOSPHATE PRIMER	-
15.	COURTAULDS COATING LTD.	-	-	INTERGARD 251	INTERZINC
16.	MARK-CHEM INCOPORATED, (FOR PHOSPHATING CHEMICAL ONLY)	RUST PREVENTIVE LIQUID DRSAIO			
17.	VCM POLYURETHANE PAINTS (FOR POLY EURETHANE PAINTS ONLY)				
18.	JOTUN PAINTS			EPOXY CQ	JOTACOTE – 2

S. No.	MANUFACTURER NAME	P2 CHLORINATED RUBBER Zp PRIMER	P4 ETCH PRIMER/ WASH PRIMER	P6 EPOXY ZINC PH. PRIMER	F9 INORGANIC ZINC SILICATE PRIMER/ COATING
				SPECIAL ZINC PHOSPHATE PRIMER	
19.	KCC PRODUCTS (KOREA)				EZ 180(N)

LIST OF RECOMMENDED MANUFACTURER'S PRODUCTS (Contd.…)

S. No.	MANUFACTURER NAME	F2 ACRYLIC-POLY YURETHANE FINISH PAINT	F3 CHLORINATED RUBBER FINISH PAINT	F6 HIGH BUILD FINISH PAINT	F7 HIGH BUILD COAL TAR EPOXY COATING
1.	ASIAN PAINTS (I) LTD.	APCOTHANE CF76 (PC 1109)	ASIOCHLOR CF 621 (PC 161)	APCODUR HB COATING 9466	APCODUR CF 300
2.	BARGER PAINT LTD.	BARGER THANE ENAMEL (81)	LINOSOL CHLORINATED RUBBER HB COATING	EPILUX 04 AND 78 HB EPOXY COATING	EPILUX 555
3.	AMERON/ GODDLASS NEROLAC PAINTS LTD.	AMERCOAT 450GL	AMERCOAT 515	AMER COAT 383 HS	AMERCOAT 78 HB
4.	JENSON & NICHOSON PAINTS	J & N 993 HB POLYURETHANE	JENSON HB CHLORINATED	EPILAC 981 ENAMEL	EPILAC SOLVENTLESS COAT

S. No.	MANUFACTURER NAME	F2 ACRYLIC-POLY YURETHANE FINISH PAINT	F3 CHLORINATED RUBBER FINISH PAINT	F6 HIGH BUILD FINISH PAINT	F7 HIGH BUILD COAL TAR EPOXY COATING
	LTD. AND CHOKUGU JENSON NICHOLSON	FINISH PAINT.	RUBBER FINISH PAINT		TAR EPOXY COATING
5.	SHALIMAR PAINTS LTD.	SHALITHANE FINISH	CHLORKOTE FINISH	EPIGARD KL FINISH	BIPIGARD'S BLACK HB COAL TAR EPOXY COATING
6.	SIGMA COATING	SIGMADOUR HS SEMIGLOSS 7530	SIGMA NUCOL FINISH 7308	SIGMA COVER CM 7456	COLTURIET TCN 300
7.	CDC CARBOLINE LTD.	CARBOLINE 132	-	CARBOLINE 191	CARBOMASTIC-14
8.	PRIMER PRODUCTS LTD.	U3/ 92 POLYURETHANE	CR-71 FINISH PAINT	42B/ 4A HIGH BUILD EPOXY	350B/ 3A, COAL TAR EPOXY COATING
9.	CORAMANDEL PAINTS CHEMICALS	-	COROCLORE CR FINISHING	COROPEX EPOXY HB COATING	COROPEX EPOXY COAL TAR COATING
10.	ANUPAM ENTERPRISES	ANUTHANE ENAMEL	ANUCHLOR HB ENAMEL	DURACOAT-6000	COROGUARD
11.	GRAND POLYCOATS	GP COAT 131, 132 GP BOND 141	GP CHILOROGAURD 631	GP GUARD HP 234	POLYGUARD GE

LIST OF RECOMMENDED MANUFACTURER'S PRODUCTS

S. NO.	MANUFACTURER'S NAME	F2	F3	F6	F7
12.	BOMBAY PAINTS LTD./ PAINTS	PENTATHANE FP 4510	HEMPATEX HIBUILD 4633	HEMPADUR HIGH BUILD 5520	HEMPADUR 1510
13.	VANAPRABHA ESTERS & GLYCERIDES,	VEGTHANE FP 3641	VEGCHLOR FP 3140	VEGPOX- 3265 VEGPOX 3562	VEGPOX 4265
14.	SUNIL PAINTS AND VARNISHED PVT. LTD.	SUNTHANE (ALIPHATIC)	SUNCHLOR HB CR COATING	LPOXY HB 'PS 901'	LPOXY BLACK P. S. 551
15.	COURTAULDS COATING LTD.	INTERTHANE	-	INTEGARD EM SERIES	INTERTUF JXA 006/ 007/ 010
16.	MARK-CHEM INCOPORATED, (FOR PHOSPHATE PAINTS ONLY)				
17.	VCM POLYURETHANE PAINTS (FOR POLY EURETHANE PAINTS ONLY)	PIPCOTHANE ALIPHATIC POLYURETHANE FINISH PAINT			
18.	JOTUN PAINTS	HARDTOP AS		PENGUARD	JOTAGUARD 85
19.	KCC PRODUCTS (KOREA)			KOPOX TOPCOAT HB ET 5740	EH 173

LIST OF RECOMMENDED MANUFACTURER'S PRODUCTS

S. NO.	MANUFACTURER'S NAME	F-8 EPOXY MASTIC COATING SURFACE TOLERANT	F-11 HEAT RESISTANCE SYNTHETIC MEDIUM ALUMINUM PAINT	F-12 HEAT RESISTANCE SILICON AL. PAINT
1.	ASIAN PAINTS (I) LTD.	APCODOR CF 640	ASIAN HR ALUMINUM PAINT (PC 300)	HR SILICON ALUMINUM PAINT (PC 189)
2.	BARGER PAINT LTD.	PROTECTOMASTIC	FERROLOT HR ALUMINUM PANT	BARGER HEAT RISISTANT SILICON ALUMINUM PAINT
3.	AMERON/ GODDLASS NEROLAC PAINTS LTD.	AMERLOCK 400		AMERCOAT 878
4.	JENSON & NICHOSON PAINTS LTD. AND CHOKUGU JENSON NICHOLSON	-	FERROTECT SYNTHETIC RUBBER H/R ALUMINUM PAINT 4000	FERRLOTECT SILICON HEAT RESISTANCE 1000
5.	SHALIMAR PAINTS LTD.	EPIPLUS 56	HEAT RESISTING LUSTROL ALUMINUM	LUSTOTHERM HIGH TEMP ALUMINUM PAINT
6.	SIGMA COATING	SIGMA ETPC ALUMINUM	HIGH TEMPERATURE RESISTANT EPOXY SUSTEM UPTO 200° C 4062	AROSTA FINISH HR
7.	CDC CARBOLINE LTD.	CARBOMASTIC-15	CARBOLINE 1248	CARBOLINE 4674
8.	PRIMER PRODUCTS LTD.	HB EPOXY MATIC 150B/ 150A		
9.	CORAMANDEL PAINTS CHEMICALS	-	SILVOTOL HR ALUMINUM PAINT	CPC SILICONE HR ALUMINUM PAINT
10.	ANUPAM ENTERPRISES	ANUMASTIC-102	-	ANUPAM HEAT GUARD

LIST OF RECOMMENDED MANUFACTURER'S PRODUCTS

S. NO.	MANUFACTURER'S NAME	F8	F11	F12
11.	GRAND POLYCOATS	GP PRIME GUARD 235		-
12.	BOMBAY PAINTS LTD./ HEMPEL MARINE PAINTS	HEMPADUR 1708	KANGAROO HHR ALUMINUM 4950	HEMPADUR HIGH BUILD 5520
13.	VANAPRABHA ESTERS & GLYCERIDES,	VEGEPOX MASTIC 2255	VEG HR AL PAINT TO IS211339	VEG HHR AL PAINT TO 600°C
14.	SUNIL PAINTS AND VARNISHED PVT. LTD.	LPOXY HIGHBUILD P.S.901	-	-
15.	COURTAULDS COATING LTD.	INTERPLUX	-	INTERTHERM 50
16.	MARK-CHEM INCOPORATED, (FOR PHOSPHATE PAINTS ONLY)			
17.	VCM POLYURETHANE PAINTS (FOR POLY EURETHANE PAINTS ONLY)	-		
18.	JOTUN PAINTS	JOTUMATIC 87		SOLVELITT HEAT RESISTANT SILICON PAINT
19.	KCC PRODUCTS (KOREA)	EH 4158H		QT 606

Rev. : 0
Edition : 1

SPECIFICATION
FOR
VENTS, DRAINS AND WELLS

SPECIFICATION NO.: MEC/S/05/21/15

(OIL & GAS SBU)
MECON LIMITED
DELHI 110 092

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3.	Wells Installation 1½ Dia Taps	MEC/SD/05/21/15/02 (Sheet 2 of 2)
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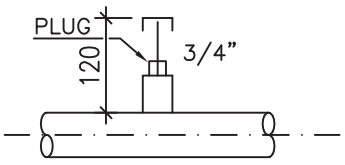
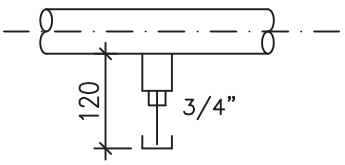
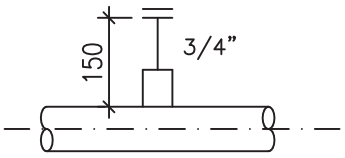
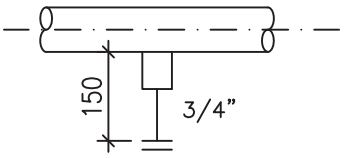
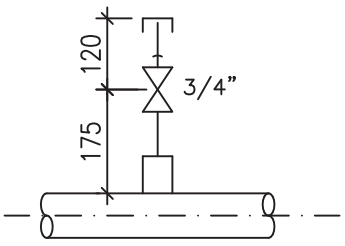
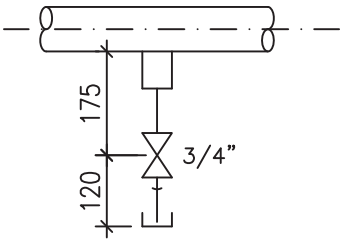
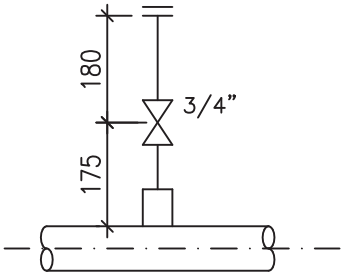
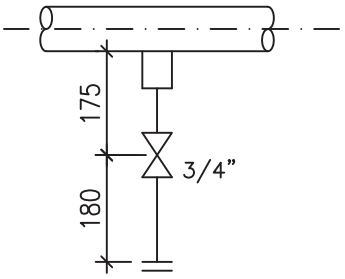
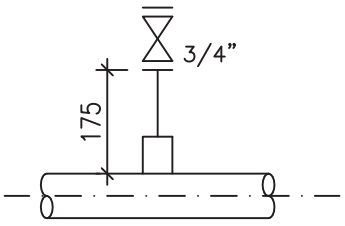
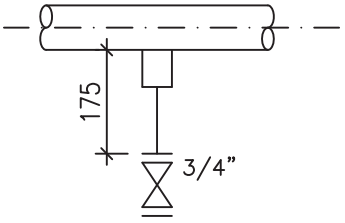
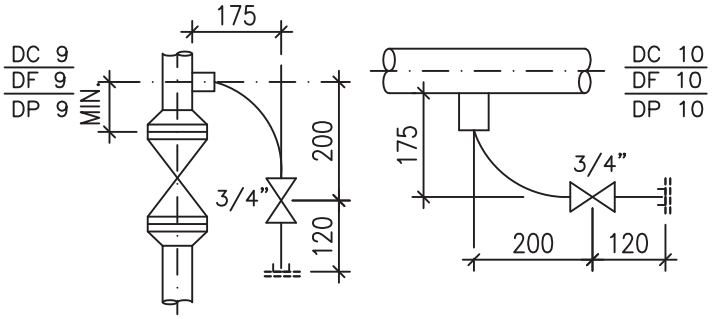
5.	Pressure Tapping	MEC/SD/05/21/15/05

TYPE	VENT	DRAIN
V1 / V1P		D1 / D1P 
V2		D2 
V3 / V3P		D3 / D3P 
V4		D4 
V5		D5 

NOTES:–

1. DIMENSIONS ARE VALID FOR 75mm (MAX.) THICKNESS INSULATION FOR HIGHER INSULATION THICKNES INCASE DIMENSIONS AS REQUIRED.
2. VENTS & DRAINS SHALL BE PROVIDED WITH GATE, GLOBE OR PLUG VALVE WITH HALF COUPLING OR STUB IN WITH CAP OR FLANGE, BLIND FLANGE, AS PER PIPING SPECIFICATIONS.
3. VENTS/DRAINS CAN BE PROVIDED ON FLAT SIDE OF ECCENTRIC REDUCERS ON SIZES 4" & ABOVE.
4. LEGEND V=VENT, D=DRAIN, C=CAP, F=FLANGE, P=PLUG
5. PLUGGED END OF VALVE OR FITTING SHALL BE THREADED.



REV NO	DATE	ZONE	DESCRIPTIONS	BY	APPRD	REVISIONS	REFERENCES	DRG. NO.

SECTION: P&PD	NAME	DATE	CHKD	DATE
DSGN				
DRWN				
APPROVED				

VENT & DRAIN FOR LINES 2" & ABOVE

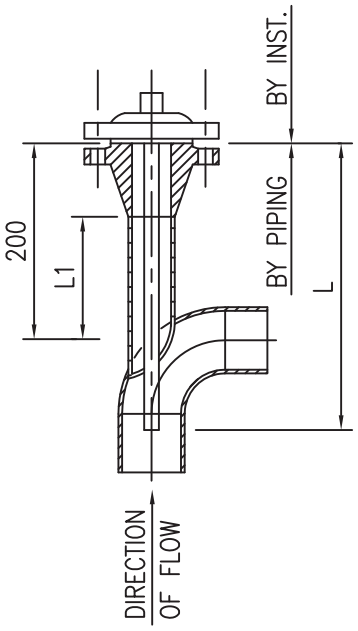
MECON LIMITED

SCALE : N.T.S.

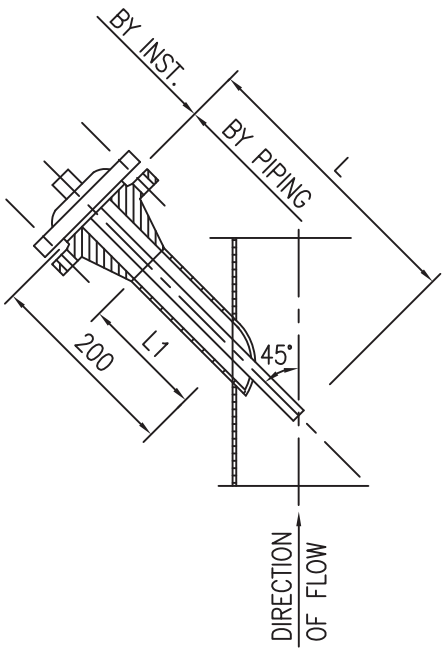
1322 of 1910

DRG.NO MEC/SD/05/21/15/01

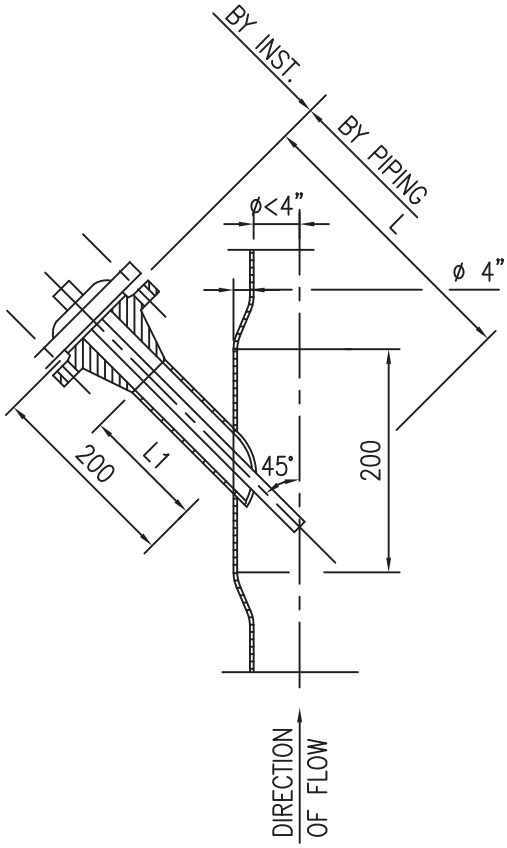
REV 0



TYPE TW-1



TYPE TW-2



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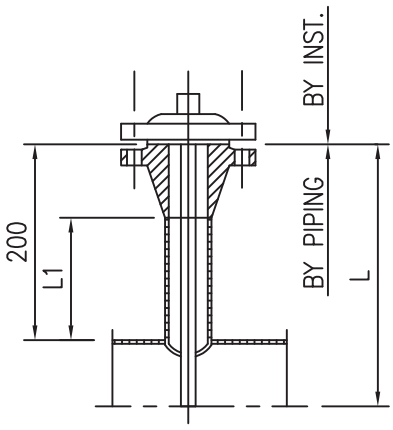
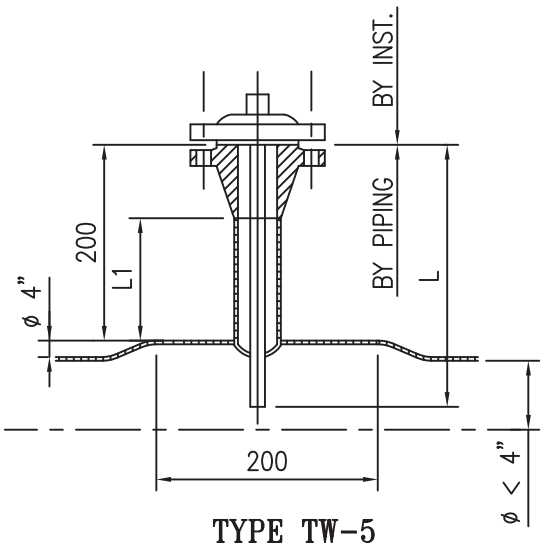


TYPE TW-3



TYPE TW-5

LINE DIA	L 1.5" FLANGED WELL
4"	200
6"	300
8"	300
10"	300
12"	300
14"	300
16"	400
18"	400
20" & LARGER	500
VESSELS	AS REQUIRED

1. ELBOW MIN. 4" ø OR LARGER
2. VERTICAL LINE 4" ø OR LARGER
3. HORIZONTAL LINE 4" ø OR LARGER
4. VERTICAL LINE DIA LESS THAN 4"
5. HORIZONTAL LINE DIA LESS THAN 4"

NOTES:

1. BOLTS, NUTS AND GASCKETS BY PIPING.
2. MIN. CLEARANCE FOR REMOVAL L+550
3. L1 DIMENSIONS ARE CALCULATED FOR WN, RF FLG. ONLY.
4. IN CASE ANY DEVIATION IS REQUIRED FOR INSTALATION TAPS FROM THIS STD. INST. DEPTT. TO BE CONSULTED.

REV NO	DATE	ZONE	DESCRIPTIONS	BY	APPRD	REFERENCES	DRG. NO.
			REVISIONS				

SECTION: P&PD	NAME	DATE	CHKD	DATE
DSGN				
DRWN				
APPROVED				

WELLS INSTALLATION
1½" DIA TAPS

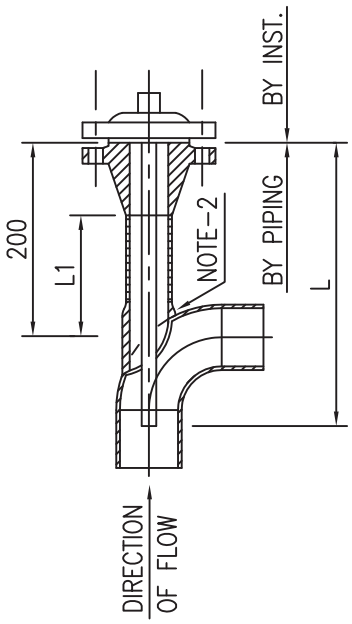
MECON LIMITED

SCALE : N.T.S.

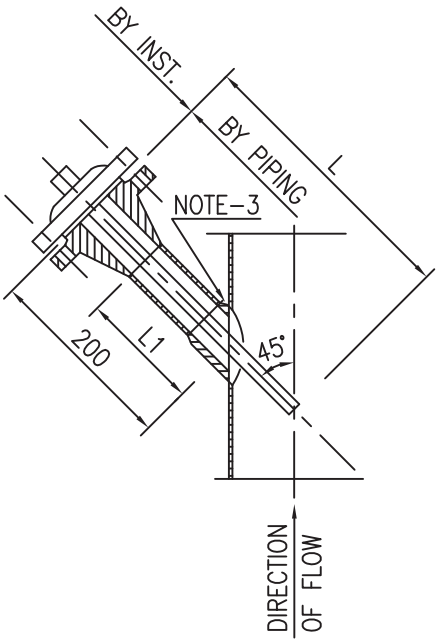
1323 of 1910

DRG.NO MEC/SD/05/21/15/02 (SH. 1 OF 2)

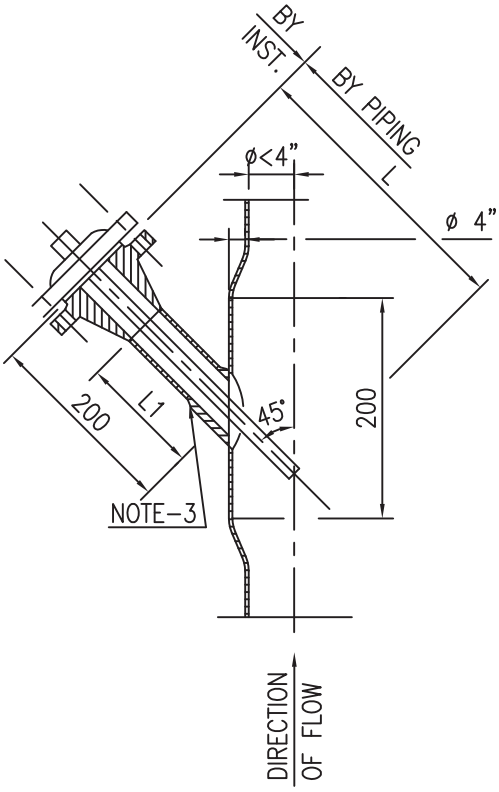
REV 0



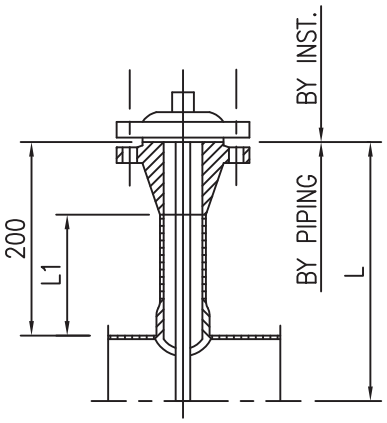
TYPE TW-6



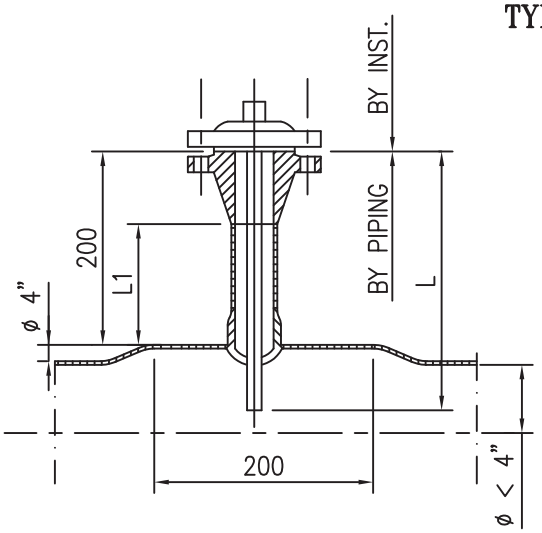
TYPE TW-7



TYPE TW-9



TYPE TW-8



TYPE TW-10

LINE DIA	L 1.5" FLANGED WELD
4"	200
6"	300
8"	300
10"	300
12"	300
14"	300
16"	400
18"	400
20" & LARGER	500
VESSELS	AS REQUIRED

6. ELBOW MIN. 4" ø OR LARGER
7. VERTICAL LINE 4" ø OR LARGER
8. HORIZONTAL LINE 4" ø OR LARGER
9. VERTICAL LINE DIA LESS THAN 4"
10. HORIZONTAL LINE DIA LESS THAN 4"

NOTES:

1. BOLTS, NUTS AND GASCKETS BY PIPING.
2. MIN. CLEARANCE FOR REMOVAL L+350.
3. COUPLING TO BE SPECIAL LENGTH.

REV NO	DATE	ZONE	DESCRIPTIONS	BY	APPRD	REFERENCES	DRG. NO.
			REVISIONS				

SECTION: P&PD

	NAME	DATE	CHKD	DATE
DSGN				
DRWN				

APPROVED

WELLS INSTALLATION
1 1/2" DIA TAPS

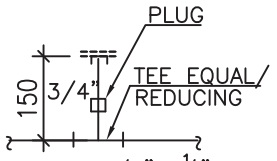
MECON LIMITED

SCALE : N.T.S.

DRG.NO MEC/SD/05/21/15/02 (SH. 2 OF 2)

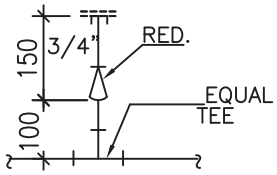
REV 0

VC 2
VF 2
VP 2



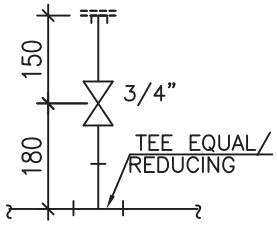
VENT ON LINE 3/4"–1½"

VC 2
VF 2
VP 2



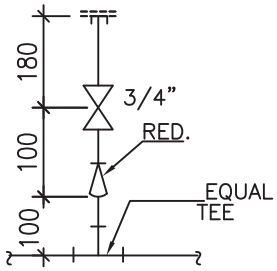
VENT ON LINE 1"–1½"

VC 3
VF 3
VP 3



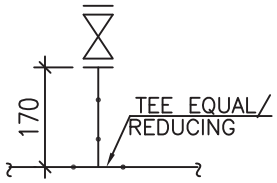
VENT ON LINE 3/4"–1½"

VC 4
VF 4
VP 4



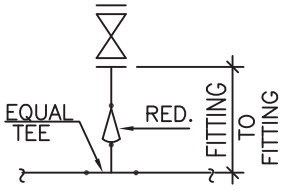
VENT ON LINE 1"–1½"

VC 5
VF 5

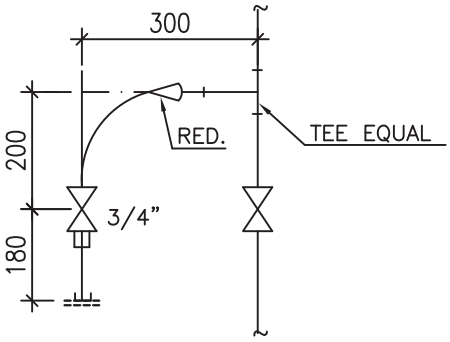


VENT ON LINE 3/4"–1½"

VC 6
VF 6

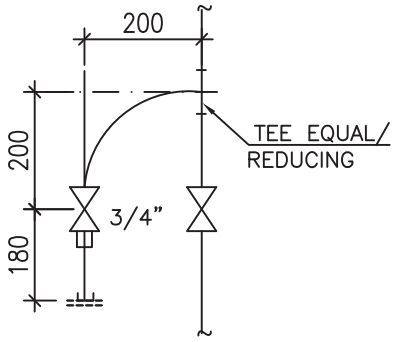


VENT ON LINE 1"–1½"



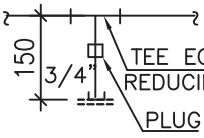
DRAIN ON LINE 1"–1½"

DC 7
DF 7
DP 7



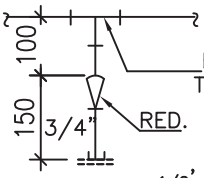
DRAIN ON LINE 3/4"–1½"

DC 8
DF 8
DP 8



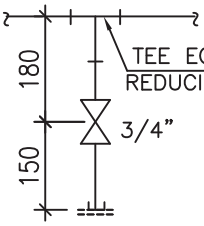
DC 2
DF 2
DP 2

DRAIN ON LINE 3/4"–1½"



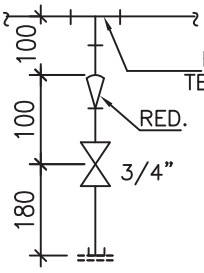
DC 2
DF 2
DP 2

DRAIN ON LINE 1'–1$^{1/2}$'



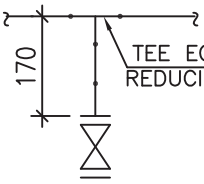
DC 3
DF 3
DP 3

DRAIN ON LINE 3/4"–1½"



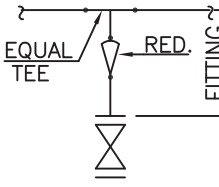
DC 4
DF 4
DP 4

DRAIN ON LINE 1"–1½"



DC 5
DF 5

DRAIN ON LINE 3/4"–1½"



DC 6
DF 6

DRAIN ON LINE 1"–1½"

NOTES:–

1. DIMENSIONS ARE VALID FOR 50mm (MAX.) THICKNESS INSULATION. FOR HIGHER INSULATION THICKNES INCASE DIMENSIONS AS REQUIRED.
2. VENTS & DRAINS SHALL BE PROVIDED WITH GATE, GLOBE OR PLUG VALVE
3. LEGEND V=VENT, D=DRAIN, C=CAP, F=FLANGE, R=REDUCER, COUPLING OR SWAGE, P=PLUG
4. PLUGGED END OF VALVE OR FITTING SHALL BE THREADED.

REV NO	DATE	ZONE	DESCRIPTIONS	BY	APPRD
REVISIONS				REFERENCES	DRG. NO.

SECTION: P&PD

	NAME	DATE	CHKD	DATE
DSGN				
DRWN				

APPROVED

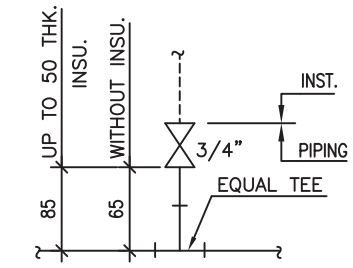
VENT & DRAIN ON LINES 1½" & BELOW

MECON LIMITED

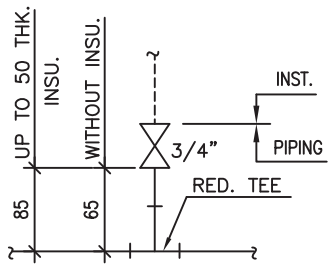
SCALE : N.T.S.

DRG.NO MEC/SD/05/21/15/03

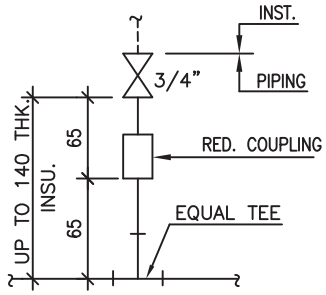
REV 0



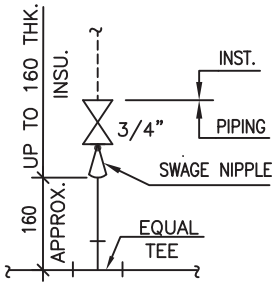
PC-1 ON LINE 3/4"



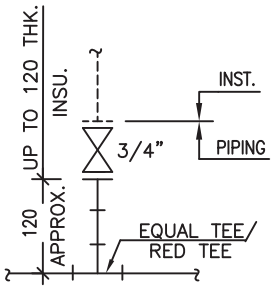
PC-2 ON LINE 1"-1 1/2"



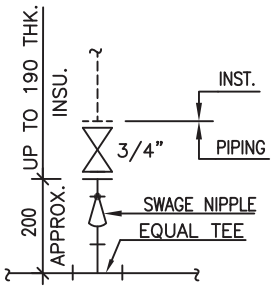
PC-3 ON LINE 1"-1 1/2"



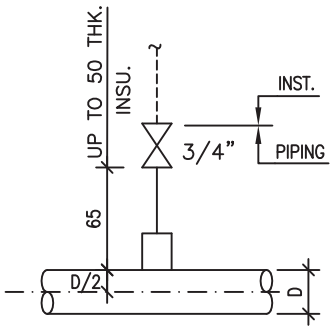
PC-4 ON LINE 1"-1 1/2"



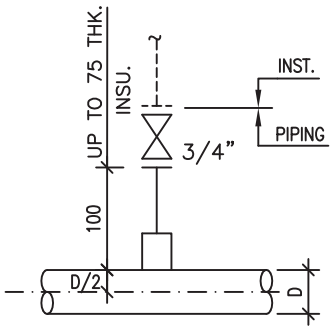
PC-5 ON LINE 3/4"-1 1/2"



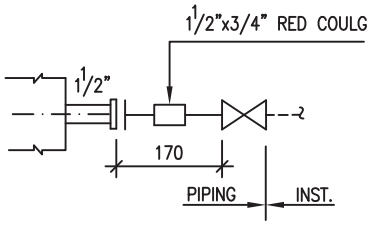
PC-6 ON LINE 1"-1 1/2"



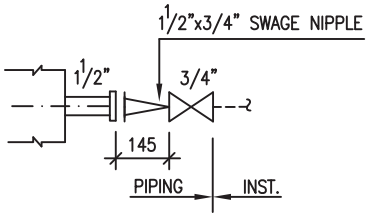
PC-10 ON LINE 2" & ABOVE



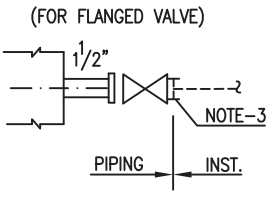
PC-11 ON LINE 2" & ABOVE



PC-12



PC-13



PC-14

PC-15 WITH 2" VALVE

ON VESSELS/ COLUMNS

NOTES:-

1. THE INDICATED DIMENSIONS ARE IN MINIMUM WHICH ALSO COVER INSULATION TO THE EXTENT SHOWN ABOVE. IN HIGHER THICKNESS OF INSULATION THAN INDICATED, THE DIFFERENCE SHALL BE ADDED IN THE DIMENSIONS SHOWN ABOVE ACCORDINGLY.
2. PRESSURE TAPPING SHALL BE PROVIDED WITH GATE, GLOBE OR PLUG VALVE WITH TEE, HALF COUPLING OR STUB-IN, AS PER PIPING SPECIFICATION.
3. IN CASE OF FLGD. VALVES BOLTING & GASKET ON BOTH SIDES OF VALVE SHALL BE IN PIPING SCOPE.
4. IN CASE OF TAPPINGS PROVIDED OTHER THAN INDICATED IN THIS STD FOR LAYOUT REASONS DETAILED DIMENSIONS WILL BE CALLED OUT.

REV NO	DATE	ZONE	DESCRIPTIONS	BY	APPRD	REFERENCES	DRG. NO.
REVISIONS							

SECTION: P&PD

	NAME	DATE	CHKD	DATE
DSGN				
DRWN				

APPROVED

PRESSURE TAPPING

MECON LIMITED

SCALE : N.T.S.

DRG.NO MEC/ SD/05/21/15/05

REV 0

05.00 ELECTRICAL SYSTEM

05.01.01 Scope and Brief Description of Work

The scope of work includes the design, detailed engineering, construction /manufacture or procurement of electrical equipment, shop testing, packing, transportation, loading and unloading, delivery at site, storage at site, handling, erection, pre-commissioning tests and commissioning of all equipment/system including preliminary acceptance test, performance guarantee and post commissioning services and insurance during transit, storage, erection and commissioning. The job shall be done on turnkey basis including Mechanical,Civil and Structural jobs.

Bidder shall comply with complete scope of work given in tender specification. Items/Services/tests etc. not specially mentioned but considered necessary for smooth and trouble free operation of the system shall be treated as included in the scope of the Bidder.

This Package is on complete turnkey basis. Hence, entire equipment/system stipulated in tender are in the scope of Bidder. Entire electrical system including illumination, Earthing Fire Fighting, Fire Detection Alarm, Communication System etc, are in the scope of Bidder.

The scope shall include provision of commissioning spares required during testing and commissioning.

The indicative power supply scheme is enclosed DRG. No. MEC/05/28/23UU/NGCS/TD/020, Sheet 1 of 1, &MEC/05/28/23UU/NGCS/TD/022, Sheet 1 of 1, Rev. 0.

Major equipment covered under scope of work shall be as follows:

- Switchyard work for Tapping Power Supply from APDCL Switchyard inside Plant premises
- 33 kV Cable In Cable Out(CICO) HT Switchboard
- 6.6 kV HT Switch Board.
- HT Transformers, each of rating 33/6.9 kV, 10 MVA(minimum),ONAN type with NIFPS System.
- Distribution Transformers for Auxiliary loads, 2x 630 kVA (Minimum) 6.6/0.433 kV, AN type -2 sets.
- HT and LT motors, Actuators.
- LT Switch Board.

- MCCs.
- HT VFD panel for HT Compressor Motor(Inverter Duty).
- HT Power Factor Compensation Equipment
- Control cabinet / Console – one for each compressor.
- Local push button stations.
- 110 V, 300 AH, DC Plante battery(Minimum), battery charger and DCDB.
- UPS, UPS battery and UPSDB.
- MLDBs,ACDBs / LDBs / Junction Boxes etc.
- Lightning protection and earthing for entire plant area and electronic earthing. Also earthing for all equipment within the scope of supply.
- All power cables (both HT&LT) and control cables (FRLS) type and cable accessories etc.
- Cable trenches, supporting structures, conduits, prefabricated GI cable trays ,FRP Cable Trays, Cable racks, other associated accessories like cable glands, lugs, termination/jointing kits, ferrules, clamps including trefoil clamps for single core cables, cable markers, cable identification tags, and all other hardware material as per requirement.
- Fire sealing materials for laying termination and sealing of cables.
- Complete electrics of material handling equipment like cranes, lifts, hoists, etc.
- Complete electrics of air-conditioning and ventilation systems in all the premises under battery limit.
- Water drainage pumps in required numbers with complete electrics including source feeders, pumps/motors, cable laying, etc for various areas (Cable cellars, Switchgear Buildings etc).
- Fire protection system including Fire Detection and Alarm System for the complete plant, etc.
- Welding sockets(FLP & Non-FLP type), Utility sockets (FLP & Non-FLP type), 24 V sockets (FLP & Non-FLP type), Portable hand lamps (FLP & Non-FLP type) etc. Miscellaneous items i.e. Danger board, caution board, shock treatment chart, first aid box, elastomericinsulatingrubber mats per IS-15652, rubber hand gloves, Earth discharge rod, phase marker etc.
- Building internal electrics, and lighting control system.
- Roof top on-grid PV solar Electric system at control room and Administration building.
- Illumination for the entire plant and boundaries(for non-hazardous and hazardous area) including street light, high mast, landscape lighting and feeder pillars.
- FLP (CIMFR tested PESO Approved) type double-compressionnickel-plated brass cable glands, tinned-copperlugs,clampingmaterialetcfor cable termination.
- Installation, erection accessories.
- Safety items.

- CCTV,IT (RJ45, CAT6 Cable, fiber cable network rack and switches etc),TELECOM Services.

For compressor motor, vibration, bearing and winding temperature detection, monitoring, interlocking, signaling & annunciation, micro-processor based temperature controller shall be provided for each motor by the Bidder.

The detailed specification and schedule of quantities also covering the minor equipment shall be worked out by the Bidder for the total implementation of the job. The relevant standard and guidelines shall be followed in this case.

Note: All Electrical equipment in hazardous area shall be suitable for Flameproof area Zone -1 & 2 (Gas IIA and IIB) – temperature class T3. Control station equipment shall have minimum flame proof Ex-d protection enclosure for Zone-1 and 2. Motors shall have EX-d / Ex-de flame proof enclosure with increase safety terminal box.All Equipment will be certified by CIMFR or equivalent testing agency (NABL accredited) and valid PESO license shall be available.

05.01.02 Area Classification

Hydrocarbonhandlingareashavebeengenerallyclassifiedaszone1&2,gasgroupIIA/IIB as perIS:5572,APIRP-500,OISD-113andIPRules.All equipment to be installed in these areas shall be suitable for the area classification with temperature classT3(200ºC), tested by CIMFR or equivalent testing agency (NABL accredited) and valid PESO license/certificate shall be available.

Electrical Equipment for Hazardous Area

The electrical equipment for hazardous areas shall be considered as per IS-5571and petroleum rules and Gas group shall be selected based on the hazardous area classification. The minimum requirement is summarized below.

Equipment	Zone-1/ Zone-2
MV Motors	Ex-d/ Ex-de
HV Motors	Ex-d/ Ex-de
Push Button Station	Ex-d
Motors Starters	Ex-d
Plug & Socket	Ex-d
Welding Receptacle	Ex-d
Lighting Fixtures	

i) Lighting Fitting ii) Control Gear Box	Ex-d
Junction Boxes	Ex-d
Hand lamps i) light fitting ii) Transformer unit iii) Plug & Socket	 Ex-d Ex-d Ex-d
Break Glass Unit (Fire Alarm System)	Ex-d
Lighting Panel/Power Panel	Ex-d
Transformers	Transformer installation shall be in safe area

For equipment uses in hazardous area for which type of protection is not specified in the above table, type of protection shall be referred from OISD-149.

Note:

As additional safety features, the following requirements for electrical equipment shall be followed:

All electric motors for agitators/mixers and metering pumps handling flammable material shall flame proof Ex-d type irrespective of the area being classified aszone-2 on zone-I.

All electric motors for vertical sump pumps handling flammable material shall be flameproof type. Irrespective of the area classification (whetherzone-1 orzone-2), all lighting fixtures within the storage areas shall be flame proof type.

All emergency/critical lighting fixtures and associated junction boxes in hazardous areas (whether zone-I andzone-2) shall be flameproof type.

Even though fired heaters in process units are not considered for area classification, all electrical equipments associated with firedheatersinprocessunitsshallasaminimum besuitable forinstallation in Zone-2 area.

Building suchasCompressor sheds insidetheprocessareashallbe designedtoallow adequate ventilation toallow areaclassification asZone-2. Lightingequipment, EOTcraneetc. inthe compressor and lube oil shedshallbeflameproof type, Allother electrical equipment shall besuitable for respective Zone- l andZone - 2area.

All motors for hazardous areaZone-lshall preferably' beflameproof type.Pressurised

motors maybe provided inexceptional cases.

05.01.03 Statutory Approval of Works

Allworksrelatingtostatutory approvals ofthecomplete installationfromcompetentauthorities likePESO,OISD, CPCB,CEA,DGMS,StateelectricityAuthority/Board, local authorities etcshall bein thescopeofcontractor.

TheapplicationonbehalfoftheownerforsubmissiontoOISD/PESO/ElectricalInspector /DGMSetc.along withcopies ofrequiredcertificatesanddrawings,completeinallrespects,shallbepreparedby thebidderandsubmittedtotheEngineer-in-chargeforonwardtransmission wellaheadof timesothattheactualcommissioningofequipmentarenotdelayedforwantofinspectionb y the PESO/ElectricalInspector/DGMS/OISD etc.TheactualLiaisonwork shallbearranged bythebidder andnecessarycoordinationandliaisonsworkinthisrespectshallberesponsibility ofthe contractors.
However,theOwneronsubmissionofbillsalongwithdocumentaryevidenceshall reimburseanyfeepaid tothestatutoryAuthorityin thisregards.

Allworksrelatingtostatutoryapprovalsofthecompleteinstallation,fromcompetentauth ority likePESO,OISD, CPCB,CEA,DGMS,CPCB, Stateelectricityauthority/Boardetcshallbeinthescopeofbidder. After audit if any points are required for compliance/certification/commissioning, same shall be done by the bidder free of cost.

05.01.04 Construction Power

For construction power supply successful bidder shall make their own arrangement. through nearest source of power supply . Bidder shall have to make their own arrangement for further feeding to various places. This shall include required all Electrical Equipment MCCB feeders ,Power and Control cables etc. If necessary successful bidder may arrange DG set for their own.

05.01.05 Battery Limits

HT Power Supply shall be tapped from State Utility 33 kV MRS Switchyard inside the Plant premises which shall be constructed by APDCL on depositary basis. The Double Circuit Line from KAMALPUR Grid Substation at a distance of 5km to 10 kM which shall feed power supply to the plant MRS Switchyard. The scope of

work of the bidder started from this switchyard through tapping of 33 kV HT XLPE Cable and shall be terminated to 2 Nos 33 kV Cable In Cable Out(CICO) VCB panels for the Compressed Air Station Complex. Supply, laying, termination associated works(i.e Earthing, Lightning Protection, Illumination, Fencing minor civil works and also coordination works from APDCL shall be in the scope of the bidder.

The necessary Safety and compliance for the Electrical system after audit of Electrical Inspector and other State/Central Govt Agency shall be in the scope of Bidder.

The further Power Distribution scheme has been explained in 33 kV, 6.6 kV Power Distribution Single Line Diagram MEC/05/28/23UU/NGCS/TD/020. The 33 kV Power supply shall further distributed through 2 nos. 33/6.9kV 10 MVA ONAN Power Transformers along with terminations at both ends and down below, All the auxiliary distribution (AC, DC & UPS) shall be done by the Bidder. The cables shall be routed through underground trenches.

05.01.06 Overall Power Distribution Scheme

The overall power distribution scheme of the proposed Compressor Complex shall be further distributed through 33kV, 6.6 kV & 415 V Power Supply. The HT LT Basic Power Distribution Single Line Diagram is shownin“33 kV & 6.6 kV Basic Power Distribution Single Line Diagram drawing no MEC/05/28/23UU/NGCS/TD/020& further LT distribution system shall be distributed through 2 nos. LT Distributed Substation drawing no MEC/05/28/23UU/NGCS/TD/022.

05.01.07 **Power Distribution scheme at Compressor Complex**

As described earlier, Power requirement shall be met from proposed APDCL Grid for HT/LT loads and very selective LT loads shall be fed from captive DG sets as per requirement The power shall be stepped down from 33 kV to6.6kV at proposed Main Receiving Substation area through two nos. transformers as described below:

SrNo.	QTY.	CAPACITY, MVA	UTILIZATION UNIT
1.	2	10	33/6.9kVONAN Power Transformers forCompressor Complex

The Power Supply shall be further distributed through 1 no 6.6 kV Switchboard and it shall be fed power supply to 6.6 kV HT compressors through VFD .The 6.6 kV Power Supply shall further distributed to 2 nos. 6.6 kV Double ended substations for 415 V Power Supply.

This LT Switchboard third section shall be connected with LT DG set with AMF panel. Battery, Batterychargercum DCDB has been envisaged for HT panels and other equipment .

The power factor compensation equipment is envisaged at 6.6 kV Bus for improvement of the overall power factor to 0.96 lag and above. The equipment shall comprise capacitor unit of suitable rating with series air core reactor, busbars, lightning arrestors, isolators and discharge PTs etc. to render the installation complete and safe for intended operation.

The 6.6 kV bus section shall be connected to indoor type capacitor banks of suitable rating with series air core reactor. The rating of capacitor bank shall be selected during engineering stage considering actual load data and system requirement.

Supply, laying & termination of all HT, LT and other power and control cables for Compressor Complex along with Substation is included in the scope of work.

Bidder shall include all installation equipment and services in his scope for the equipment being supplied by them.

33 kV Indoor CICO panels including Relay, Metering, Control panel shall be housed in MRS area Building. The Control Room apart from Remote Breaker Control Panel it shall also be housed APDCL Grid Metering Panel(Main for APDCL & Check Metering for IGGL) , APDCL Yard Equipment Control & Relay Panel . The required AC ,DC, Illumination etc power supply shall be fed from HT cum LT Substation building for these panels. The minimum indicative size of the building has shown in tender drawing, considering all panels it may increase during Engineering stage and

shall be provided accordingly. Power Transformers shall be adjacent to this building. Sub lighting distribution panel shall be planned for control and admin building in such a manner that separate metering can be done for lighting and HVAC system. Sub lighting distribution panel of the building (admin and control room) shall have two incomer facility to take feed from On Grid SPV system of 20KWp/40KWp for control room/admin building and normal power.

HT cum LT Substation building (Left Wing & Right Wing) shall have 6.6 kV switchboard, Motor VFD Panels, Battery charger cum DCDB, Distribution Transformers, LT PCC (LT Power Control Centers),Power Distribution Board(PDB),AC Distribution Board(ACDB) , Main Lighting Distribution Board(MLDB), MCCs, FDA,CCTV Control Panels ,UPS along with Battery Substation Automation System (SAS) equipment and miscellaneous Electrical panels, instrumentation etc. The minimum indicative size of the building has shown considering all panels it may increase during Engineering stage.

For details of 33kV , 6.6 kV & 415 V Power Supply refer the HT LT Basic Power Distribution Single Line Diagram as shown in “33 kV & 6.6 kV Basic Power Distribution Single Line Diagram " drawing no MEC/05/28/23UU/NGCS/TD/020& further LT distribution system shall be distributed through 2 nos LT Distributed Substation drawing no MEC/05/28/23UU/NGCS/TD/022.

In HT cum LT Substation Building itself, one no 415 V Switchboard (PCC-01) LT Double Ended transformer feeding Switchboard along with third incoming section(Emergency) fed from DG set shall be installed for catering to LT loads of MRS,HT cum LT Substation auxiliaries(i.e AC, Ventilation ,FDA,CCTV, Area &road lighting etc of the proposed complex.

Other 415 V Switchboard (PCC-02) LT Double Ended transformer feeding Switchboard along with third incoming section(Emergency) fed from DG set shall be installed for catering to LT loads of Process MCCS ,PDBs (ie. Compressor, Fire Fighting etc), However Load segregation ,feeder selection shall be finalised during detailed engineering stage .

For emergency loads, suitable capacity DG Sets are envisaged as an alternate power source.
The entire Basic Power Distribution facility of the factory area has been explained through Single Line Diagrams and Electrical Building layouts drawings.

05.02 ELECTRICAL SYSTEM DESIGN

Design Criteria

1.01 Standards

The design, manufacture, assembly and testing as well as performance (including safety, earthing and other essential provisions) of equipment and accessories covered under this specification shall, in general, comply with the following:-

- Bureau of Indian Standards (BIS)
- International Electrotechnical Commission (IEC)
- Institute of Electrical and Electronics Engineers (IEEE)
- National Environmental Policy Act (NEPA)
- Oil Industry Safety Directorate (OISD), India
- PNGRB Regulations, India
- Oil Mines Regulations
- Directorate General of Mines Safety (DGMS), India

  Apart from other International standard shall also be followed for respective equipment and system
- American Petroleum Institute (API)
- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- British Standards (BS)
- Deutsches Institutfür Normung eV (DIN)
- Directorate General of Mines Safety (DGMS), India
- Instrument Society of America (ISA)
- National Association of Corrosion Engineers (NACE)
- National Electrical Code (NEC)
- Energy conservation building code 2017
- Green Rating for Integrated habitat Assessment-2019
- National Electrical Manufacturers Association (NEMA)

The list of APPLICABLE CODES AND STANDARDS (INDICATIVE) for various disciplines are also placed at respective places in the bid.

Due care shall be exercised such that overall design provides conformity to process

requirement, ease of construction, installation, commissioning, start-up operation and maintenance and shall be safe to operate under all conditions. All equipment supplied and all work done including system design and detailed engineering shall also comply with the statutory requirements of Govt. of India and the respective governments of state in which the plant is situated. The installation shall also conform to Indian Electricity Act and Indian Electricity Rules.

In case, the Bidder is not in a position to comply fully with certain IS specifications or in respect of certain items for which there are no IS specifications, the Bidder shall bring out the same in his offer and the Bidder may base his proposals on latest issue of IEC recommendations or other reputed national or international standards subject to the approval of the Purchaser. However, wherever specified in this specification, IEC or other standards shall be followed.

The components and materials used and the equipment supplied shall conform to high standards of design, engineering and workmanship and shall be suitable for efficient operation and reliable service in industrial conditions.

1.02 Environmental Conditions, Design Ambient & De-rating considerations

1. For system design, following environmental conditions are to be considered.

S.N.	Environmental condition	Data
1.	Maximum ambient temp.	50 deg. C
2.	Humidity	95 % not occurring simultaneously with maximum temperature.
3.	Design Altitude	Less than 1000 M from MSL
4.	Environment	Dusty &Corrosive

2. The design ambient temperature for all equipment shall be considered as the maximum ambient temperature specified above, unless specified otherwise.

3. For Field &various Technological areas, ambient temperatures in different units of a shop shall be considered, asmentioned in TS.

4. For Electrical rooms, control rooms following ambient temperatures shall be maintained, unless specified otherwise.

S.N.	Electrical premises type	Max Temp.
1.	Cable basements/ Cable Cellars	+ 45 Deg. C (force ventilated)
2.	HT CUM LT SUBSTATION Building Main Switchgear Roomwith LTPCCs MCCs, PDBs, Drives ,MLDBs etc	+ 35 Deg. C (Air conditioned)
3.	Control rooms, SAS Rooms, FDA CCTV	+ 24 Deg. C (Air conditioned)

Howeverequipment selection and de-rating shall be based on **maximum ambient temperature specified above** including the equipment in Electrical/ Control rooms so that failure of Air-conditioning shall not effect the performance of equipment.
Derating of PCs, Printers, Monitors for maximum ambient temperature is not required.
Distribution Transformers, Capacitor Rooms, Battery Rooms shall have required rating and nos of Exhaust Fans.. Exhaust fan in battery room shall be flame proof type and switch and sockets shall be provided outside battery room.

Standard Voltage levels:

Standard voltage levels to be adopted in the plant are specified as follows& same shall be followed unless mentioned otherwise in the Technical specification (TS).

S.N.	Description	Data
1.	HT AC	33 kV, 3 phase, 50 Hz, SolidlyEarthed. 6.6 kV, 3 phase, 50 Hz, Resistance earthed.
2.	LT AC	415V, 3 Phase, 50 Hz, 4 wire, solidly earthed. .
3.	AC control and signaling voltage.	240V, AC obtained using suitable control transformers with manual/auto changeover facility as specified in TS.

S.N.	Description	Data
4.	Control voltage for HT switchgear equipment, HT MCC	110 V DC
5.	Special socket outlets for portable lamps	24V, single phase, 50 Hz, AC obtained through suitable transformers
6.	Solenoid valves	24V,DC, unearthed
7.	Machine tools lighting	240V, single phase, 50 Hz, AC lighting obtained through suitable transformers.
8.	Sockets for Welding purposes	415V, 63A/100A, 3 pin plus earth with plug interlocked switch
9.	Sockets for hand tools*	240V AC,15A, 2pin plus earth with plug interlocked switch, power obtained through suitable transformers.
10.	Illumination system*	240V AC, 50Hz obtained through suitable transformers.
11.	Automation system equipment like SAS, PLC, RIO, PC, Servers etc, Weighting system & other electronic panels	240V AC, 50 Hz, obtained through UPS
12.	Cranes& Hoist	As per equipment specification.

1.03 Symmetrical short circuit ratings:

The three phase symmetrical short-circuit ratings of the switchgear at the different voltage levels shall be as follows unless specifically indicated otherwise in the Technical specification:

S.N.	Description	Data
1.	33 kV switchgear	25 kA for 3 sec
2.	6.6 kV switchgear	40 kA for 3 sec .
3.	415 V switchgear	50 kA for 1 sec

1.04 Permissible variations in Power supply:

The system/unit/plant/equipment shall be designed so as to be suitable for the following variations in incoming voltage and frequency unless specifically indicated in the Technical specification:

S.N.	Description	Voltage	Frequency
1.	For HT system :-	+/-10%	+/- 3%
2.	For LT system	+/-10%	+/-3%
3.	For Control voltage AC	+/-10%	+/-3%
4.	For Control voltage DC	+/-10%	NA

In case of sensitive equipment which require more stringent quality of power supply with lesser variations to achieve the desired performance, the supplier shall provide the necessary regulator/stabilizer required for before such equipment.

The rated short circuit withstand duration for 33 kV &6.6 kV and 415 V including MCCs will be 3 sec and 1 sec respectively.

Each 33/6.9kV Transformer along with the incoming 33kV and 6.6kV feeder's cable size shall be designed based on the following load considerations.

a. HT Compressor– 3nos (working) & 1 no (standby)
b. LT load- As Required

However the Power Transformer ,LT Distribution Transformer minimum ratings are specified in the Specification.
The Cable sizes for 6.6 kV shall be minimum 3Cx240 Sqmm and uniformly used in the plant where LT cable maximum 3CX240 Sqmm shall be used.

Criteria for selection of voltage levels for drive motors

AC squirrel cage induction motors (SCIM) of ratings **up to** 200 kW and slip ring motors up to 250 kW shall be fed at LT, 415V, 3 phase 4 wire 50 Hz, with DOL. However, soft starter with DOL bypass shall be provided for drives rating in range of 90 kW to200 kW where full torque load starting is not required (like for fans, pumps).

For motors above 1000 kW, the Motors shall be fed from 6.6 kV Switchboard through MV VFD panel.

Motor Starting and permissible voltage dips:

Voltage dip on starting of the largest motor shall be limited to 15% of the nominal voltage at the motor terminals during DOL starting.

System Earthing

In general 33 kV system shall be Solidly earthed (Earthed as per State utility guidelines) .6.6 kV system is resistance earthed system and 415 V system will be solidly earthed.
If any specific earthing or specialized earthing is required for the system and the project same shall be considered by the bidder.

1.05 Power Distribution system design

The power distribution system shall meet the following guide lines:

1. Two number of 415V Load Center Substation (LCSS) comprising LTPCC and other associated equipment shall be provided for feeding Motor control centers, MCPs, PDBs, MLDBs, VFD drive panel for LT Motors and auxiliary power distribution boards as required for the plant. The PCCs in LCSS shall be fed from 2 X 100% rated transformers (2x630kVA minimum) in 2 sets . The rating of the transformer shall be so sized that in case of outage of any one transformer, the other transformer shall be loaded 90% rating of name plate rating. The LT Load distribution of the both LT PCC has described earlier in Power Distribution Scheme.

2. Suitable numbers of 415V Motor control centers shall be provided for feeding power supply to motors of rating less than or equal to 90kW, motorizedvalves/dampersetc.Allmotors(upto90kW)ofonetechnologicalunit will be grouped area wise and fed from separate MCC for ease of

maintenance and shut down. Motors of one technological unit will not be fed from MCC of other technological units. MCCsshall be conventional type in general.

3. Field located Power supply panels (MCB DB/ Local Starter Panels) shall be fed from LTPCC/MCC/PDB as per their load.

4. Fixed speed application LT Motors of rating **greater than 90 kW** shall be provided with independent Motor control Panel (MCP) which shall be fed directly from LTPCC. Power devices like MCCB, Contactor, Control transformers, shall be located in MCPs. Electronic type Over current relay (EOCR) with combined protection & display shall be provided. MCPs shall be located in MCC room.

5. Remote I/O (RIO) panels shall be provided near MCC area for communication with PLC.

6. For emergency loads as per process design/requirement, 2 Nos DG sets with AMF & emergency power distribution system shall be provided, unless otherwise specified in TS. For such emergency loads, emergency MCCs shall be provided with two incomers and one bus coupler. One incomer shall be fed from normal power and the other shall be fed from emergency power. Four pole MCCB/ACB shall be provided for incomers & bus-couplers having interface with DG source.

7. MPCB/ Motor duty MCCB, contactor and overload relay rating for the low voltage general purpose induction motors shall be selected as per type-2 coordination chart of selected manufacturer. However the minimum contactor rating shall be 25A. (AC-3 duty).

1.06 Outgoing Feeder Selection for MCC, Local Starter Panels, Local standalone Control Panels

1. **Power supply feeders** shall be provided with MCCB (microprocessor based with over current, short circuit & earth fault release).
2. **Motor feeders** shall be provided with Motor protection MCCB, contactor, overload protection device (Intelligent Motor Controller/EOCR/Thermal overload relay), and other auxiliary equipment like selector switch, indicating lamps, auxiliary contactors etc. as per requirement.

S.N.	Motor Feeder Panel type	Overload/Overcurrent Protection device
1.	Conventional MCCs	EOCR relay with combined protection and display
2.	Utility Panels & Local Starter panels	Thermal overload relay or above

MPCB/MCCB shall not be used for Motor overload protection.

8. **LT Motor starting and permissible voltage dips are to be considered as below:**

   a) Voltage dip on starting of the largest L.T. motor shall be limited to 15% of the nominal voltage at the motor terminals.

   b) Total voltage drop during running of a motor from LCSS to motor during steady state shall be limited to 6%.

   c) Voltage drop at the terminal of other equipment shall be as per the minimum voltage required for proper functioning of the equipment recommended by their manufacturers.

9. Inside Electrical panel, wires wherever laid in groups shall be neatly installed in FRLS material rack.

10. All electrical panels like HT panels, Drive panels, MCC panels etc shall have provision of heaters in panels to avoid condensation of moisture.

Substations and other requirements

All erection/installation accessories, cable trenches, cable support structures/cable gallery, cable termination at both ends, cable fixing, support materials etc. for all equipment within the plant area including cables from the nearby substation through a separate cable trench is within the scope of supply of Bidder.

The electrical distribution schemes will be subject to approval of purchaser/purchaser's consultants.

Miscellaneous items such as relays ,type of relays, relay ranges, number of poles for relays, scale of meters, CT ratios, links, fuses, switches, indication lamps, terminal blocks, auxiliary relays, timers associated with main relays , size of control cables shall be supplied as per the

approved scheme to achieve scheme requirements.

All CTs shall be of 1A secondary. Control cable from CT to panel shall be of 4mm^2 of copper.

All erection/installation accessories, cable termination, cable fixing, dressing, tag numbers, route markers, supporting materials for all equipment within the Plant area shall be part of the Bidder's scope.

The substation building shall be provided with cable cellar of 4mtr clear space. The substation premises main Switchgear Room shall be AC. The cable cellar shall be provided with proper pressurized ventilation system. The control room shall be provided with air conditioning facilities.

MCC shall have duplicate incoming supply. MCC will have Incomers and Bus-coupler as ACBs whose minimum rating shall be 630 Amps. There shall also be interlocking between two incomers and bus coupler of motor control centre so that only two can be ON at a time.

All outgoing feeders of PDB and further down below more than the rating of 20A shall be fed by MCCBs.

All MCCBs shall have Microprocessor based numerical releases for (minimum) over current, short circuit and earth fault releases. Auto Bus Transfer (ABT) scheme shall be provided for HT and LT substations using single microprocessor based unit capable of communicating with SCADA.

Power supply to miscellaneous loads like A/C, Power sockets, Welding sockets, Cranes etc shall be fed through dedicated ACDB/PDB.

For Substation auxiliary , SAS system, UPS ,Battery Chargers the LT power supply shall be fed from dedicated ACDB/PDB.

PDBs shall be two nos. ACB/MCCB incomer with bus coupler. All the PDBs shall have One incomer from normal power Supply and other incomer shall be fed from DG set power supply.

Motor space heater power supply shall be fed from respective MCC having 415/230V isolation transformer for this purpose. Space heaters will be interlocked with motor main power supply.

Base frame/ base channel/ base plate, if required for 6.6kV/415 V switchboards to flush them with FFL shall be under scope of Bidder. Similarly cross channels shall be provided by the

Bidder over cable trenches & floor cutouts for installation of these switchboards.

Earthing ring shall be provided around the shop. It will consist of earth pits and strip joining them.

Earthing grid of Compressed Air Plant area shall be connected to nearby plant grid in more than 2 places.

Lighting supply shall be derived through separate lighting distribution board (MLDB) which will be fed from LT switch board. It shall feed SLDB's and area lighting DBs of required capacities at required locations. Separate socket distribution board shall be provided to cater power sockets in CAS plant. Capacities and numbers of incoming/outgoing feeders shall be decided by the Bidder.
At building level power distribution board shall be provided. For admin and control building, panel with two incomer shall be envisaged to be fed from PV solar electric system.

Selection of components and cable size for MCCs shall be as per chart given in Annexure-I.

Bidder to submit a system wise drive list indicating process interlocks, permissive conditions for start and tripping etc. with places and mode of control for each drive, control system philosophy with provision of various control, indication, measuring devices at various places. This shall be approved by the purchaser. Based on above approved philosophy Bidder shall have to provide all equipment/materials and prepare a control scheme/logic diagram.

Above mentioned control philosophy and interlocking logic shall be prepared based on the technological requirement.

1.07 Relay Co-ordination and relay Setting Calculation

The relay setting calculation shall be carried out considering the following aspects

1. Fault level for upstream feeding end equipment shall be considered for relay setting calculation. This fault level value for the upstream feeding end system shall be obtained from state utility department during detailed engineering.
2. Relay co-ordination for all the breakers from the received of power from state utility is in the scope of the bidder shall be achieved. For that collection of data and network components from state utility shall be obtained from State Power Utility & necessary coordination in this regard shall be done by the successful bidder.

3. The relay setting chart with recommended settings, design calculation & graphs shall be submitted from the feeding end breakers of utility up to the incomer of the LT PCC & HT switchboard.
4. Beyond incomer of LT PCC & HT Switchboard up to the load, co-ordination shall be achieved by total discrimination between successive breakers through releases or Relay &fuses as applicable as per the TS of the respective equipment.
5. While selecting the release ranges and the tripping curves for the LT equipment, bidder shall ensure total discrimination between the successive breakers during overload, short circuit and earth fault.

1.08 Mitigation of Harmonics in system design

The Power distribution system shall be designed such that the system complies with harmonic values as stipulated under IEEE -519:2014. Accordingly the value of Total Harmonic Distortion(THD) and Total Demand Distortion (TDD) for voltage and current harmonics shall comply with the standard Table-1 & Table-2 as mentioned in IEEE – 519 respectively.

1.09 Colour coding of Electrical Equipment

S N.	DESCRIPTION OF EQUIPMENT	COLOUR	PAINTSHADE (RAL CODE)
I.	**POWER DISTRIBUTION EQUIPMENT**		
1.	HT isolator	Traffic Grey A	7042
2.	Transformer	Squirrel grey	7000
3.	Bus-duct	Light grey	7035
4.	Power Control Centers (PCC)	Light grey	7035
II.	**MOTORS**		
1.	HT motors	Traffic Grey A	7042
2.	415V LT AC motors	Silver Grey	7001
3.	Inverter duty Motors	Dark Grey	7030

S N.	DESCRIPTION OF EQUIPMENT	COLOUR	PAINTSHADE (RAL CODE)
III.	**MOUNTED ELECTRICS**		
1.	Equipment installed on or along with motors viz. Tacho generators, brake etc.	Same as that of motor	
2.	Equipment installed on mechanism but separate from motor viz. Limit switches, pull chord switches, belt sway switches, speed switches, load cells, photo electric relays etc.	Traffic Grey A	7042
IV.	**CONTROL GEAR**		
1.	VFD panels, UPS panels, Automation system panels, Relay panels, Weighing controller panel, TR controller panel, HT MCC, HT VCB, MCC, PDB, MLDB, MCP, Soft starter, LDB etc. including crane control panels	Light grey	7035
2	Lighting distribution and power distribution board	Light grey	7035
3.	Fire fighting panel	Carmine Red	3002
4.	Local control box, Junction box	Traffic Grey A	7042
5.	Control desk	Light grey	7035
6.	Pulpit equipment	Light grey	7035
7.	Telecommunication panel	Blue grey	7031
V.	**MISCELLANEOUS EQUIPMENT**		
1.	Junction boxes	Traffic Grey A	7042
2.	Conduit/pipe pull boxes	Traffic Grey A	7042

S N.	DESCRIPTION OF EQUIPMENT	COLOUR	PAINTSHADE (RAL CODE)
3.	Light fittings	Traffic Grey A	7042
4.	415 V Welding sockets	Grass green	6010
5.	230 V Power sockets	Yellow orange	2000
6.	24 V transformer sockets, lamp sets etc.	Sulfur yellow	1016

1.10 6.6 KV VFD feeder with bypass arrangement for HT compressor:

In the 6.6 kV HT Switch Board For Each Compressors including 3 nos working and 1 no Standby shall have One VFD feeder and one By pass DOL feeder which shall be used for Motor Starting and Running. The 6.6 kV HT Switchboard VFD feeder shall be worked as Power Supply Feeder and the By Pass DOL feeder shall act as DOL feeder and relevant motor protection shall be part of the feeder during DOL operation.

During VFD operation the necessary Protection, Metering and Annunciation shall be part of VFD panel .

The Compressor Motors shall be Suitable for **Inverter duty** and it shall also be capable to **withstand Starting Current and Running current during DOL operation** .

In addition to the 6.6 kV VFD with Bypass 6.6 kV DOL feeder the Off Load HT Isolator panels consisting of Double throw & Single throw Isolators shall be there . The OFF Load Isolators shall be rated minimum 630A ,25 kA for 3 Sec with Copper Bus bars. Necessary Control Protection ,Indications shall be part of the panel/system. Through this Off Load Isolators panels the changeover flexibility shall be obtained during not working of Compressor-1,2&3 VFD & BY PASS DOL.

The detailed scheme through a Electrical SLD sketch (Drg No MEC/11/E1/23UU/TS/SKETCH 1 of 1 Rev 1) has been explained .

1.11 Spares Philosophy

The spare philosophy for various equipment shall be as follows:

1. LTPCC shall be provided with **minimum four (two in each section covering minimum & maximum rating) or 20%** spare feeders whichever is higher.

2. MCC, PDB, ACDB and MLDB shall be provided with **20%** spare feeders or one of each type/ratingwhichever is higher with minimum of two numbers in each bus section.

3. LDB, SLDB (or MCBDB) for lighting and utility sockets shall be provided with minimum 30% of spare feeders or nine numbers, whichever is higher.

4. ACDB of UPS shall be provided with 40% spare feeders.

5. 20% spare terminals shall be provided in each module of MCC, MCP and each ACB panel.

6. 20% spare terminals shall be provided in all junction boxes, LCS and local control panels / local starters.

7. Control desk and control cabinet shall be provided with 30% spare terminals.

8. Marshalling panel of MCC and PLC shall be provided with 20% spare terminals.

9. Relay panels / relay modules shall have 20% spare relays of each type fully wired up to the terminal blocks.

10. 20% spare interposing relays fully wired up to the terminal blocks shall be provided in all type of Control& Controller panels.

11. 10% spare components of each type shall be provided in each control desk/control cabinet / signaling panel.

12. Spare I/O philosophy for any Controlleror SAS system shall be as follows:

- Min. of 20 % of I/O modules used (with at least one module of each type) for input and output shall be offered as spare for each IO Panel of programmable controller and the same shall be mounted and wired to the terminal block in the cubicle suitably.
- No. of spare Channel per card shall be 20 %.
- Provision shall be provided with empty slots for future expansion for 20% I/O modules.

- Minimum 50 % spare memory capacity shall be available in the system for Purchaser's use after loading of application and system software.

13. The over head cable bridge/trenches shall be designed considering future cable laying and shall have 20% spare space for installation of future cable trays.

1.12 Selection of Cables

1.12.01 General

1. All LT power cables shall be 3.5 / 4 coresXLPE. All HT Power cables shall be 3 core XLPE cables.
2. Lighting cable from SLDB to light fitting JB shall be XLPE/PVC insulated. From JB to fitting the cable shall be PVC insulated.
3. Minimum size of the cables used in LT power feeders shall be 6sq.mm for aluminium conductor and 4sq.mm for copper conductor.
4. Maximum cable size shall be 240sq.mm for LT Application.
5. The minimum cable size selected for applications in the power circuits of cranes and other moving mechanisms shall be 4sq.mm with copper conductor. For brake power supply, minimum size shall be 2.5sq.mm copper.
6. Flexible copper cables shall be used for power supply to vibrating mechanisms &Power Junction Boxes shall be provided to terminate the flexible cable.
7. For hoists, shuttle conveyors, plough feeders etc shall be provided with flexible / festoon cable system, through EPR insulated, PCP/CSP sheathed flexible cables.
8. Cables used for circuits of brakes, solenoids, field windings and secondary windings of measuring transformers shall be copper conductor with cross-sectional area not less than 2.5sq.mm. For Tacho generators, screened cables of minimum 1.5 sq.mm copper shall be used.
9. Cables used for control circuits of Local control stations, limit switches, belt protection switches, proximity switches, PLC DI/DO, PVC insulated and PVC sheathed multicore cables with stranded copper conductors having a minimum cross-sectional area of 1.5sq.mm shall be used. The number of cores may be standardized as 3, 5, 7, 10, **12**, 14, 19, and 24.

10. Recommendation of OEM of Variable Frequency Drives shall also be considered while selecting Cables and shall be provided as per IEC TS 60034-25:2014 as per requirement
11. Special screened/shielded cables with minimum 1.5 sq.mm copper shall be used for mA and mV signals. For Load cells, Junction box to Control panel, minimum 1.0sq.mm un-armoured, special/screened cable in GI conduits shall be used.
12. Minimum 20% spare cores shall be provided in multi-core control and signal cables
13. For calculating the current rating of LT power cables de-rating factor of 0.65 shall be considered.

1.12.02 HT Cable sizes for LT sub-station transformers/Power supply Feeders

The cable size shall be calculated based on the withstand capacity of cable at design short circuit rating considering breaker opening time of 0.25 seconds. However, standard size of cable shall be 240sq.mm aluminium unless specified otherwise in TS.

1.12.03 Cable for Incomer of MCC / PDB / MLDB/MCP

1. Cable size for incomer of MCC & PDB shall be selected on the basis of current rating corresponding to MD including spare and voltage drop.
2. Cable size for incomer of MLDB shall be selected on the basis of current rating corresponding to lighting transformer and voltage drop.
3. Minimum size of cable shall be 185sq.mm aluminium& maximum size shall be 240sq.mm aluminium.
4. Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.

1.12.04 Cables for LT & HT Motors

1. Cable size for HT motors shall be selected on the basis of rated nameplate current, starting & running voltage drop as specified below and withstand capacity at design short circuit rating of the system considering breaker opening time of 0.25 seconds.

2. However, standard size of cable shall be 240 sq.mm aluminium.
3. Cable size for LT motors shall be selected on the basis of rated nameplate current and starting & running voltage drop. For limitation on account of voltage drop refer clause 1.08 above.
4. However, minimum size of Cables for LT motors has indicated in Annexure-1A
5. For LT motors of rating 110 kW & above, Power JB shall be provided near the motor. From power JB, flexible copper cable with one lower size as indicated in Table-1A shall be used.

1.12.05 Cables for Illumination System

1. The minimum size of the cable for feeding incoming power to SLDB or MCBDB having 32A / 63A incomer shall be 4Cx25sq.mm / 4cx50 sq mm, aluminium.
2. Cable size for SLDB (or MCBDB) to light fittings shall be 3x2.5sq.mm. 3rd core shall be used for earthing.
3. In case of concealed wiring for light fittings & sockets 5A rating, single core, FRLS, PVC insulated, stranded copper conductor wire of size 2.5 sqmm in GI conduit shall be used. For utility sockets of rating 15A, AC point wiring, light point Switch boards, minimum cable size shall be 4sq.mm copper in MS conduit shall be used for concealed wiring.

1.12.06 Cables for Automation System

1. All Cables connecting I/Os from field to PLC or remote I/O panel shall be of stranded copper conductor of type YRY as per IS: 1554 and of size minimum 1.5 sq.mm.
2. Communication bus/cables, FO communication cables shall be laid in GI pipe. Separate GI pipe shall be used for each communication bus/cable & FO cable. The route for redundant communication bus/cables, FO communication cable shall be different.

1.12.07 HT Power Factor Compensation System

6.6 kVHT Power Factor Compensation system final rating shall be designed after finalization of all HT /LT loads. Total 6.6 kV HT Power factor Compensation System (MVAR/kVAR) shall be designed considering the following philosophy.

In 6.6 kV total Power Factor Compensation system shall be splitted in Two equal size for Section-1 & section-2 . For Example Total Compensation System 1600 kVAR then it shall be splitted 800 kVAR in Section-1 & Section-2 of Switchboard.

1.13 For PLC interfacing

Required control, metering and indications required from HT Switchboard & LT Switchboard shall be done through Software or hard wired.

Adequate numbers of CT- PT outputs and potential free contacts including aux. relays and aux. CTs shall be provided for this purpose.

Total running hours for all the HT motors shall be made available in PLC.

Local/remote section shall be realized in PLC for all the HT motors and big critical LT motors.

The Philosophy shall be finalized finalized during detailed engineering stage. Bidder shall include complete wiring from breaker contacts, contacts of aux. relays, and contacts of trip relays for all the HT/LT motor feeders to provide control & annunciation in DDCMIS as well as to control panels for Compressors

It shall be possible to know tripping of all the 6.6 kV feeders and status of voltage, frequency, current, etc. prior and just after the tripping. Scanning time shall be selected between 0 and 3 seconds. It shall also be possible to take a print out of above parameters and recording of disturbances. It shall be possible to generate report for weekly, monthly and yearly generation and shift-wise alarm/trip events with date and time display.

Required transducers and wirings to hook up all above analog and digital inputs and outputs shall be included in the scope of the Bidder.

Actual number of inputs/outputs to/from DDCMIS shall be finalised during detailed engineering stage. Transducers shall be of dual out put type.

1.14 <u>Clearances, approaches, stairs& exits</u>

1. Clearances inside the electrical rooms shall be as below:

S.N.	Description of Space / Clearance	Min. Space (in mm)
1.	Back clearance of a Single front panel	1250
2.	Front to front clearance between drawout/ semi- drawout panel boards	2500
3.	Between two panel boards installed in a row	1000 (For similar small panels it can be 200)
4.	Between front of the panel to the wall of the room	2000
5.	Between the wall and end of the switchgear/MCC	1000
6.	Back to back clearance	1500
7.	Back to front clearance	2000
8.	Between the bottom of the ventilation duct and top of the electrical equipment	1000

2. The height of rooms housing 415V LT Switchgear/PCC, HT Switchboard shall be decided considering sufficient clearance between panel top to various ducts (Ac,Ventilation), MVWS pipes etc. However, for such rooms minimum 4.5mtr clear height shall be provided. For MCC rooms, VFD rooms, RIO rooms, Control rooms provided with air conditioning system, clear gap between tallest panel top to bottom of false ceiling shall be 1.0 mtr (minimum).

3. The clearance between the ceiling of the electrical room (room without false ceiling) and top of the tallest equipment shall not be less than 1.0mtr where the equipment are to be maintained from top and additional height of lifting tackle wherever required.

4. In all rooms, 20% spare space shall be provided for installation of future panels.

05.03. TECHNICAL SPECIFICATIONS OF MAJOR EQUIPMENT

05.03.01 33 kV SWITCHYARD EQUIPMENT (MAJOR)FOR INTERCONNECTING WITH APDCL ADJACENT MRS SWITCHYARD

A) 33 kV Outdoor Switchyard equipment

a) For the connectivity with APDCL/State Utility outdoor Switchyard (Which shall be constructed on Deposited Basis inside plant premises) ,the requiredDouble/Multi pole Rail Structures, 33 kV manual/electrically operated isolators, manual earth switches, , LAs, Structural posts, Conductors, Cables, Insulators etc. as required for the switchyardis in the bidder's scope. The Fencing ,Approach roads, Gravel filling or PCC flooring &earthing lightning protection ,external Illumination etc are also in the scope of bidder.

b) Outdoor equipment shall be suitable for service under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to growth of fungi and mildew. Indoor equipment in non-air conditioned environment shall also be designed for same conditions.

c) All outdoor equipment colour shall be of shade 697 as per IS:5, while indoor equipment shall be shade 631 of IS:5

B) 33 KV Isolator/ Disconnecting switches

The isolator shall conform to the latest edition of IEC 129 / IS 9921 or other equally reputed national or international standards.

The isolator shall be triple pole gang operated (double break in horizontal execution)suitable for outdoor installation in open yard under the specified site conditions. The earth switches, wherever provided, shall be constructionally interlocked so that the earth switches can be operated only when the isolator is open and vice versa. The isolator shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation. There shall be necessary electrical interlocking between the earth switch & isolator in addition to the mechanical interlocking and interlocking between the breaker and isolator, so as to ensure that the isolator is not operated in breaker closed position and other such similar interlocking as mandated by DGMS.

C) Lightning Arrestor (LA)

The lighting arrestor shall conform to the latest edition of IEC 99-4 or other equally reputed national or international standards.

The LA shall be station class, heavy duty, non-linear resistance, type gapless (without any series/ shunt gaps), and hermetically sealed lightning arrestor, outdoor type suitable for installation in open yard/four pole structure.

The LA shall be designed to provide maximum protection against lightning and switching surges. The Surge Arrestor shall be suitable for duty cycle of circuit breaker in the system and shall be capable of discharging over-voltages occurring during switching of unloaded transformers, reactors and long lines.

All other Equipment (i.e Rail Pole, Conductors ,Tubular Bus tubes Clamps connectors, insulators etc for Switchyard as required shall be considered as per State Utility/ REC standard specification and to establish the Grid Connectivity.

05.03.02 HT SWITCHBOARD (INDOOR)

33 kV CICO Switchboard & 6.6 kV Switchboard

1.0 TECHNICAL PARTICULARS AND DESIGN PARAMETERS

Sl. No.	PARTICULARS	HT SWBD	
1.	Type	Metal Enclosed, Floor Mounting, Free standing, natural air cooled type	
2.	Service	Indoor	
3.	Enclosure IP	IP4X or better	
4.	Standard		
	i) Switchboard	IS/IEC 62271-1,IS/IEC 62271-200 & IEC 60694	
	ii) Circuit Breaker	IS/IEC 62271-100	
	iii) Vacuum Contactor	IEC 62271-106	
	iv) Instrument Transformers	IEC 61869- 1, 2, 3	
5.	Nominal system voltage (kV)	6.6	33
6.	Max. system voltage (kV)	7.2	36
7.	Power frequency withstand voltage (kV) rms for 1 minute	20	70
8.	Peak impulse test withstand voltage (kVp)	60	170

Sl. No.	PARTICULARS	HT SWBD
9.	No. of phases and frequency	3ph. 50 Hz
10.	Design Ambient	50 Deg C
11.	Design Altitude	As mentioned above
12.	DC Control Voltage	110 V DC
13.	Spring charge motor voltage	240 V AC
14.	Aux supply voltage	230V AC
15.	Control voltage for 2nd trip coil	From UPS, as per UPS voltage
16.	Busbar	
16.1	Bus Color code	RYB
16.2	Busbar Material	Electrolytic Grade Copper
16.3	Busbar Rated Current	Next higher standard rating as per the calculated load requirement
17	Internal Arc withstand duration for rated short circuit rating, AFLR	1 sec
18	System Earthing	Solidly Earthing for 33 kV Resistance Earthing for 6.6 kV
19.	Circuit Breaker	
19.1	Continuous Current Rating	As per the load requirement fulfilling short circuit requirement
19.2	Short Circuit Rating	25 kA for 3 Sec 40 kA for 3 Sec
19.3	Rated making Current	2.5 times the Short circuit rating
19.4	No of trip coils	Two (2)
19.5	Duty cycle	O-0.3s-CO-3min-CO
19.6	Duty class	E2, M2 & C2
20.	CT Ratio	Secondary Current 1A (Primary as per design & load)

Sl. No.	PARTICULARS	HT SWBD
21.	Potential Transformer	
21.1	Configuration for resistance earthed/ Unearthed	STAR/ STAR/ STAR/ Open Delta
21.3	Ratio	(HT/√3) / (0.11/√3) / (0.11/√3) / (0.11/3)
21.3	VA Burden	Actual as per the calculation during DE. 50% loading to be considered.
21.4	Accuracy	0.5/ 3P/ 3P
22.	Control & auxiliary supply changeover scheme	Auto with Manual provision
23	Type tests to be conducted, if any	Type TC for same rating and similar design panel to be submitted.
24	Clearance in air	As per IEC / Type tested design unless specified otherwise
25.	Control & Relays location	Mounted on LV chamber of breaker panel, unless specified otherwise.
26.	Termination requirement	Cable from bottom
27.	Requirement of Base Frame and height	To be provided, factory build, 40mm height
28.	VCB type (Floor rolling trolley mounted or cassette type)	Floor rolling trolley mounted
29.	Requirement of Uniform depth	All feeders in one switchboard shall have same depth.
30.	Type of earthing provision – Earthing truck/ Integral earth switch	Fault making type, to be considered as specified in TS
31.	Numerical Relay port- RJ45(Copper) or FO	FO Ports, 2 Nos, PRP compliant
32.	Surge Suppressor requirement	To be provided in all feeders
33.	Requirement of Withdrawable bus link panel	Required in the bus riser panel

Sl. No.	PARTICULARS	HT SWBD
34.	Requirement of Voltage Presence Indicator (VPI)	Required. To be provided with indication and PFC for interlock
35.	Gland plate thickness	For 3 core cable – 3.0mm CRCA For single core cable – 5.0mm AL

2.0 General Requirement

1) The switchboard shall be of metal clad, single busbar, self standing, indoor cubicle type, fitted with Vacuum circuit breakersin fully draw out execution.

2) The circuit breaker used in the panel shall be fully type tested as per latest applicable in IS/IEC standard.

3) The panel shall be internally arc compliant (IAC) tested for AFLR configuration in line with IEC 62271-200 for the specified rating and duration. Type test report for the same shall be submitted during drawing approval stage.

4) The panel shall be constructed with CRCA sheet steel or Aluzinc sheet steel. For Aluzinc construction, doors and covers shall be painted as per the approved colour. For CRCA construction, complete panel shall be painted. The sheet steel thickness shall be as per the IAC & IP type tested design.

5) The cubicle shall be provided with a position changing arrangement to move the breaker truck and change position from outside without opening the cubicle door. Facilities for pad locking in each position shall be provided.

6) All circuit breaker trucks of same rating shall be identical in all respects and shall be interchangeable with similar breaker panel. However, it shall not be possible to insert circuit breaker of lower current rating into cubicles of higher current rating.

7) All circuit breakers in the particular project shall be of same make, model & design expect for the continuous current rating.

8) Manufacturer of the HT switchboard panel shall be same as the manufacturer of Circuit Breakers.

9) Where lockable local/remote selector switch is called for , it shall be ensured that:

i) The breaker can be operated locally only if the breaker truck is in the test position and the local/remote selector switch is in local position.

ii) The breaker can be operated from remote panel (in shop) only when the breaker truck is in service position and the local/remote selector switch is in remote position.

iii) The breaker can be tripped locally regardless of the position of the breaker truck or local/remote selector switch.

3.0 Mechanical Design

1) Each cubicle shall be of sheet steel clad, floor mounted, free standing design, compartmentalized construction confirming to loss of service continuity of LSC2B and shall have separate compartments for VCB, bus bars, CTs and outgoing cables and metering & protection devices.

2) Each HT compartment shall be isolated to confirm to internal arc compliance requirement.

3) Switchboard shall be extensible on both sides.

4) Minimum panel width shall be 800 mm upto 11kV switchboard

5) All supporting insulators in bus chamber shall be easily accessible with detachable covers for easy replacement.

6) CTs shall be located in such a way that that they are easily accessible from rear of the panel.

7) Removable lifting arrangement for each transport unit shall be provided.

8) Doors shall be provided with padlocking provision and the door shall not be forming part of the draw-out truck

9) Separate back covers with handles shall be provided for bus chamber, and cable chamber. The back cover shall be necessarily in two parts for easy handling.

10) Independent explosion vent shall be provided for each HT compartment i.e CB chamber, bus chamber, cable chamber to comply to the internal arc requirement

11) Earthed metallic barriers between compartments and between vertical sections of adjacent panels shall be ensured.

12) Control cables entry shall be from bottom and on front side.

13) Screw wire mesh in the power cable chamber of incoming & outgoing feeders shall be provided.

14) Suitable slotted channel shall be provided in the cable chamber for clamping the cable for support.

15) The controls, indicating lamps, relays and meters shall be mounted on breaker panel in separate control cubical and shall be mounted for uniform appearance.

16) A manually operated device shall be provided to enable manual charging of closing springs.

17) Manual / Mechanical tripping arrangement shall be for each cubical for emergency tripping of CBs.

18) Mechanical and electrical Anti pumping feature shall be provided for all breakers

19) Each switchboard cubicle shall have mimic diagram in the front and rear of the panel. This shall be painted. Colour of strip shall be finalized during detailed engineering. Mimic shall be 10mm wide for busbars and 7mm wide for others. Stickers are not acceptable.

20) Continuous earth bus shall be provided throughout the board.

21) The position of various control switches, push buttons, levers etc requiring manual operation shall be at a height not less than 450mm and shall not exceed 1850 mm.

22) The Phase – Phase and Phase – Earth clearances shall be as per the type tested design unless specified otherwise.

23) CT/PT ratio and class, breaker rating, BIL should be marked on anodized AL plate label and shall be provided at rear of each switchgear panel.

24) Each control cubicle shall have 5-15A, 240V switch with 6 pin socket, space heater with thermostat, protection MCB, door switch operated LED illumination lamp.

25) CB & Cable compartment shall be provided with separate space heater & separate thermostat with common Ammeter of 48 sqmm size and MCB.

26) `Bus link' truck cannot be withdrawn with the buscoupler in `Service' position.

4.0 Main Bus Bar and Connections

1) Power buses of EC grade aluminium alloy equivalent to 63401 range 2 as per IS-5082 –1981 or high conductivity electrolytic grade copper as per IS : 613-1984 as per technical particular. The bus bars shall be silver plated at joints.

2) The busbars (horizontal as well as vertical) shall be insulated by heat shrinkable, non tracking, low absorption type **full voltage insulation grade sleeving confirming to** International standard.

3) Reusable removable shroud of full voltage insulation grade shall be provided at all joints in busbar chamber.

4) The continuous current rating of the main horizontal bus shall not be less than the rating of the incomers, unless specified otherwise.

5) The vertical bus rating

For incomer	:	Not less than that of horizontal bus
For outgoing	:	Not less than that of the outgoing breaker, irrespective of relay setting or CT ratio.

6) Jumpers in cubicle shall be of same current rating as breaker.

7) Final operating temperature under continuous operation in enclosure shall be limited as per IEC62271-1 considering the given design ambient temperature.

8) Both horizontal and vertical bus bars to be designed and supported to withstand the thermal and dynamic stress corresponding to rated short time and peak withstand current specified.

9) Cross-section of main horizontal bus to be uniform throughout the switchboard.

10) Busbar coding shall be done as specified in technical particulars. Phase identification by color in each panel shall be done.

11) Bus bar joints and tap off connections of bolted type with type of bolts as per the short circuit type tested panel.

12) Busbar supports shall be provided as per the short circuit type tested design. Bus bar support of non-hygroscopic material having high impact and dielectric strength with an anti tracking contour shall be used.

5.0 Auxiliary Buses for Control Supply

1) Control supply buses for AC and DC

2) PT secondary voltage bus

3) UPS bus as applicable as per the technical particulars

4) These busses shall be either through wires of suitable size or electrolytic grade tinned copper busbar as per the technical particulars.

6.0 Control & Auxiliary Supply

1) Control & Auxiliary supply buses shall run throughout the switchgear.

2) Two numbers DC incoming feeder shall be taken in each switchboard controlled by MCB's. Failure of any DC supply shall be monitored & annunciated in the switchboard as well as PFC for remote annunciation shall be given.

3) Two numbers AC incoming feeder for auxiliary supply shall be taken in each switchboard controlled by MCB's. Failure of any AC supply shall be monitored & annunciated in the switchboard as well as PFC for remote annunciation shall be given.

4) Wherever UPS bus has been specified for 2^{nd} trip coil, two numbers UPS incoming feeder for 2^{nd} trip coil shall be taken in each switchboard controlled by MCB's. Failure of UPS supply to switchboard shall be monitored & annunciated in the switchboard as well as PFC for remote annunciation shall be given.

5) Each feeder panel shall have one MCB each for controlling its AC & DC supply.

6) Sub circuits shall be protected with MCB in each feeder panel for indication lamps, closing circuit and tripping circuits separately.

7) Auto changeover feature and manual changeover option shall be provided for both AC & DC aux supply using timers and contactors and auto-manual changeover selector switch, unless specified otherwise.

7.0 Internal Control Wiring

1) Control wiring shall be carried out by 1100V grade FRLS PVC insulated, single core multi stranded copper wire of minimum cross section 1.5 sq. mm except for CT circuits which shall be 2.5 sqmm.

2) Wire from CT chamber to relay chamber shall be run in heatproof earthed metallic flexible conduits to have protection against heat & mechanical damage due to flash over in HV chamber.

3) Wiring and terminal arrangement for all panels shall be carried out as per approved scheme.

4) Flexible wires protected against mechanical damage for wiring to door mounted devices shall be provided. No bunch of wire shall contain more than 12 wires.

5) Wires identified at each end in accordance with schematic diagrams by printed type ferrules.

6) All connections external to a feeder, all the auxiliary contacts of the breaker shall be brought to terminal blocks.

7) Interconnection between panels of adjacent shipping sections to be brought out to a separate terminal block.

8) Wiring shall not be joined or tied between the terminal points.

9) Not more than two connections shall be provided on any one terminal.

10) All spare contacts shall be wired to TB.

11) All telemetering signals shall be wired to separate set of terminal strips.

12) All internal control wiring shall be terminated with **round lugs only.**

8.0 External Terminations

8.1 Control Terminations

1) **800V grade** stud type terminal blocks made of polyamide material (STH4 of connectwell or OAT6 of Elmex or Equivalent), washers, nuts and identification strips shall be provided.

2) All terminals going out of the switch board shall be brought to a separate terminal block marked "External Termination". These will be easily accessible. Terminal blocks in separate groups shall be provided for SCADA/ Automation, remote control panels, transformer marshalling boxes, local push button stations, etc.

3) External terminal block shall be provided in the relay chamber with proper truff arrangement for cable dressing. Terminal blocks shall be placed separately for internal looping and external looping.

4) All CT and PT wires shall be first brought to disconnecting type TBs.

5) All metering CT-PT wires shall be brought to test terminal blocks before connecting to circuits.

6) Overall 20% spare terminals in each feeder shall be provided. The spare terminals shall be distributed appropriately during design stage.

7) Gland plate for control cables shall be of adequate size to accommodate and to facilitate glanding of all the control cables coming from external equipment.

8.2 Power Terminations

1) Suitable for accepting cable/bus trunking as specified/ required.

2) Sufficient space and support arrangement inside each panel to accommodate HT cable termination kits and sealing kits suitable for the size and number of XLPE cables.

3) Minimum height of termination point from gland plate shall be 900mm for 33kV switchboard and 600mm for 11kV and below switchboard.

4) Rear extension is not permitted, unless specified otherwise. Dummy panels shall be provided adjacent to the feeders, where the required number of cable terminations cannot be accommodated in the cabling chamber of the feeder.

5) Where more than one cable have to be terminated per unit, the arrangement shall permit connection and disconnection of cables separately without disturbing other cables.

9.0 Earthing Devices

1) Either integral earthing switch or separate earthing truck shall be provided to facilitate earthing of busbars and any feeder circuit.

2) The earthing truck shall have making capacity same as associated switchboard having annunciation, indication and interlock scheme. Alternatively, front operated mechanically interlocked earthing switch with making capacity same as associated switchboard shall be provided.

3) Earthing truck shall have PT and alarm provision. Minimum 1 no. earthing truck for feeder earthing and 1 no. for busbar earthing shall be provided for each board unless specified otherwise. It shall not be possible to use bus earthing truck for feeder earthing and vice-versa. In case more number of earthing trucks are required due to different width of panel, same shall be provided.

4) Wherever an integral earth switch is provided, it shall be possible to switch on the earthing switch only when the breaker truck is in the isolated position.

5) Interlock provision shall be there so that incomer can not be closed if bus earthing device is connected.

6) Indicating lamps shall be provided for status of earth connection, on all outgoing feeder for “Feeder earthed” and on incomers for “Bus earthed”.

7) Suitable sheet steel enclosure shall be provided for covered parking of earthing trucks within the substation building.

10.0 Protective Earthing

1) Continuous earth bus of minimum size 50x6 and meeting requirement as per IEC 62771-200 cl 5.3.2 made of copper, designed to carry the peak short circuit and short time fault current as specified for the switchboard.

2) Provided at the bottom extending throughout the length of the board, bolted/brazed to the frame work of each panel with an earthing terminal at each end for terminating external earth conductor.

3) All non-current carrying metal work (including metallic cases of instruments and other panel mounted components effectively) bonded to the earth bus.

4) Hinged doors earthed through flexible multi-stranded insulated copper wire.

5) Looping of earth connection resulting in loss of earth connection to other devices when the loop is broken not permitted. No looping is allowed for connection of multiple components to earth bus.

6) Withdrawable units provided with self aligning, spring loaded, copper earth contacts of make before/break after type, ensuring earth continuity from service to the test position.

11.0 Protection Requirement

11.1 Electrical Protection

Selection of protective scheme will be based mainly on reliability, sensitivity, selectivity. All main protections shall be fast acting type in order to clear the faulty system from the healthy system in earliest possible time to minimize damage to equipment and ensure continuity of power supply.

11.2 Protective scheme requirement

1) Protective relays shall be provided as per the specified protection for each type of feeder . All relays shall conform to the requirements of IS:3231 / IEC-60255 / IEC 61000 or other applicable standards

2) All protective relays shall be of **microprocessor based numerical type** and shall comply to IEC 61850 standard, Edition-2 for communication. Further, the test levels of EMI as indicated in IEC 61850 shall be applicable. The relays shall

generate GOOSE messages as per IEC 61850-9-2 standards for interlocking and also to ensure interoperability with third party relays. Each relay should also generate an ICD file in EXCEL format for engineering/ integration to a vendor independent SCADA/ Automation system.

For protective relays, the scope shall include the following:

a) Necessary software and hardware to up /down load the data to/from the relay from/to the laptop loaded with all necessary software.

b) Incomers, Buscouplers and all outgoing feeders shall be provided with relay having Graphical Display unit.

c) The relays should have front and rear ports for communication e.g. Front network port for local communication for relay settings, modifications, extraction and analysis of fault/event/ disturbance records from a laptop and a Rear fiber optic/ Copper port on IEC61850 standard for remote communication to SAS system.

d) The relays shall have the following tools for fault diagnostics

1. Fault record: The relay shall have the facility to store fault records with information on cause of trip, date, time, trip values of electrical parameters.
2. Event record: The relay shall have the facility to store at least 1000 time stamped event records with 1ms resolution.
3. Disturbance records: At least 30 secs of disturbance records with 12 recording shall be provided in the offered Numerical relays. Each record shall store data from all the analogue channels, at least 10, used in the relay for protection and at least 32 digital channels. The data from DR function shall be available in IEEE format.

e) All relays shall be flush mounted in dust proof cases and shall be mounted on front fascia of control cubical.

f) All protective relays shall be in draw out or plug-in type or with plugin terminals, modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in scope of supply.

g) Complete signals from / to SCADA/Automation shall be routed through numerical relay. Relay shall be selected accordingly so that Number of IO's confirm to this requirement. Scheme shall be suitable for complete remote control & operation of the feeder through relay. For open and close command from SCADA/ Automation through relay shall be routed through aux relay to

the trip/ close coil. Direct trip/ close coil switching through BO is not permitted.

h) Number of BI/ BO shall be decided as per the system requirement in line with the above specification however minimum 20 BI & 10 BO shall be considered in all the relays.

i) Protective relays shall have LED indicating lamp to indicate operation of relay and type of fault.

j) Protective relay shall have facility to filter out inrush currents so that lower setting for short circuit protection could be utilized

3) The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided.

4) Relay ranges, exact type & number of aux. relays, timers shall be finalized during drawing approval stage. Further requirement of aux relays shall be as follows:

a) All timers and Auxiliary relays shall have flag indicators.

b) Each feeder will be provided with master trip relay. Master trip relay shall be hand reset and shall have 2 NO and 2 NC contacts wired to TB in addition to those required by the protection/control scheme.

c) All protective relays and Aux relays shall be provided with at least one extra isolated pair of contacts wired to terminals exclusively for future use.

d) VAA type/ Equivalent aux. relays shall be provided for each transformer fault and each external signal interface except emergency stop PB signal.

e) Various protections/ tripping coming from external source to a feeder shall be connected to master trip relays through aux. relays with flags.

f) For contact multiplication of circuit breaker, only bi-stable aux relays shall be used.

g) Trip circuit supervision shall be provided for each trip coil of the circuit breaker.

5) All AC operated relays shall be suitable for operation at 50 Hz AC. Voltage operated relays shall be suitable as per the provided PT secondary voltage and current operated relays for 1 amp CT secondary unless specified otherwise. All DC operated relays and timers shall be designed to operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

6) Independent timers, where applicable, shall be of solid state type.

7) Contact arrangement, number of poles/ways in control/selector switches shall be finalized during drawing approval stage.

8) Each incomer/ tie feeder shall have provision to receive inter trip from the other end feeder. Each outgoing feeder shall be provision to give inter trip signal to the downstream feeder.

The details of protection requirements shall be as given below for each type of feeder of 6.6 kV Switchboard**.** This shall be utilized to finalize the protection requirement during detailed engineering.

Sl No	Type of feeder	Protection
1	Buscoupler	• Over-Current and Earth fault (50, 51, 51N, 50N) • Check Sync Relay (25). • High speed tripping relay, close & trip circuit supervision relay, aux relays, time delay as required. Composite protection relay for ABT scheme.
	Incomer	• Over-Current and Earth fault (50, 51, 51N, 50N). • Fuse failure protection of line PT (97) (for alarm). • Check Sync Relay (25). • Non direction power flow (67, 67N). • High speed tripping relay, close & trip circuit supervision relay, aux relays, time delay as required. • Stand by earth fault relay (51G) for transformer.
2	LinePT/ Bus PT	• HT Fuse on primary • Relays for use in interlock of other feeders,incomers&buscouplers • MCB on secondary • Under voltage (27) with timer & Over voltage (59) with timer • Fuse Failure (97) (for alarm) * Neutral displacement relay (60) * Line PT/Bus PT protection Relay may be mounted in Incomer &Buscoupler panel .it shall be decided during DE

Sl No	Type of feeder	Protection
3	Outgoing Transformer feeder / Converter Transformer	• Over-Current and Earth fault Protection (50,51,51N,50N) • Sensitive earth fault protection (50G) with CBCT • Flagged aux relays for transformer faults • High speed tripping relay, close & trip circuit supervision relay, aux relays, time delay as required. • Provision of inter-trip from downstream switchboard. • Dedicated Stand By Earth Fault Relay 51G if it's not available in LT side Switchboard • Dedicated Trafo differential protection relay (87T) (wherever applicable).
4	Outgoing Power Feeder	• Over-Current and Earth fault Protection (50,51,51N,50N) • Sensitive earth fault protection (50G) with CBCT
5	Motor Feeder (If applicable)	• Motor Protections composite (99) which includes ▪ Thermal Overload (49) ▪ Unbalance –asymmetry(46) ▪ Loss of load/ Under power (37) ▪ No of start protection (66) ▪ Stalled protection(51LR) ▪ Under & over voltage protection(27 & 59) ▪ Locked rotter during starting (51S) ▪ Out of step (55) for synchronous motors only. • Sensitive earth fault protection (50G) with CBCT • Motor differential protection (87T), as applicable • Time delayed U/V relay. • Over-Current and Earth fault (50, 51, 51N, 50N). • High speed tripping relay, close & trip circuit supervision relay, aux relays, time delay as required. Provision for taking RTD/BTD input

Sl No	Type of feeder	Protection
6	Capacitor Feeder	• Over-Current and Earth fault Protection (50,51,51N,50N) • Sensitive earth fault protection (50G) with CBCT • Neutral current unbalance protection (60N) for cap • Capacitor restraint feature • Under voltage with timer (27+2). • Over voltage protection (59). High speed tripping relay, close & trip circuit supervision relay, aux relays, time delay as required.

12.0 Measuring and Indicating Instruments

1) All indicating instruments shall conform to IS : 1248-2003 and IS - 2419-2012.

2) Shall be capable of withstanding system fault current taking into account CT saturation.

3) Shall be back connected, flushed with control cubical door.

4) Shall have square flush case, non-reflecting type, clearly divided and indelibly marked scales, sharply out lined pointers and zero adjusting device.

5) All analogue meters shall be taut band type having size of 96 sqmm.

6) The minimum scale reading shall not be more than 10%. Maximum reading shall be 150% full load for transformers panel and 600% of full load reading of motor panels. 120% to 600% shall be compressed scale for motor feeders.

7) Each voltmeter shall be calibrated with coil hot.

8) Class of accuracy shall be 1.0 or better for analogue meters and 0.5 for digital meters.

9) Digital multi function meter (MFM) shall be provided for each feeder unless specified otherwise. MFM shall be provided with Modbus RTU communication port for connection to SCADA. The MFM shall be true rms type, have accuracy class of 0.5 for all the parameters. The MFM shall be 3 line 7 segment, 31/2 digit LED display, external powered, site configurable for CT/PT ration, 3 Phase measurements. Display-Current, Voltage, Active & Reactive power, PF, frequency, four quadrant active, reactive and apparent power & energies, THD

& Individual voltage & current harmonics indications. MFM shall be suitable for harmonic measurement & display up to 31st harmonic.

10) MFM with Modbus RTU protocol shall be looped with shielded wire for communication. Max 8 devices per loop shall be considered. All looping to be brought to one panel where RS 485 to Ethernet converter shall be installed for external connection to SCADA/ Automation system through Ethernet switch.

The details of metering requirement are elaborated below for 6.6 kV Switchboard. This shall be utilized to finalize the metering requirement during detailed engineering.

Sl No	Type of feeder	Metering
1	Incomer/ Buscoupler/ TIE feeder	• Ammeter -3 Nos • Multifunction meter • Ammeter for heater-1 no
2	LinePT/ Bus PT	• Voltmeter-3 Nosfor Line PT • Ammeter for heater-1 no
3	Outgoing Transformer feeder	• AmmeterwithASS • Multifunction meter • Ammeter for heater-1 no
4	Motor Feeder	• AmmeterwithASS • Multifunction meter • Ammeter for heater-1 no • Separate Interposing CT for Remote Metering-1 no
5	Outgoing Power Feeder	• AmmeterwithASS • Multifunction meter • Ammeter for heater-1 no

Sl No	Type of feeder	Metering
6	Capacitor Feeder	• AmmeterwithASS • Multifunction meter • Ammeter for heater-1 no

33KV Cable In Cable Out (CICO) VCB Panel

The 33 kV Cable In cable out (CICO) panels shall have Indoor type with HT Switchboard parameters. The detailed has mentioned as per SLD. The relay protection, metering & local control shall be part of the HT Switchboard.

For remote control wall mounted control panels shall be there.

33 kV CICO HT Switchboard

The detail protection metering of 33 kV HT Switchboard are as follows:

Sl No	Type of feeder	Protection	Metering
Metering	Incomer CICO Breaker	▪ Over-Current and Earth fault (50,51,51N,50N) ▪ U/O voltage protection (27,59) with timer (2) ▪ Directional protection ▪ Frequency protection • Transformer differential protection relay (87T) & restricted earth fault relay (64R) shall be considered in upstream 33 kV CICO	▪ Multifunction meter including energy meter High accuracy type ▪ Ammeter (Digital 3 Ph meter) ▪ Voltmeter (Digital 3 Ph meter)

13.0 Circuit Breaker

13.1 Electrical Features

1) Type – Gang operated, triple pole, floor rolling truck mounted breaker
2) Arc quenching medium : vacuum
3) Rated operating sequence: O-0.3sec-CO-3Min- CO unless specified otherwise
4) Auxiliary contacts : 6 NO + 6 NC minimum. Continuous Rating- 10A

13.2 Operating Mechanism

1) Spring charged stored energy mechanism to ensure high speed closing and tripping independent of operating forces.
2) Closing spring charged through universal motor with provision for manual charging through handle, insertion of handle to decouple the motor. Motor shall be automatically disconnected when the spring is charged. Spring charging motor shall operate between 85-110% of the specified voltage.
3) Spring charging motor to automatically charge the closing spring for next closing operation when the breaker is closed.
4) Closing and tripping initiated through dc operated coils designed to operate at 85-110% and 70 - 110% of rated control voltage respectively. Additional provision for closing and opening without electric power by mechanical means shall be provided.
5) Trip free feature for all means of closing. Anti pumping feature to be provided
6) Non-reset type operation counter to be provided for each breaker.
7) Mechanical indication shall be provided to show:
   i) Breaker ON & OFF
   ii) Closing spring charged & discharged.
   iii) Service and test position

13.3 Drawout Features

1) Distinct positions viz SERVICE, TEST and ISOLATED. Service & test position shall be inside the panel with VCB door closed.
2) Latching facility for 2 positions inside the panel with door closed
3) Provision to move the breaker from one position to another through a detachable device from outside without opening the door.
4) Power connections - Self-aligning, plug-in type, spring loaded contacts between silver plated copper and silver plated copper.

5) Control connections - plug socket type mechanically coded to prevent wrong insertion; continuous rating 16 A minimum. Provision for locking of control plug to avoid looseness during operation shall be considered.

13.4 Safety Interlocks

1) Breaker cannot be closed in any intermediate position other than the 2 fixed positions within the panel.
2) With the breaker closed, it cannot be moved from any of the position to another.
3) Rack in / out of circuit breaker from test to service position and vice versa shall be allowed only with door closed. Door interlock shall have defeat feature.
4) It shall not be possible to open the circuit breaker enclosure when the breaker is ON or to have access to any part of the draw out assembly which is live when the circuit breaker is in the service position.
5) Unless control connections are engaged
   i) Door cannot be closed
   ii) Breaker cannot be moved to `Service' or ‘Test’ position
6) Unless control connections are disengaged, breaker cannot be withdrawn from the panel.
7) Insertion of breaker into `Service' position not possible if safety shutters are not free.
8) Door can be opened only when breaker is OFF and in `Test'/ ‘Isolated’ position
9) Remote closing of breaker not permitted with door open.

13.5 Safety Shutters

1) Spring loaded, positively operated by the travel of the breaker.
2) Locking facility in the closed position.
3) Independent operating mechanism for bus side and cable side shutters.
4) Shall be made of Metallic material.
5) Busbar/ cable marking on safety shutters.

14.0 Current Transformer (CT)

1) Separate cores shall be used for, protection and measurement purposes. CT’s on incomer side shall be mounted before incomer breaker and CT’s for outgoing feeder shall be put after the breaker.

2) Short time ratings and insulation level of CT's shall be similar to rating of associated breaker. However, time duration for short time rating of CT's upto 100A primary shall be for 1 second.

3) Where outputs and accuracy are not specified, these shall be such as may be required by the circuits in which they are used. Generally the protection CT's and metering CT's shall have 5P20 and 0.5 class respectively, unless otherwise specified.

4) CT's shall be bar primary type, cast resin insulated type. CT may be wound primary type upto 400A primary, after which bar primary type only shall be used.

5) The CT ratios & VA burden shall be finalized during detailed engineering as per the load requirement and burden calculation.

6) Vk calculation, magnetizing curve, ALF and burden calculation for PS class CTs shall be submitted for differential protection application.

7) Core balance CTs (where specified) matching the relay provided for earthfault and sensitive to detect a minimum primary current of 2 Amps.

8) Insulation class of CTs shall be class B.

9) CT nameplate shall be labeled on metering compartment at appropriate location for ease of operation & maintenance.

15.0 Potential Transformers (PT)

1) Shall be of cast resin insulated type mounted on withdrawable floor rolling truck and accessible from front.

2) Bus potential transformer shall be provided for each bus of the switchboard in separate cubicle .

3) Line PT shall be provided in separate cubical or along with the incoming breaker as defined in the technical particular. Rating of line PT's shall be similar to bus PT's

4) High voltage side of PTs shall have fuses. Low voltage star winding side shall have fuses/ MCB and low voltage open delta winding side shall have MCB

5) Low voltage star winding shall have all three phase and neutral connections brought out to terminals and one phase shall be earthed.

6) Insulation levels of PTs shall be similar to rating of associated board.

7) Accuracy class 0.5/3P/3P shall be used unless specified otherwise.

8) VA burden shall be selected based on meters and relays connected with the PT and the same shall be finalized during engineering.

9) Insulation class of PTs shall be class B. The voltage factor of PTs shall be 1.9 for 8 hours irrespective of the type of earthing.

10) PT nameplate shall be labeled on metering compartment at appropriate location for ease of operation & maintenance.

16.0 Fast response current/ voltage/ power transducers, wherever specified

1) Response time shall be maximum 20millisecond
2) Accuracy shall be +/- 0.5%
3) Distortion factor < 0.2%
4) Output shall be 4-20mA
5) Frequency shall be 50 Hz
6) Input shall be 1A for Current and 110V for voltage
7) Transducer shall be suitable for ambient condition inside panel

17.0 Ethernet switch

All Numerical relays shall be prewired for IEC61850 connection and brought to Bus PT panel or any other panel as decided during drawing approval stage. These relay shall be connected to SCADA/ Automation system through these Ethernet switches located in the appropriate panel. Space and mounting arrangement, for mounting of the LIUs shall also be provided in the respective panel.

Industrial grade, Managed Ethernet Switches, IEC 61850 compliant and without cooling fan shall be provided along with the panel. There will be two Ethernet switches for parallel redundant connection. Wiring from relay to switch to be done in double star configuration. Relay to switch on 100MBPS FO or copper port, in line with the type of relay port, with 20% spare ports. 2 Giga ports for external looping for each switch. All the switched in one switchboard shall be identical. Make: Ruggedcom (Siemens)/ Garretcom/ Hirschman.

18.0 Metal Oxide Surge Suppressor –

Station class, 10 kA, Surge suppressors shall be provided for all feeders, unless specified otherwise, to limit the switching surges to values recommended by standards. Surge suppressor shall be installed after the CT when placed in the outgoing cable compartment. The voltage rating of the surge suppressor shall be decided during detailed engineering depending upon the earthing system and the standard rating available with the manufacturers of surge arrestors. Detailed calculation shall be submitted by the bidder during drawing approval stage.

19.0 Annunciation Schemes and Annunciators

1) Minimum 6 window annunciator shall be provided for PT panels and 12 window annunciator shall be provided for all other type of feeders

2) Annunciation signaling (as applicable) on individual panels shall be provided:

   i) All transformer warning / signaling conditions

   ii) Trip circuit unhealthy – 1 & 2 as applicable

   iii) All feeder protection faults

   iv) Control supply failure

   v) PT fuse failure / MCB tripping

   vi) Relay internal failure

   vii) Bus-coupler failed to close on auto-changeover

   viii) Any other signal as decided during detailed engineering

3) Annunciator shall be of microprocessor based facia window type, programmable and suitable for NO/NC potential free contacts.

4) Two different audio signals for trip and alarm. DC fail annunciation shall be inbuilt in the Annunciators.

5) Test, accept and reset facilities (with push button) shall be provided for each Annunciator.

6) 20% spare fascias shall be provided subject to minimum 2 windows. Spare annunciation points shall be wired upto terminal blocks.

7) Clustered LED's with high light intensity shall be used in the Annunciator window.

8) All trip signal facia shall have red color and non trip signal white color.

9) The cover plate of facia shall be flush with panel.

10) It shall be capable to receive simultaneous signals.

11) It shall be capable to receive signal during testing mode.

12) It shall be ensured that spurious signals due to influence of external electromagnetic / electrostatic interference on the annunciation wiring and switching disturbances from neighboring circuits within panels does not affect the annunciation system.

Sequence shall be as follows

Description	**Visual**	**Audio**
On occurring of fault/ test	Flashing	On

On accepting	Steady on	Off
On reset (fault cleared)	Off	Off
On reset (fault persists)	Steady on	Off

13) Warning and emergency points shall be as per the list approved during detail engineering stage. In general all tripping points and alarm points shall be annunciated.

20.0 Indicating Lamps

1) LED indication lamp shall be provided with low voltage glow protection.

2) LEDs used shall be of the colour of the lamp

Color shall be as follows;

Type of lamp	**:**	**LED Colour**
On	:	Red
Off	:	Green
Service	:	Red
Test	:	Green
Trip on fault	:	Amber
Trip ckt. Healthy	:	White
Spring Charged	:	Blue
DC Supply Fail	:	Red
Ready to close	:	Blue
Feeder Earthed/ Bus Earthed		Green
R,Y & B Phase	:	Red, Yellow & Blue

21.0 Control and Selector Switches

1) Control switches for circuit breaker ON/OFF control - 3 position spring return to neutral with lost motion device and pistol grip handle.

2) Other control and selector switches such as local-off-remote, Auto-manual changeover switch, Sync Selector switch, Trip selector switch etc as applicable - stay put type with wing type knobs.

3) Ammeter selector switches - 4 position, make before break type.

4) Voltmeter selector switches - 7 position unless specified otherwise

5) Contact Rating :

Continuous	10 amps
AC 11	4 amps, 240V
DC 11	0.5A, 110V, L/R - 40 ms

22.0 Push Buttons

1) Contact Rating :

Continuous	10 amps
AC 11	4 amps, 240V
DC 11	0.5A, 110V, L/R - 40 ms

2) Colour :

Accept	Blue
Reset	Black
Test	Yellow

23.0 Labels

1) Labels made on non-rusting metal, preferably Anodized Aluminium, with engraved inscription of black letters on white background and shall be riveted.
2) Switchboard designation nameplate at the center of the board with letters not less than 25 mm high.
3) Panel designation number on each panel, both in front and rear. (Min 10mm Height)
4) Inscription plate for each feeder, both in front and rear. (Min 5 mm height)
5) Door front mounted devices to have labels directly below them. (Min 3mm height)
6) Labels for equipment/component inside the cubicle shall be painted at base and sticker on equipment.
7) Label designation and size of lettering subject to approval.
8) Bus side and cable side shutters labeled for identification.

24.0 Surface Treatment

All metal parts of the panel to undergo surface treatment that includes de-rusting, cleaning, chemically degreasing, pickling in acid, cold rinsing, phosphating and passivating followed by powder coating to shade RAL 7035.

25.0 Auto Changeover and Momentary Paralleling Scheme

All the switchboards with sectionalized buses will be normally operated with the bus coupler breakers in open condition.

Auto / Manual / Independent changeover between the two normal incomers and their bus-coupler will be provided with the following features through appropriate selector switch.

25.1 Auto Mode

For prolonged under voltage on any one of the bus sections, the respective incoming breaker will trip and the bus coupler breaker will close provided the other bus section is healthy and bus coupler is selected for auto changeover. Total changeover time will be adjustable between 1 to 5 seconds. This auto changeover will be blocked if the incoming breaker had tripped on fault. In case bus coupler trips on auto closing, no further closing shall be permitted till the system is reset. Changeover back to the normal source of supply will be affected manually.

25.2 Manual Mode

Manual live changeover facility will be provided for all the switchboard. For planned outage of one of the normal incoming supplies, the respective selected incomer will be tripped automatically after the bus section breaker is closed manually. Also for restoration of normal power supply, the buscoupler will trip after the respective incoming breaker is closed. For this purpose, a trip selector shall be provided for selecting the breaker to be tripped and momentary paralleling shall be done after phase comparison of both the power supplies through check synchronization relay. Thus, depending on the selection made, the selected breaker will be tripped once all the three breakers are closed manually, thus maintaining continuity of supply for the complete switchboard.

A timer with a time delay on pick up of 0.5. - 5 sec will be provided, for annunciation of the running breaker failing to trip within a preset time, (i.e. If the two sources remain paralleled for more than a preset time). Latest breaker tripping provision will be included in the changeover scheme for prolonged paralleling..

25.3 Independent Mode

Provision for manual independent (dead bus) closing of a bus-coupler after an intentional manual trip/ outage due to under voltage of any one incomer will be provided.

26.0 TESTING OF EQUIPMENT

For Testing of Equipment Refer Testing Chapter

1 No. VFD Transformer and 1 No. Distribution Transformer feeders shall be provided as spare feeders in each section of 6.6kV board.

05.03.03 POWER TRANSFORMERS

Design

Design shall be generally as per IS 2026. Transformer shall be suitable for rated frequency 50 Hz, with variation as specified above . Insulation level shall be designed according to the voltages specified below. The power rating of the transformer is tentative only. The power rating of the transformer shall be calculated considering the future provision given for a new compressor.

	Nominal system voltage		**6.6 kV**	**33 kV**
1.	Max. system voltage (kV)	:	7.2	36
2.	One minute power frequency withstand voltage (kV)	:	20	70
3.	Peak impulse test withstand voltage (kV)	:	60	170

Transformers shall be capable of delivering rated current at an applied voltage up to 105% rated voltage without exceeding the temperature limits specified below. Overload capacity shall be as per IS 6600. Transformers shall be operable at its rated capacity at any voltage within $\pm$ 10% of rated voltage of the particular tap.

Permissible maximum temperature at rated output and principal tap over an ambient temperature of 50^0C.

- Top oil (by thermometer) : 35^0C
- Windings (by resistance method) : 45^0C
- Maximum Hot spot temperature : 55^0C

Transformers shall be designed to withstand the thermal and dynamic stresses due to short circuits at its terminals. Unless otherwise specified the duration of short circuit shall be as per IEC. However design calculation shall be submitted considering 5 seconds duration.

Disconnecting chamber at the cable terminal box shall be provided.

Magnetic Circuit shall be made of low loss CRGO silicon steel shall be used. Laminations shall be annealed in a non-oxidising atmosphere to relieve stresses and restore the original magnetic properties of CRGO sheets after the cutting and punching operations.

Flux density at normal over voltage or frequency shall be such that under 10% over voltage condition it shall not exceed 1.6 tesla.

OLTC shall be provided with AVR and LDC in Auto mode.

Frequency response analysis shall be done on each of the Transfomer during routine testing.

Over voltage capability of the transformers shall be as per IS and shall match with the connected equipment.

Windings

Material shall be electrolytic grade work hardened copper of high proof stress with more numbers of radial supports. Completed core and winding shall be vacuum dried in full vacuum and impregnated immediately.

Insulating materials shall be compatible with transformer liquid under all service conditions. Leads to the terminal board and bushings shall be rigidly supported.

Insulation

Inter-turn and inter coil insulation shall be designed such that dielectric stress is uniformly distributed throughout the windings under all operating conditions.

Tank

Fully assembled transformer with its radiators, conservator and other fittings shall withstand for one hour a pressure corresponding to twice the normal head of liquid or to the normal pressure plus 35 KN/sq. m, whichever is lower, measured at the base of the tank. Tank shall be provided with inspection opening and cover/with handling equipment) to provide access to bushing connections. Form of cover shall be such as to prevent any stagnant water deposit and to drain gas bubbles towards the buchholz relay. Tank shall be capable of withstanding of 600 mm of mercury.

Conservator and Breather

Conservator mounted on frame, integral with tank in such a manner that under all conditions and the lowest oil level the bushings remain under the head of liquid. Conservator volume shall be sufficient to maintain oil seal from ambient to oil temp. of 90^0C.

Silica gel breather with inspection window and oil level shall be mounted at 1.4 m from ground level and connected to conservator.

Prismatic type oil level gauge shall be provided with max. and min. levels marked on it. Tap and valves shall not be fitted to oil gauge. 150 mm diameter dial type magnetic level gauge with alarm and trip contacts shall also be provided.

Breather shall be connected with rubber bellow inside the conservator tank for expansion and contraction of oil.

Buchholz Relay

Buchholz relays shall be double float relay as per IS 3677. Shut off valves shall be provided on either sides of the buchholz relay.

Potential free, self reset independent alarm and trip contacts rated to make, break and carry 2 amps at 110 V DC shall be provided. No auxiliary relay shall be used to multiply the contacts. Contacts are to be wired to the marshalling box.

Cooling

The cooling system provided shall be as per the data sheet.

Radiators shall be detachable type directly mounted and shall have flexible earthing arrangement. Bolted, gasketted and flanged connections shall be used for connecting the radiators to the tank.

Additional spare radiator fins shall be provided along with isolation valves.

The following accessories shall be provided for each radiator/radiator bank.

- Top and bottom shut off valves and blanking plates
- Bottom drain plug and top filling plug, air release plug
- Lifting lugs
- Neutral bushing CTs
- Thermometer pockets with thermometers in the inlet and outlet pipes (for separately mounted radiator banks).

- Top and bottom filter valves for each separately mounted radiator bank.
- Pressure reducing devices with alarm and trip .
- Air release devices
- Earthing arrangement
- Bi-directional rollers/rails
- Rail for transportation with provision for extension for HT station transformer
- Spare radiator fins along with isolation valves
- Any other accessories required.

Valves and connections

Valves shall be of sluice type with hand wheels. They shall be made of gun metal and shall be provided with padlocking facility to lock in closed/open position, blanking plates or screwed plugs and clear indication of open and closed position.

Terminations

It shall be possible to withdraw the transformer easily after disconnecting the connections without disturbing the OH line/cable/busduct terminations. For cable termination, air insulated cable box shall be provided which shall be suitable for the type and number of cables specified. Cable end box shall be self-supporting. For OH line termination, proper bushing shall be provided. For bus duct termination, proper matching flange arrangement shall be provided.

Bushings

Bushing shall conform to IS 3347 and 2099. Clamps and fittings shall be made of steel or malleable iron shall be hot dip galvanized. Neutral bushings shall be provided as required for earthing of neutral point. All the HT bushings shall be provided with suitable connectors and clamps.

Minimum rated current of line bushings shall be 1.5 times rated current of the corresponding windings. Bushing rated 400A and above shall have non-magnetic clamps and fittings only.

Creepage distance for the bushing shall not be less than 25.4mm/kV of the higher system voltage.

Bushing Current Transformers

Bushing CT shall be removable at site without opening transformer tank

cover/active part. Secondary leads of 4mm^2 shall be brought to a weatherproof terminal box and from there to the marshalling box.

Oil temperature Indicator (OTI) / Winding Temperature Indicator (WTI)

Digital display type thermometer shall be provided with alarm and trip settings, manual reset and maximum reading display. There shall also be two independent potential free contacts for alarm and trip signals.

Marshalling box

All outgoing connections from the transformer i.e. buchholz relay, temp. indicators, level indicators, CT secondary, alarm contacts for annunciations, etc. shall be wired to a marshalling box. Degree of protection of enclosure shall be IP 55 class.

All other standard fittings and accessories like name plate, first fill of oil as per IS -335 with 10% excess in drums, cooling system complete with accessories including detachable radiators, drain and sampling devices, air release device, lifting lugs, conservator with sump, drain valve and detachable end plate, dehydrating breather, etc shall be provided along with the transformer.

In addition, contractor shall supply all the accessories like bidirectional rollers, radiators, etc so as to complete the transformer in all respect.

Contractor shall also provide dedicated remote tap changer control panel for all the transformers with all indications, control, annunciations, etc.

On Load Tap Changer

A. Electrical Design

- Generally as per IS 8468
- Automatic motor operated, resistive transition impedance type.
- Tap changer shall change the effective transformation ratio without providing phase displacement.
- The tap changer shall have the same rating as the associated transformer with respect to rated current, rated voltage, no. of phases, insulation level, over loading capability and short circuit withstand capacity.
- No. of steps and rated step voltage shall be as per Technical Particulars.

- Shall be suitable for connection to line end of neutral and of the winding as specified.

- DC control supply voltage shall be 110V DC.
- Separate Diverter Tank for OLTC shall be provided for Power Transformer

B. General Arrangement

- Diverter switch contacts shall be housed in a separate oil chamber not communicating with the oil in the main tank of the transformer.

- The oil used shall be transformer oil conforming to IS 355.

- The OLTC oil chamber shall have oil filling and drain plug, relief vent and glass window for seeing the level. A oil surge relay (hand reset type) also shall be filtted, the outlet of which shall be connected to a separate conservation.

- A mechanical tap position indicator shall be provided locally.

- A mechanical operation counter shall be provided to indicate the number of operations completed.

- The main contacts, switching contacts and transition contacts shall be of copper with maximum temperature rise of contacts at 150% of rated current of transformer limited to 20° C.

C. Control Features.

- The OLTC shall have the following control regimes,

a) Local manual operation

b) Local electrical operation

c) Remote electrical operation through RTCC.

d) Fully automatic operation through AVR.

- In manual regime, the OLTC shall be operable by a person standing at

ground level. The electrical operation shall be inhibited automatically once manual operation is restored to.

- For electrical operation, a suitable 3 phase, 415V AC motor and associated starter with thermal O/L relays, fuses, etc. shall be provided.

- The manual electrical operation, either local or remote shall cause one tap movement only. The control switch is to be returned to the OFF position between successive operations.

- Once a switching sequence has started, it shall always be completed. The tap changer shall not stop in an intermediate position even in the event of control power failure.

- Mechanical stop shall be provided to prevent overrunning beyond the extreme tap positions. An electrical interlock through limit switches shall also be provided to cut off power for electrical operation.

- A reverse tap change signal during an operation shall be ignored till the mechanisms comes to rest and resets the circuit for a fresh operation.

- Emergency stopping provision shall be provided both at the local and remote control panels.

- An indication ‘tap change in progress’ shall be available at the remote control panel.

- Power and control circuit of motor shall be inter-locked.

- If control is set to ‘automatic’, it shall not be possible to operate the OLTC by manual electric or hand operating gear.

D. Local OLTC Control Cabinet

- Dust vermin and weather proof outdoor type with lockable door.

- Shall house the drive motor for OLTC, starter, local control equipment, indicators for tap position, counters, etc.

E. List of accessories for OLTC.

- Operation counter

- Local tap position indicator
- Conservator
- Dehydrating breather
- Drain plug and oil filling plug
- Local OLTC control cubicle

Technical requirement of HT transformer

1. Rated capacity(tentative)	:	10 MVA (Minimum)
2. Cooling	:	ONAN
3. Voltage LV/HV	:	33kV/6.9 kV
4. Duty	:	Outdoor
5. Specification to be complied with	:	IS 2026
6. Winding connection	:	Delta/Star
7. Vector group	:	Dyn11
8. Termination	:	HV : Cable LV : Cable
9. Tap changer	:	OLTC (17 steps)
10. Impedance	:	8.35 % (with no +ve-tolerance)
11. Withstand time without injury for 3 ph. short ckt	:	5 secs
12. Overload capacity	:	As per IS
13. Radiator	:	Detachable
14. Transformer Losses		
No load losses	:	8.0kW
Load losses	:	60kW (at 75 Deg C)
No positive tolerance in losses is acceptable		

05.03.04 NITROGEN INJECTION FIRE PROTECTION SYSTEM

Nitrogen Injection Fire Protection and Extinguishing System for Transformers -

The Power Transformers shall be supplied with Nitrogen injection fire protection system.

General Description

Nitrogen injection fire protection system designed for oil filled transformers, shall prevent

tank explosion and the fire during internal faults resulting in an arc where tank explosion will normally take 3-4 seconds after arc generation and also extinguish the external oil fires on transformer top cover due to tank explosion and / or external failures like bushing fires, OLTC fires and fire from surrounding equipments. It should be fully automatic and shall require minimum maintenance and practically no running cost.

The system shall work on the principle of DRAIN AND STIR and on activation, shall drain a pre-determined quantity of oil from the tank tope through outlet valve to reduce the tank pressure and inject nitrogen gas at high pressure from the lower side of the tank through inlet valves to create stirring action and reduce the temperature of top oil surface below flash point to extinguish the fire. Conservator tank oil shall be isolated during tank explosion and oil fire to prevent aggravation of fire.

After draining out the oil shall be collected in the stainless steel tank of required volume. The stainless steel tank supply is in the scope of the bidder.

A] **Codes and Standards**

The design, manufacture, and performance of equipment shall comply with all currently applicable standards, regulations and safety codes, particularly to the following standards.

- IS: 2147-Degree of protection provided by enclosures for electrical equipment
- IS 5216 -Guide for safety procedures and practices in electrical works
- Tariff Advisory Committee (TAG) Regulations
- National Fire Prevention Association (NFPA) Regulations
- NIFPS equipment offered by the supplier, if conform to other standards, salient points of difference between the standards adopted and the specified standard shall be clearly brought out in the offer. Four (4) copies of the reference standards in English language shall be furnished along with the offer.

1.1 System Requirements

a) All large oil filed transformer, as indicated in project scope of works are to be provided with Nitrogen Injection Fire Protection System (NIFPS). Accordingly, the Contactor shall co-ordinate with the transformer manufacturer for fittings the accessories without affecting the overall performance of transformer. Fittings of all the accessories of NIFPS shall be done in transformer manufacturer's work.

b) In the fire-fighting system nitrogen shall be used as fire quenching medium. The fire protective system shall prevent transformer oil tank explosion and possible fire in case of internal faults. In the event of fire by external causes such as bushing fire. OLTC fires, fire

from surrounding equipment etc, it shall act as a fast and effective fire fighter. It shall accomplish its role as fire preventer and extinguisher without employing water and / or carbon dioxide. Fire shall be extinguished within 3 minutes (Maximum) of system activation and within 30 seconds (maximum) of commencement of nitrogen injection.

Activation of the fire protective system (NIFPS)

The supplier of NIFPS shall ensure that the probabilities of chances of malfunctioning of the fire protective system are practically zero. To achieve this objective, the supplier shall plan out his scheme of activating signals which should not be too complicated to make the fire protective system inoperative in case of actual need. The system shall be provided with automatic control for fire prevention and fire extinction. Besides automatic control, remote electrical push button (red colour) substation control room, one at the Nitrogen storage room near the transformer bay and local manual control in the fire extinguishing cubicle shall also be provided. The following electrical-signals shall be required for activating the fire protective system under prevention mode / fire extinguishing mode.

1.2 Auto Mode

<u>For Prevention of fire</u>:

- Differential relay operation
- Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay)
- Tripping of all circuit breakers (on HV &LV/IV side) associated with transformer is the pre-requisite for activation of system.

1.3 For extinguishing fire

- Fire detector
- Buchholz relay paralleled with pressure relief valve or RPRR (Rapid Pressure Rise Relay)
- Tripping of all circuit breakers (on HV & LV/IV side) associated with transformer is the pre-requisite for activation of system.

5.4 Manual Mode (Local / Remote)

- Tripping of all circuit breakers (on HV & LV/IV side) associated with transformer is the pre-requisite for activation of system.

5.5 Manual Mode (Mechanical)

- Tripping of all circuit breakers (on HV & LV/IV side) associated with transformer is the pre-requisite for activation of system.
- The system shall be designed to be operated manually in case of failure of power supply to fire protection system.

5.6 Constructional Features and System Components

Transformer isolation shall be an essential pre-condition for activating the system. The system shall consist of following equipments:

1. Fire extinguishing cubicle placed on a plinth at about 5-10 meters away from the transformer.
2. Control box placed in the control room.
3. Pre-stressed not return valve in the conservator pipe / high speed pneumatically operated ball valves. Backup valve of same type may be provided to the main valve, if necessary.
4. Required number of fire detectors on the tank top cover.
5. Signal box fitted on the tank top or tank sidewall Terminating signals from PRV, fire detectors differential relay, buchholz relay, and PNRV/Pneumatic valve and for cable connection to control box.
6. On line testing facility of the system.
7. Required no. of Fire Detectors on top cover of the Transformer and Tap changer.
8. Special Isolation Valve between Buchholz relay and Transformer oil conservator (TCIV).
9. Required quantity of Fire Retardant Low Smoke (FRLS) cables.
10. Required quantity of Fire Survival cables.
11. Pipes and Pipe Fittings.

5.7 Nitrogen injection fire protection system should be a dedicated system for each oil filled transformer / reactor. It should have a Fire Extinguishing Cubicle (FEC) placed on a plinth at a distance of 5-10 m away from transformer / reactor or placed next to the fire wall (if firefighting wall exists). The FEC shall be connected to the top of transformer/reactor oil tank for depressurization of tank and to the oil pit (capacity is approximately equal to 10% of total volume of oil in transformer/reactor tank) from its bottom through oil pipes. The fire extinguishing cubicle should house a pressurized nitrogen cylinder(s) which is connected to the oil tank of transformer/reactor oil tank at bottom. The Transformer Conservator Isolation Valve (TCIV) is fitted between the conservator tank and Buchholz relay. Cable connections are to be provided from signal box to the control box in the control room, from control box to fire extinguishing cubicle and from TCIV to signal box. Fire detectors placed on the top of transformer/reactor tank are to be connected in parallel to the signal box by Fire survival cables. Control box is also to be connected to relay panel in control room for receiving system activation signals.

5.8 Operation

On receipt of all activating signals, the system shall drain pre-determined volume of hot oil from the top of tank (i.e. top oil layer), through outlet valve, to reduce tank pressure by removing top oil and simultaneously injecting nitrogen gas at high pressure for stirring the oil at pre-fixed rate and thus bringing the temperature

of top oil layer down. Transformer conservator isolation valve blocks the flow of oil from conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.

The system shall be provided with automatic controls for fire prevention and fire extinction and besides remote electrical push button control on control box and local manual control in the fire-extinguishing cubicle shall be provided.

5.9 System Activating Signals

a) To avoid transformer explosion two fast trip signals given by circuit breaker of transformer and Buchholz relay paralleled with pressure relief valve/ pressure and temperature sensors to initiate:

i. Explosion prevention by opening quick depressurization valve to release the internal pressure and to prevent the transformer explosion.

ii. Oil cooling – by injecting a large flow of nitrogen at the transformer base to limit the damages of overheated parts affected by short circuit and to evacuate the very explosive hydrogen gas by dielectric oil.

b) i. The fire protection back up system should be initiated by two signals from one of the high temperature sensors, located on the transformer cover and by the operation of Buchholz relay paralleled with pressure relief device/ pressure and temperature sensors. The drain valve should open out within 3 second. The nitrogen injection shall cause stirring of transformer oil and should immediately drop its surface temperature below flash point to extinguish fire with a minimum possible time. Nitrogen injection should continue for sufficient time, which will further cool the transformer and prevent any re-combustion.

ii. Fire protection back up system shall be provided to function in case if all transformer electrical protections leading to breaker trip or if all pressure sensors have failed during the incident, by the conventional nitrogen fire extinguishing method.

In case of fire, even if the circuit breaker has not tripped, the system shall inject nitrogen into the transformer tank even when the transformer is live but after giving warning signal to the operating personnel to manually isolate the circuit breaker.

c) The system shall be of automatic operation and in addition, remote push button control through control box and manual local control in fire extinguishing cubicle are to be provided.

d) During the initiation/activation of sensing devices mentioned in 19.04.00 (a) & 19.04.00 (b) above, for prevention of tank explosion or for fire protection, the oil from the conservator tank should be isolated, by action of PNRV/POBV.

5.10. Contract Particulars

a)	Power supply, for control box/ Fire Extinguishing Cubicle (lightning):	:	110V. D.C / 230V A.C
b)	Fire extinguishing cubicle Dimensions/Weights/Capacity	:	Suitable for 10MVA Transformer
c)	Control box Dimensions/ Weights	:	Suitable for 10MVA Transformer
d)	Nitrogen cylinder capacity	:	Suitable for 10MVA Transformer
e)	Fire detectors heat sensing temperature:		141°C

5.11 System components

Nitrogen injection fire protection system shall broadly consist of the following components. However, all other components which are necessary for fast reliable and effective working of the fire protective system shall deemed to be included in the scope of supply.

5.12Fire Extinguishing Cubicle (FEC)

- The FEC shall be made of CRCA sheet of 3 mm (minimum) thick complete with the base frame, painted inside and outside with post office red colour (shade 538 of IS-5). It shall have hugged split doors fitted with high quality tamper proof lock. The degree of protection shall be IP55. The following items shall be provided in the FEC.
- Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer.
- Oil drain pipe with mechanical quick drain valve.
- Electro mechanical control equipment for draining of oil of pre-determined volume and injecting regulated volume of nitrogen gas
- Pressure monitoring switch for back-up protection for nitrogen release
- Limit switches for monitoring of the system
- Butterfly valve with flanges on the top of panel for connecting oil drain pipe and nitrogen injection pipes for transformer/ reactors

- Panel lighting (CFL Type- Indian make)
- Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.

5.13 Control cubicle

Control cubicle is to be placed in the control room for monitoring system operation, automatic control and remote operation. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided.

- System on
- TCIV open
- Oil drain valve closed
- Gas inlet valve closed
- TCIV closed*
- Fire detector trip *
- Buchholz relay trip
- Oil drain valve open*
- Extinction in progress *
- Cylinder pressure low *
- Differential relay trip
- PRV / RPRR trip
- Transformer/reactor trip
- System out of service *
- Fault in cable connecting fault fire detector
- Fault in cable connecting differential relay
- Fault in cable connecting Buchholz relay
- Fault in cable connecting PRV / RPRR
- Fault in cable connecting transformer /reactor trip
- Fault in cable connecting TCIV
- Auto/ Manual / Off
- Extinction release on / off
- Lamp test
- Visual/ Audio alarm*
- Visual/ Audio alarm for DC supply fail *

The doors, removable covers and panels shall be gasketed all round with neoprene gaskets

The system shall be microprocessor based and suitably interfaced with SAS /SCADA system.

5.14 Transformer Conservator Isolation Valve

Transformer conservator isolation valve (TCIV) to be fitted in the conservator pipe line, between conservator and Buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator. The TCIV should be of the best quality as malfunctioning of TCIV could lead to serious consequence. The closing of TCIV means stoppage of breathing of transformer/reactor.

Locking plates shall be provided for pad locking.

5.15 Arrangements Required on Transformer Tank

1. Oil drain opening with pipe, flange and manual gate valve at about 120mm below the top cover.
2. Nitrogen injection openings with suitable size of pipe with flange and manual gate valve on tank sides at about 50-200mm from the bottom plate.
3. Flanges on the conservator pipe between Buchholz relay and conservator tank for fixing PNRV/POBV.
4. Provision for pressure and temperature sensors if required.
5. Supply and welding of the fire detector brackets on top cover of the transformer / reactor oil tank. The system shall be complete with adequate number of fire detectors (quartz bulb).

5.16 Fire detectors

The system shall be complete with adequate number of fire detectors (quartz bulb) fitted on the top cover of the transformer / reactor oil tank.

5.17 Signal box

It shall be mounted away from transformer main tank, preferably near the transformer marshalling box, for terminating cable connections from TCIV & fire detectors and for further connection to the control box. The degree of protection shall be IP55.

5.18 Cables

– Fire survival cables (capable to withstand 750° C.) of 4 core x 1.5 sq. mm size for connection of fire detectors in parallel shall be used. The fire survival cable shall conform to BS 7629-1,BS 8434-1, BS 7629-1 and BS 5839-1,BS EN 50267-2-1 or relevant Indian standards.

- Fire Retardant Low Smoke (FRLS) cable of 12 core x 2.5 sq. mm size shall be used for connection of signal box / marshalling box near transformer/reactor and FEC mounted near transformer/reactor with control box mounted in control room.
- Fire Retardant Low Smoke (FRLS) cable of 4 core x 2.5 sq. mm size shall be used for connection between control box to DC and AC supply source, fire extinguishing cubicle to AC supply source, signal box/ marshalling box to transformer conservator isolation valve connection on transformer/reactor.

5.19 Pipes

- Pipes complete with connections, flanges, bends and tees etc. shall be supplied along with the system.

5.20 Other items

- Oil drain and nitrogen injection openings with gate valves on transformer / reactor tank at suitable locations.
- Flanges with dummy piece in conservator pipe between Buchholz relay and conservator tank for fixing TCIV.
- Fire detector brackets on transformer tank top cover.
- Spare potential free contacts for activating the system i.e. in differential relay, Buchholz relay,
- Pressure Relief Device / RPRR, Circuit Breaker of transformer
- Pipe connections between transformer / reactor and FEC and between FEC and oil pit required for collecting top oil.
- Cabling for fire detectors mounted on transformer top cover
- Inter cabling between signal box, control box and Fire Extinguishing Cubicle(FEC).
- Butterfly valves /Gate valves on oil drain pipe and nitrogen injection pipe which should be able to withstand full vacuum.
- Supports, signal box etc. which are to be painted with enameled paint.

05.03.05 DRY TYPE DISTRIBUTION TRANSFORMER-RESIN CAST

1.0 TECHNICAL PARTICULAR

Sl. No.	Particulars	Parameters

Sl. No.	Particulars		Parameters
1.	Type		Cast resin encapsulated dry type, three phase, core type with circular concentric windings.
2.	Application/ Duty		Distribution
3.	Continuous rating		630 kVA(minimum)
4.	Voltage Ratio (HV/LV)		
4.1	Primary voltage		6.6 kV
4.2	Secondary no load voltage		433V
5.	Voltage Variation (HV/LV)		As explained above
6.	Control Voltage		110 V DC
7.	Aux supply voltage		240V AC
8.	Frequency		50 Hz
9.	Voltage and frequency variation		As per Sec-A of GTS
10.	Conductor		Copper
11.	Insulation class		Class F
12.	Temperature rise at rated output and principal tap at the specified design ambient temperature		
12.1	Winding (by resistance method)		Limited to class B insulation
12.2	Core, other parts adjacent to winding and metallic part		Within safe limit of core and adjacent materials
12.3	Enclosure		65°C
13.	Cooling		Air natural (AN)
14.	Degree of Protection		IP23 for indoor application
15.	Winding connection		Delta / Star
16.	Vector group		Dyn 11
17.	Neutral grounding		Solidly earthed
18.	System earthing	HV	Resistance Earthed

Sl. No.	Particulars		Parameters
		LV	Solidly Earthed
19.	Percentage impedance & Tolerance		As per IS 2026-1, unless specified otherwise
20.	Termination	HV	Cable end box suitable for termination of 1 no. 3C x 240 mm^2 XLPE cable
		LV	Flange throat Suitable for Cable Termination
21.	Bushing mounted CT's		
	LV Neutral bushing CT for standby E/F protection	Ratio	1000/5A(However it shall be finalized during drawing approval stage,) secondary 5A
		Class	5P20, 15VA
22.	Tap changer		Manually operated Off Circuit (Bolted link type)
	a) Range		±5%
	b) Total tap positions		5
	c) Taps above nominal voltage		2
	d) Taps below nominal voltage		2
	e) Voltage per step variation		2.5 %
23.	Painting type & Paint shade and paint thickness		Polyester based powder coating, Shade RAL 7035, Minimum paint thickness of 100 microns
24.	Flux density at rated voltage and freq		1.5 Tesla (Max)
25.	Magnetizing current		1% of rated current (Max)
26.	Current density		2.5A / sqmm (Max)
27.	Creepage for the epoxy bushings/ insulators		25mm/ kV corresponding to the highest system voltage applicable
28.	Air clearances		As per CBIP manual
29.	Distance between bi-directional		1000 mm

Sl. No.	Particulars	Parameters
	rollers	
30.	Losses	As given in this chapter.
31.	Type test	One transformer of each lot offered for inspection shall be type tested for impulse, load loss and temperature rise at Govt or third party NABL accredited laboratory

2.0 STANDARDS FOLLOWED

This specification is generally based on the following standards :

Sl No	Standard Name	Description
1	IS-11171 (1985-R2001)	Specification for Dry Type Power Transformers
2	IS-2026, Part 1 to 4	Specification for Power Transformers
3	IEC 60076-11 (2018)	Power Transformers- Part 11 – Dry Type Transformers
4	IEC 60076-12 (2008)	Power Transformers- Part 12 – Loading guide for Dry Type Transformers
5	IEEE C57.12-01 (1988)	Dry type transformer Specification

Latest version of standard applicable shall be followed during engineering.

3.0 ELECTRICAL DESIGN

1) Insulation level for primary winding shall be designed as per the following applicable data

Sl. No.	Description	6.6 kV System
1.	Nominal system voltage – Primary winding (kV)	6.6
2.	Max. system voltage (kV)	7.2
3.	One minute power frequency withstand voltage (kV rms)	20

4.	Peak impulse test withstand voltage (kVp)	60
5.	Short circuit level considered for winding design (MVA)	450

2) Transformers shall be capable of delivering rated current at an applied voltage up to 105% rated voltage without exceeding the temperature limits.

3) Overload capacity of the transformer shall be as per IEC 60076-12 (2008) unless specified otherwise.

4) Shall be operable at its rated capacity at any tap with voltage variation of + 10% of corresponding to voltage of the particular tap.

5) Inter turn and inter coil insulation shall be designed such that dielectric stress is uniformly distributed throughout the windings under all operating conditions.

6) Transformers shall be designed to withstand the thermal and dynamic stresses due to short circuits at its terminals or symmetrical/ asymmetrical faults on any winding. Short circuit withstand capacity for the bolted fault at the secondary terminals shall not be less than 2 second duration as specified in IS 2026-Part 5 with respect to fault level specified.

7) The maximum temperature at the end of the specified duration shall not be more than 250°C with the temperature prior to short circuit corresponding to maximum permissible overload.

8) The transformer should withstand the extreme load variation without any cracking of the casting. For this test certificate of Environmental (E2), Climatic (C2) and Fire behavior (F1), according to IEC 60076-11 shall be furnished.

4.0 MECHANICAL DESIGN

1) Transformer enclosure shall be welded/ bolted CRCA sheet steel construction, free standing, with suitable size of louvers backed with wire mesh. Base shall be suitably reinforced to prevent any distortion during lifting. Base channels shall be provided with bidirectional flat rollers with pulling eyes and lifting hooks to facilitate handling. The minimum thickness of sheet steel enclosure shall be 2.0 mm CRCA.

2) All fasteners and bolts etc. shall be stainless steel. All surfaces to be painted shall be thoroughly cleaned, made free from rust and given two coats of zinc based primer followed by polyester based powder coating.

3) The transformer shall be provided with separate weatherproof HV/LV terminal boxes and disconnecting chamber with links on the side of transformer so as to facilitate withdrawal of transformer without disturbing the HT and LT cables/ busduct connected to transformer.

4) Safety limit switches for each door shall be provided and wired in such a way that the incoming supply may be disconnected when any one side of the enclosure is opened with transformer in energized condition.

5.0 MAGNETIC CIRCUIT

1) Transformer core shall be low loss, non-ageing, high permeability PRIME GRADE CRGO, perfectly insulated and clamped to minimize noise and vibrations.

2) Core, framework and clamps arranged and tightened to securely hold laminations in order to prevent any settling or displacement in case of heavy shocks during transport, handling or short circuits.

3) Flux density under specified over voltage or frequency conditions shall not exceed 1.5 tesla at rated voltage and frequency unless specified otherwise in technical particulars

4) Transformers shall be designed to withstand 110% over-fluxing corresponding to rated voltage. Duration of the over-fluxing shall be as per the CBIP manual.

5) Core material shall be directly procured either from CRGO manufacturer or through their authorized service centre/distributor and not through any contractor. Test certificate for the same shall be submitted at the time of inspection.

6) Bidder shall use hydraulic core lifting facility to avoid any jerk at the time of core building.

6.0 WINDINGS

1) Material shall be electrolytic grade copper.

2) Shall be subjected to shrinkage treatment.

3) Completed high voltage winding to be heated and dried before vacuum casting in resin.

4) Shall be braced to withstand shocks due to rough handling, and forces due to short circuit, switching or other transients.

5) Permanent current carrying joints in winding and leads shall be brazed.

6) Lead busbars to the terminal support insulators shall be rigidly supported.

7) Current density shall be maximum 2.5A/mm^2 unless specified otherwise in technical particulars

7.0 INSULATION

1) Inter turn and inter coil insulation shall be designed such that dielectric stress is uniformly distributed throughout the windings under all operating conditions.

2) The windings shall be provided with insulation class F, having temperature rise in winding limited to that of class B insulation.

8.0 TERMINATIONS

1) For Cable termination on HT side

   a) Three insulated terminals housed within a flanged air insulated bolted type cable end box suitable for the type and number of cables specified/ required.

   b) Air insulated disconnection chamber with inspection opening shall be provided.

   c) Shall be provided with earthing terminals for termination of XLPE cable screen and shall be with necessary disconnecting link.

   d) It shall be possible to withdraw the transformer easily after disconnecting from disconnecting link without disturbing the cable terminations. Cable termination box shall be supported from bottom so that after withdrawing the transformer, it remains at its same position.

   e) Removable CRCA gland plated, 3.0 mm thick (Aluminium, 5mm thick wherever applicable for single core cable).

2) For Busduct termination on LT side (Not Applicable)

   a) Four insulated terminals housed within Air insulated chamber with inspection opening and flanged to suit termination of busduct. Flange ends and inspection openings shall be provided with gaskets.

   b) Neutral bushings shall be provided as required for earthing of neutral point. This shall be connected to brass / tinned copper bar and brought to ground level through epoxy insulators.

3) The Clearance in HT & LT termination chamber shall be as per CBIP guidelines.

4) The HT and LT terminals shall be brought to the terminal point through suitable bushings. This is required to ensure physical segregation of termination point from the active part compartment.

9.0 BUSHINGS & SUPPORT INSULATORS

1) Conforming to IS 2099 for HT and IS 7421 for LT system.

2) Bushing shall be epoxy type, non hygroscopic, homogenous and free from cavities.

3) Minimum rated current of bushings shall be 1.5 times rated current of the corresponding winding terminal.

4) Clamps and fittings made of steel or malleable iron shall be hot dip galvanized or powder coated

5) Neutral bushings shall be provided as required for earthing of neutral point. This shall be connected to brass / tinned copper bar and brought to ground level through epoxy insulators.

10.0 BUSHING CURRENT TRANSFORMERS (WHERE APPLICABLE)

1) CTs for REF protection and back up earth fault shall be provided on the neutral end as per the requirement

2) For differential protection, CTs shall be provided on primary side and secondary side as per the requirement

11.0 WINDING TEMPERATURE INDICATOR

1) Local winding temperature indicator (WTI) shall be multi channel (minimum 6 Channel) digital scanner type for measuring temperature of winding. The instrument shall be provided with 4 numbers of change over potential free contacts brought out to separate terminal blocks for winding temperature alarm & trip (2 contacts for each). Contact rating shall be minimum 5 Amps. Two numbers of temperature sensors (RTD) per phase shall be provided at LV side, all wired up to TB. Aux. power supply for the scanner shall be fed using DP MCB.

2) For remote Winding temperature indication, the Scanner shall be provided with two 4-20 mA isolated signal in one phase (preferably Y phase) for interface with plant automation system & indication.

12.0 MARSHALLING BOX

1) All outgoing connections from the transformer i.e temperature indicators, CT secondary, fault contacts for annunciation shall be wired to a marshalling box.

2) Made of CRCA sheet steel with min. 2mm thick, degree of protection of enclosure shall be IP55. Removable gland plate at bottom.

3) DP MCBs shall be provided at the AC Aux Power supply incoming & distribution. MB shall have 5-15A, 240V switch with 6 pin socket, space heater with thermostat, protection DP MCB, door switch operated LED illumination lamp.

4) Control wiring within marshalling box shall be done using 1.1KV grade, minimum 1.5sq.mm multistranded FRLS copper wire.

5) Secondary leads of bushing CTs shall be brought to the marshalling box with 4 sq.mm copper armoured cable.

6) Door shall be provided with toughened glass for clear visibility of digital scanner from outside.

13.0 OFF-CIRCUIT TAP LINK

1) Bolted link type within enclosure, with easy accessibility. Suitable and convenient access door shall be provided.

2) Designed for sustained over current of at least 150% of the rated current of the winding

3) Tap position configuration diagram shall be provided on the access door.

14.0 RATING PLATE

Each transformer shall be provided with a stainless steel rating plate giving the details as per IS:2026 (Part-I). The marking shall be indelible (engraved by itching) and the rating plate shall be located on the front side. Exact value of transformer % impedance, as determined by tests shall be engraved on it.

15.0 EARTHING

1) All metal parts of the transformer with the exception of individual core laminations, core bolts, and clamping plates shall be maintained at fixed potential by earthing.

2) Two tinned copper earthing terminals with nuts, washers etc. to be provided at diagonally opposite corners suitable to connect 75x12 GI strip.

16.0 NOISE

Noise level shall be low and shall be within limit depending on the rating of the transformer as per Table 8 of IEEE C57.12.01-1988.

17.0 TRANSFORMER LOSSES

The transformer losses have not been specified in IS-11171. Accordingly transformer

losses as per the prevailing ECBC-2017 is indicated below. In case Indian standard is updated with the loss values at the time of approval of drawing, the same shall be applicable. Alternatively the losses indicated below or the latest ECBC published shall be applicable.

Sl.No.	Dry type transformer Rating kVA	Max. Losses at 50% Loading (kW)	Max. Losses at 100% Loading (kW)
		Up to 22kV class	
1.	630	3.34	8.82

18.0 LIST OF FITTINGS AND ACCESSORIES

Following mandatory fittings and accessories shall be provided over and above the requirement as per TS and standards

1) Identification plate and Rating & diagram plate (Stainless Steel)
2) Off-circuit tap link along with tap connection plate
3) HV, LV and neutral bushings.
4) Earthing terminals and lugs
5) Inspection doors & cover
6) By-directional flat rollers with locking arrangement
7) Lifting lugs and jacking pads.
8) Haulage holes.
9) Danger plate indicating “Entry prohibited under energized condition"

05.03.06 LOW VOLTAGE SQUIRREL CAGE INDUCTION MOTOR

Sl.No.	Parameters	Description
1.0	**Standard**	IS 12615/ IEC 34 & IEC 72
2.0	**Constructional Features**	
(i)	Frame size & rating	As per IS 1231. However, kW ratings of continuous

		(S1) duty motors shall be selected from Standards motor ratings as indicated in Appendix-1 (Table-1A)
(ii)	Motor body	Grey iron casting as per IS:210
(iii)	Motor Feet	Integrally cast with the stator
(iv)	Protection for Motor & Bearing	IP – 55 (with canopy for motor if installed outdoor)
(v)	Shaft ends & Extension	Cylindrical as per requirement Proper drilling and tapping shall be provided for mounting of tachos for speed feedback (if required)
(vi)	Bearings	- For motor of rating upto7.5 kW, ball bearings shall be used for both DE & NDE end. - For ratings above 7.5 kW the DE shall be provided with roller bearing and NDE shall be provided with ball bearing. - Bearings shall be suitable for running of motor in either direction. - Motors above 280 frame size shall be provided with grease nipples for in situ greasing.
(vii)	Hazardous Area safety design	As per Hazardous area classification requirement conforming to latest Indian Standard& OISD Guideline. Motors shall have EX-d / Ex-de flame proof enclosure with increase safety terminal box.
(viii)	Greasing point	At DE & NDE sides .
3.0	**Terminal box**	
(i)	Location	RHS viewed from DE / On top
(ii)	Suitability	- 4 Core Al/Cu Cable - Extension shall be done to receive the aluminium cables to avoid cramping of the cables in the terminal box .

(iii)	Rotation	4 X 90 deg.
(iv)	Earthing stud	Inside Terminal Block for termination of 4th core
4.0	**Cooling**	- TEFC (IC-411) - Effective irrespective of direction of rotation
5.0	**Quality of operation**	
(i)	Vibration intensity	Shall be limited as per IS 12075
(ii)	Noise level	As per IS: 12065-1987
(iii)	Balancing	Motors shall be dynamically balanced with full/half key on the shaft- end and fan
6.0	**Electrical design**	
(i)	Power Supply	415 V 3 phase with variation as mentioned
(ii)	Starting& Rotation	Starting- DOL, Rotation suitability – Bidirectional
(iii)	Min Voltage for Start & Run	85 % of rated voltage at terminal
(iv)	Starting Torque	>= 160 % Rated Torque
(v)	Breakdown or pullout torque	Minimum 200 % of the rated torque
(vi)	Starting current	Shall be as per latest edition of IS 12615.
(vii)	Duty	S1/ as specified in TS/ As perprocess requirement
(viii)	Starts/Hour permissible	3 in quick succession from cold or twoin quick succession from hot start, under rated load condition..
(ix)	Max speed permissible	120% over speed for 2 minutes
(x)	Overload capacity	Capable of withstanding 160% Overload for 15 sec.
(xi)	Efficiency	Shall confirm to IS 12615-2011 or latest edition.
(xii)	Derating	Motor designed at 40 deg.C shall be derated suitably for mentioned ambient temperature .
(xiii)	Motor connections	Motor with frame size 90 shall be connected in star and of frame sizes more than 90 shall be connected in delta

		For delta connected motors 6 leads shall be brought out .
(xiv)	Insulation	Class F
(xv)	Permissible temperature rise	Limited to class 'B' (120 deg absolute)
(xvi)	Torque Type	Normal / High / High slip type / Stall Torque type (as required for the specific application)
(xvii)	Space Heater	Out door motors above 45 kW Indoor Motors above 110 kW
(xviii)	No. of Poles	4 pole (unless specific drive requirement or economics call for other poles).
(xix)	Testing	As per approved QAP during engineering stage.
(xx)	Mounting	Normally horizontally foot mounting. Other type of mounting as per specific requirement.
(xxi)	Earthing	2 nos. on the body on the opposite side and one inside the TB.

- Effective equipotential bonding straps toguard against the occurrence ofsparksdueto presence ofcirculating currents shall beprovided intype Exn,ExeandExpmotors.

05.03.07 HIGH VOLTAGE SQUIRREL CAGE INDUCTION MOTOR

A) HIGH VOLTAGE INVERTER DUTY SQUIRREL CAGE INDUCTION MOTOR

S.N	Parameters	Description
1.0	**Type**	• HT Squirrel cage induction motor. Voltage grade shall be 6.6 kV. • Inverter Duty
2.0	**Standard**	IEC 60034& OTHER STANDARDS
3.0	**Constructional Features**	
i.	Frame size & rating	As per IEC
ii.	Stator Frame	Fabricated Steel / High grade cast Iron

iii.	Stator Core	Laminated sheets of high grade low loss silicon steel
iv.	Motor body	Grey iron casting as per IS:210-1978
v.	Casing Feet	Integral with the motor frame
vi.	Body Design	Prevent breakage or other failures due to vibrations normally encountered in heavy industries
vii.	Protection for Motor & Bearing	IP – 55 as per IS 4691-1985.
viii.	Shaft ends	Forged Steel shaft.
ix.	Bearings	Bearings shall be decided during Engineering stage as per Recommended by Compressor supplier Lubricating oil temperature and pressure to be measured and monitored.
x.	Bearings insulation	Against circulating shaft currents
xi.	Hazardous Area safety design	As per Hazardous area classification requirement conforming to latest Indian Standard Motors shall have EX-d / Ex-de flame proof enclosure with increase safety terminal box.
xii.	Indication of direction of rotation	By Arrow blocks on non-driving end. Motor shall be capable of bidirectional rotation.
xiii.	RTD & BTD (PT100 type)	• All motors shall be provided with PT100 type (duplex) 6 nos. or (simplex 12 numbers) stator winding temperature detectors & 2 nos. Bearing (DE & NDE) temperature detectors (duplex) for monitoring alarm and trip conditions. • For HT motors, temperature of each RTD (for winding , bearing) should be taken to VFD drive for monitoring and control. Through Industrial Ethernet communication, temperature parameters will be communicated to main Plant automation system (DCS) for online monitoring. Limit value contacts for alarm and tripping shall be generated in the VFD along with the display of winding and bearing temperature. • Local Dial Gauge to be provided for DE & NDE Bearing temperature indication for Motors rated 1000kW and above.
xiv.	Vibration probes &	• Shall be provided for X and Y axis at DE & NDE

	Vibration Monitor	end of motor bearing. • Accordingly vibration pads shall be provided. • Vibration monitoring shall be achieved by providing Vibration monitors at field (pedestal mounted). • Vibration monitors shall connect with VFD drive for monitoring and control.
xv.	Paint shade	RAL 7030
4.0	**Terminal box**	
i.	Protection	IP – 55
ii.	Type	Main TB - Phase segregated Neutral TB- Non-Phase Segregated.
iii.	Location	RHS viewed from DE , On top 01 number for Main & neutral TB, each on opposite sides of motor. Neutral TB located opposite to main TB
iv.	Suitability	Termination of XLPE cables with heat shrinkable cable end seals. Each terminal box to have two inlets to accommodate any parallel cables as required.
v.	Reversible	To suit cable entry from Top , Bottom
vi.	Earthing stud	Inside Main TB for protective earth conductor termination
vii.	No. of additional terminal boxes	Separate TBs for Space heaters, RTDs,BTDs, Vibration monitor etc.
viii.	Fault withstand (Min.)	Rated Short circuit level of the system voltage for 0.25 sec
ix.	Interchangeability	Line side & Neutral side TBs shall be interchangeable considering bolt position & placement of Cable Box
5.0	**Cooling**	TEFC / CACA / CACW. CACW system shall be complete with temperature and pressure monitoring devices(If required).
6.0	**Quality of operation**	
i.	Vibration intensity	Shall be as per IS 12075.
ii.	Noise level	Shall be as per IS: 12065-1987.
iii.	Balancing	Dynamically balanced with full, half key on shaft end and fan
7.0	**Electrical design**	
i.	Efficiency	High efficiency design of 95% or higher at Full load
ii.	Starting& Direction of Rotation	Variable Frequency Drive. Direction of Rotation – Bidirectional.
iii.	Min Voltage for Start &	85 % of rated voltage at terminal.

	Run	
iv.	Starting Torque	To be provided to Tenderer after process fan supplier is finalized.
v.	Starting current	Controlled by VFD. Limitation as per VFD design.
vi.	Load Type	Variable Torque for Fan application
vii.	Peak transient voltage	Shall be as per VFD manufacturer requirement.
viii.	Minimum rise time	Shall be as per VFD manufacturer requirement.
ix.	No. of Poles	As per scope of work indicated in this TS
x.	Duty	Continuous, inverter duty and suitable for Process Fan application.
xi.	Stall time	• Minimum 60 sec for constant torque applications • Higher stall time as per application requirement
xii.	Starts permissible	Not applicable
xiii.	Starts / hour	Not applicable
xiv.	Overload capability	150 % of the rated current for 2 minutes at rated voltage and rated frequency.
xv.	Max speed permissible	120 % rated for 2 minutes
xvi.	Insulation	• Class F insulation with temperature rise limited to class B. • Insulation materials with additional phase insulating material, extra end-turn bracing.
xvii.	Impregnation of wound stator	VPI
xviii.	Derating for VFD	As per manufacturing and design standards
xix.	Space Heater	Required & automatically off during RUN
xx.	Surge protection	As required
xxi.	Field instruments	All field instruments for motors (i.e Transducers, Flowmeter, Flow switch, Vibration sensors, field digital displays and LCS components) shall be envisaged.

Note: Motors with heaters installed inhazardous atmospheres (Zone-1 orZone-2), shallconform totheprovisionsofar applicableIndianstandardsandtemperature classification.

- Effective equi potential bonding straps toguard against the occurrence ofsparks dueto presence ofcirculating currents shall beprovided intype Exn,ExeandExpmotors.

CERTIFICATION

The motors and associated equipment shall havetest certificates issued byrecognized independent test house (CIMFR/PESO/Baseefa/LCIE/UL/ **FM**orequivalent). All indigenous motors shall conform to Indian Standardsand shall becertified by PESO/CCOE/CMIFR. All motors (indigenous and imported) shall also have valid

statutory approvals asapplicable forthespecified location. Allindigenous flameproof motors shall have valid BISlicense &marking asrequired bystatutory authorities. Exnmotors shall besupplied with manufacturer's certificate ofconformity to IS-9628 or equivalent international standard andIndianstatutory approval.

14.0 **SPECIAL NOTE TO PACKAGE VENDOR**

Thesupply ofMotors/Inverter duty Motors isinthescope ofdriven equipment package vendor, then it istheresponsibility ofthedriven equipment package vendor tocheck thesuitability ofthe drive/motors and use in the particular hazardous area /zone.

05.03.08 Power Factor Compensation Equipment

The power factor compensation equipment is envisaged at 6.6 kV Bus for improvement of the overall power factor of 0.96 lag above upto 0.99lag .

The equipment shall comprise capacitor unit of suitable rating connected in single star formation, series air core reactor, busbars, lightning arrestors, isolators and discharge PTs etc. to render the installation complete and safe for intended operation.

Internal discharge resistors shall be designed as per IS to reduce the voltage to 75V or less.

The Bidder shall submit the sizing calculation capacitor bank. The desired power factor shall be maintained as described above.

The 6.6 kV bus section-1 & 2 shall be connected to capacitor banks of suitable rating with series air core reactor.

Capacitor feeder shall have minimum following protections:

a. O/L (by detecting harmonics also)
b. Under current
c. Unbalance (through NCT)
d. Inhibition to switch on for a time delay (user defined)
e. Short circuit
f. Over voltage

(Protections a to d shall be achieved through micro-processor based communicable type numerical relay.)

Capacitor Bank

Details of HT capacitor Bank

1.	Type of connection	:	Star, isolated neutral
2.	Bank rating in kVAR	:	As required.
3.	Bank rating in capacitance	:	As required.
4.	Method of mounting	:	Structural rack
5.	Type of steel	:	Galvanised steel with minimum galvanization of 900 gm/sq.m.
6.	Bank formation	:	By copper busbars taped to full insulation level.
7.	Insulation level	:	60 kV (impulse) 20 kV (rms) (power frequency)
8.	Busbar support insulators	:	For rated insulation with min. total creepage distance of 31 mm/kV of highest system voltage.
9.	Installation	:	Indoor.
10.	Protection	:	Each capacitor unit shall have external HRC fuse characteristic shall match with tank bursting characteristics of capacitor unit for proper protection. Internal Fuse shall also be acceptable as per manufacturer standard
11.	Discharge devices		Directly connected discharge devices to reduce the residual voltage from the crest value of rated voltage to 50 volts or less within 10 sec. after the capacitor is disconnected from the source of supply.
12.	Earth connection	:	Each capacitor units shall have distinct earth terminal clearly marked.

13.	Accessories	:	All structures insulators, clamp foundation bolts etc.
14.	RVT (for quick discharging and Unbalance protection)	:	3 phase star/open delta

Reactors

1.	Duty	:	Current limiting reactor in capacitor circuit.
2.	Standard	:	IEC 289
3.	Location	:	Indoor, live busbar connection between capacitor and reactor.
4.			Type : Single phase, dry insulated air cored natural air cooled.
5.	System voltage	:	6.6 kV
6.	Conductor	:	Copper
7.	Reactance	:	6%
8.	Rating – current - kVAR	: :	As required As required.
9.	Insulation	:	Class F
10.	Fitting and accessories	:	As per requirement
11.	Over voltage	:	110% (continuous)
12.	Over current	:	130% (continuous)

05.03.09 NEUTRAL GROUNDING RESISTOR (TO BE INSTALLED WITH POWER TRANSFORMER NEUTRAL)

NGR shall be used in 6.6 KV system to limit earth fault current.

NGR shall be located outdoor in transformer yard and connected to secondary side of Power transformer.

Enclosure shall be of outdoor duty and with rain protection. Temperature shall be limited to 375^0C at maximum ambient of 50^0C. Temperature rise of enclosure shall be within safe limit.

Material of the resistance grid shall be punched steel. NGR shall be designed for 30 second.

Single pole isolator shall be provided on incoming side. Porcelain insulators shall be used to support the resistance grid. Isolator shall have locking provision.

NGR panel shall be supplied along with single core Aluminium HT cable (to be provided by purchaser free of cost) and termination kits to connect primary side and to connect earth electrode. Outgoing cable shall not be connected with the panel sheet. Panel shall be earthed separately.
Suitable earthfault leakage relayandalarmforfailure ofNGRshallbeprovided.

Technical Requirement of NGR

1.	Rated system voltage	:	6.6 kV
2.	System earthing	:	Resistance earthed
3.	Resistance value	:	As per NGR Rating
4.	Rating	:	Shall be decided during Engg
5.	Supporting /fixing structures	:	To be provided by the contractor

05.03.10 415V SWITCHGEAR (LTPCC-LT POWER CONTROL CENTRE)

1.0 TECHNICAL PARTICULARS AND DESIGN PARAMETERS

Sl. No.	PARTICULARS	PCC

Sl. No.	PARTICULARS	PCC
1.	Type	Metal Enclosed, Floor Mounting, Free standing, natural air cooled type
2.	Service	Indoor
3.	Enclosure IP	IP4X or better
4.	Standard	
	i) Switchboard/ PCC	IS/ IEC 61439-1 & 2 : 2011
	ii) Circuit Breaker	IS/ IEC 60947-1 & 2 : 2017
	v) Instrument Transformers	IS 16227:2016/ IEC 61869:2012
5.	Nominal system voltage (V)	415 V
6.	Rated insulation level (V)	690V
7.	Power frequency withstand voltage (kV) rms for 1 minute	Power circuit - 2.5 kV Control circuit – 1.5kV
8.	Peak impulse test withstand voltage (kVp)	12 kVp if with ACBs only 8 kVp if with MCCBs also
9.	Form of internal separation	Form 3B
10.	No. of phases and frequency	3ph, 4 wire. 50 Hz
11.	Design Ambient	50 Deg C
12.	Design Altitude	As mentioned above
13,	System Earthing	Neutral Solidly Earthed
14.	Short Circuit Rating (kA rms) & withstand duration	50 kA for 1Sec
15.	Control & Aux supply	
15.1	Control Voltage	240/110V AC as applicable
15.2	Control & auxiliary supply changeover scheme	Auto with Manual provision
15.3	Spring charge motor voltage	Same as control voltage
12.4	Aux supply voltage	240V AC
15.	Busbar	

Sl. No.	PARTICULARS	PCC
15.1	Bus Color code	RYB
15.2	Busbar Material	Aluminium
15.3	Busbar Rated Current	1250A
16.	Circuit Breaker	
16.1	Type	Air Circuit Breaker, drawout type
16.2	Operating mechanism – For incomers and buscoupler	Motor operated spring charged stored energy drawout type. (EDO)
16.3	No of poles	3 pole/ 4 pole
16.4	Continuous Current Rating (A)	For IC & BC – As per bus rating For outgoing- As per load requirement.
16.5	Short Circuit Rating (kA)	50 kA for 1Sec
16.6	Rated making Current (kAp)	2.1 times for Short circuit rating upto 50kA 2.2 times for short circuit rating beyond 50kA
16.7	Tripping mechanism	Shunt trip and series trip (release)
16.8	Auxiliary contacts	Minimum 4 NO + 4 NC
17.	Current Transformer	
17.1	CT Ratio	Secondary Current 5A (Primary as per design & load)
17.2	VA Burden	Actual as per the calculation during DE. 50% loading to be considered.
17.3	Accuracy	Class 1.0 for metering
18.	Potential Transformer	
18.1	Configuration	STAR/ STAR/STAR
18.2	Ratio	(415/√3) / (0.11/√3) / (0.11/√3)
18.3	VA Burden	Actual as per the calculation during DE. 50% loading to be considered.

Sl. No.	PARTICULARS	PCC
18.4	Accuracy	0.5/ 3P
19.	Clearance in air	P-P = 25mm P-E = 19mm
20.	Feeder Arrangement	
20.1	Incomer (Mounted in single tier arrangement)	Air circuit breakers
20.2	Outgoings Single Tier > 800A CB Double tier <= 800 A CB Multitier for 630A & below MCCB	Air circuit breakers upto 630A MDO ACB/ MCCB
21.	Termination requirement	Incomer – Cable from bottom Outgoing - Cable from bottom
22.	Gland plate thickness	For 3 core cable – 3.0mm CRCA For single core cable – 5.0mm AL
23.	Auto changeover scheme with momentary paralleling with microprocessor based under voltage relay, PT, contactors, timers etc.	To be provided
24.	Type tests to be conducted, if any	Type TC for same rating and similar design panel to be submitted.

2.0 General Requirement

1) The PCC shall be of metal clad, self standing, floor mounting, indoor cubicle type, compartmentalized construction, fitted with circuit breakersin fully draw out execution.
2) The PCC and circuit breakers used in the panel shall be fully type tested as per latest applicable IS/ IEC standard.
3) The panel shall be constructed with CRCA sheet steel. Sheet steel thickness shall be minimum 2.0 mm for load bearing members & 1.6 mm for non load bearing members.
4) Integral base frame of 75mm height and painted black shall be provided for each PCC. The base frame shall be made up of ISMC or equivalent thickness sheet steel.

5) All circuit breaker cassette of same rating shall be identical in all respects and shall be interchangeable with similar breaker panel. However, it shall not be possible to insert circuit breaker of lower current rating into cubicles of higher current rating.

6) All circuit breakers in a particular project shall be of same make, model & design expect for the continuous current rating.

7) In case any of the incomer of a PCC is fed by DG set power, all the incomer and buscoupler circuit breakers of that PCC shall be of 4 pole. All other breakers shall be of 3 pole.

8) All the provisions for necessary signals and interlocks shall be decided during engineering stage

3.0 Mechanical Design

1) PCC shall be extensible on both sides. All the outgoing feeders will have uniform depth.

2) Removable lifting arrangement for each transport unit shall be provided.

3) Where more than one cable have to be terminated per unit, the arrangement shall permit connection and disconnection of individual cables separately without disturbing other cables.

4) Double, compression type brass cable glands and crimping type, tinned, heavy duty copper lugs suitable for the type, size and number of cables to be terminated, to be supplied with the PCC for all LT power and control cables

5) Doors shall be provided with padlocking provision

6) Back covers with handles shall be provided in two parts for easy handling.

7) The controls, indicating lamps, relays and meters shall be mounted on the panel in separate control cubical and shall be mounted for uniform appearance.

8) Each PCC cubicle shall have mimic diagram in the front and rear of the panel. This shall be painted. Colour of strip shall be finalized during detailed engineering. Mimic shall be 10mm wide for busbars and 7mm wide for others. Stickers are not acceptable.

9) Continuous earth bus shall be provided throughout the board and shall be brought out of the PCC at both ends for connecting to earth pits.

10) The position of various control switches, push buttons, levers etc requiring manual operation shall be at a height not less than 450mm and shall not exceed 1850 mm from the finished floor level.

11) Each panel shall have 5-15A, 240V switch with 6 pin socket, space heater with thermostat, protection MCB, door switch operated LED illumination lamp.

4.0 Main Bus Bar and Connections

1) Three phase, neutral power busbars made of EC grade aluminium alloy equivalent to grade 63401 or 91E WP as per IS 5082, 1998(R2003), size adequate for specified rated continuous and SC current.

2) Cross-section of horizontal phase and neutral bus shall be uniform throughout the PCC. The neutral busbar shall be rated for at least 50% rating of the main bus bar.

3) The busbars (horizontal as well as vertical) shall be insulated by heat shrinkable, non tracking, low absorption type colour coded PVC sleeve.

4) Temperature rise of bus bars shall not be more than 40 deg. C above the specified design ambient temperature.

5) The continuous current rating of the main horizontal bus shall be same as that of incomer circuit breakers.

6) The vertical bus rating

For incomer	:	Not less than that of horizontal bus
For outgoing	:	Not less than that of the outgoing breaker, irrespective of relay setting or CT ratio.

7) Jumpers in cubicle shall be of same current rating as breaker.

8) Both horizontal and vertical bus bars to be designed and supported to withstand the thermal and dynamic stress corresponding to rated short time and peak withstand current specified.

9) Bus bar joints and tap off connections of bolted type with type of bolts as per the short circuit type tested panel.

10) Busbar supports shall be provided as per the short circuit type tested design. Bus bar support shall be of non-hygroscopic material having high impact and dielectric strength.

5.0 Auxiliary Buses for Control Supply

1) AC supply buses for both control and aux supply shall be provided.

2) These busses shall be electrolytic grade tinned copper busbar with proper tap-off arrangement for each feeder.

6.0 Control & Auxiliary Supply

1) Control & Auxiliary supply buses shall run throughout the switchgear.

2) Two nos. 415/240V control transformers (one in each bus section) of adequate (minimum 1.5kVA) rating with Auto, independent and Manual selector switch shall be provided for reliable control supply in each PCC.

3) MPCB/MCCB shall be provided on incoming sides of control transformer and DP MCB for outgoing side.

4) Two numbers AC incoming feeder for auxiliary supply shall be taken in each PCC controlled by MCB's. Failure of any AC supply shall be monitored & annunciated in the PCC as well as PFC for remote annunciation shall be given.

5) Each feeder panel shall have one DP MCB each for controlling its auxiliary and control supply.

6) Sub circuits shall be protected with DP MCB in each feeder panel for indication circuit, closing circuit, spring charging motor and tripping circuits separately.

7.0 Internal Control Wiring

1) Control wiring shall be carried out by 1100V grade FRLS PVC insulated, single core multi stranded copper wire of minimum cross section 1.5 sq. mm except for power circuit and CT circuits which shall be 2.5 sqmm.

2) Flexible wires protected against mechanical damage for wiring to door mounted devices shall be provided. No bunch of wire shall contain more than 12 wires.

3) Wires identified at each end in accordance with schematic diagrams by printed type ferrules.

4) All connections external to a feeder, all the auxiliary contacts of the breaker shall be brought to terminal blocks.

5) Interconnection between panels of adjacent shipping sections to be brought out to a separate terminal block, wires for interconnection properly labeled, looped and bunched inside the panel for connection at site.

6) Wiring shall not be joined or tied between the terminal points.

7) Not more than two connections shall be provided on any one terminal.

8) All spare contacts shall be wired to TB.

9) All telemetering signals shall be wired to separate set of terminal strips.

8.0 **External Terminations**

8.1 Control Terminations

1) **800V grade** stud type terminal blocks made of polyamide material (STH4 of connectwell or OAT6 of Elmex or Equivalent), washers, nuts and identification strips shall be provided.

2) All terminals going out of the switch board shall be brought to a separate terminal block marked "External Termination". These will be easily accessible. Terminal blocks in separate groups shall be provided for SCADA/ Automation, remote control panels, transformer marshalling boxes, local push button stations, etc.

3) External terminal block shall be provided with proper truff arrangement for cable dressing. Terminal blocks shall be placed separately for internal looping and external looping.

4) All CT and PT wires shall be first brought to disconnecting type TBs.

5) Overall 20% spare terminals in each feeder shall be provided. The spare terminals shall be distributed appropriately during design stage.

8.2 Power Terminations

1) Suitable for accepting cable/bus trunking as specified/ required.

2) Extension bus links properly spaced for terminating single cables of size 120 sq. mm and above as well as for terminating multiple cables of all sizes.

3) Sufficient space and support arrangement inside each panel to accommodate required size and number of cable runs.

4) Where more than one cable have to be terminated per unit, the arrangement shall permit connection and disconnection of cables separately without disturbing other cables.

9.0 Breaker Handling Truck

1) One breaker handling truck for each PCC, for withdrawing the breakers out of the PCC for maintenance.

2) Height of platform continuously adjustable with locking arrangement at any required level to suit the levels at which the breakers are mounted.

3) Adequate mechanical strength for handling the largest breaker.

4) Guide rails and stops shall be provided for safety.

10.0 Protective Earthing

1) Continuous earth bus of minimum size 50 x 6 mm copper or equivalent aluminium, designed to carry the peak short circuit and short time fault current as specified.

2) Provided at the bottom extending throughout the length of the board, bolted/brazed to the frame work of each panel with an earthing terminal at each end for terminating external earth conductor.

3) Vertical earth bus for earthing individual functional units, as applicable.

4) All non-current carrying metal work (including metallic cases of instruments and other panel mounted components effectively) bonded to the earth bus.

5) Hinged doors earthed through flexible multi-stranded insulated copper wire.

6) Looping of earth connection resulting in loss of earth connection to other devices when the loop is broken not permitted. No looping is allowed for connection of multiple components to earth bus.

7) Withdrawable units provided with self aligning, spring loaded, earth contacts ensuring earth continuity from service to the test position.

11.0 Protection Requirement

11.1 Electrical Protection

Selection of protective scheme will be based mainly on reliability, sensitivity, selectivity. All main protections shall be fast acting type in order to clear the faulty system from the healthy system in earliest possible time to minimize damage to equipment and ensure continuity of power supply.

11.2 Protective scheme requirement

1) Each circuit breaker shall be provided with micro processor based communicable release with LSIG protection as detailed in the speciation of circuit breaker.

2) Release ranges, exact type & number of aux. relays, timers shall be finalized during drawing approval stage. Further requirement of aux relays shall be as follows:

   a) Each incomer and buscoupler will be provided with master trip relay. Master trip relay shall be hand reset and shall have 2 NO and 2 NC contacts wired to TB in addition to those required by the protection/control scheme.

   b) VAA type/ Equivalent aux. relays shall be provided for each transformer fault and each external signal interface except emergency stop PB signal.

   c) Incomer of PCC when fed from transformers shall be provided with CDG 11 relay for standby E/F

   d) For contact multiplication of circuit breaker, only bi-stable aux relays shall be used.

3) Contact arrangement, number of poles/ways in control/selector switches shall be finalized during drawing approval stage.

4) Each incomer/ tie feeder shall have provision to receive inter trip from the other end feeder. Each outgoing feeder shall be provision to give inter trip signal to the downstream feeder.

12.0 Measuring and Indicating Instruments

1) All indicating instruments shall conform to IS : 1248-2003 and IS - 2419-2012.

2) Shall be capable of withstanding system fault current taking into account CT saturation.

3) Shall be back connected, flushed with control cubical door.

4) Shall have square flush case, non-reflecting type, clearly divided and indelibly marked scales, sharply out lined pointers and zero adjusting device.

5) All analogue meters shall be taut band type having size of 96 sqmm.

6) The minimum scale reading shall not be more than 10%. Maximum reading shall be 150% full load for outgoing feeder and 600% of full load reading of motor feeder. 120% to 600% shall be compressed scale for motor feeders.

7) Class of accuracy shall be 1.0 or better for analogue meters and 0.5 for digital meters.

8) Digital multi function meter (MFM) shall be provided for each feeder unless specified otherwise. MFM shall be provided with Modbus RTU communication port for connection to SCADA. The MFM shall be true rms type, have accuracy class of 0.5 for all the parameters. The MFM shall be 3 line 7 segment, 31/2 digit LED display, external powered, site configurable for CT/PT ration, 3 Phase measurements. Display-Current, Voltage, Active & Reactive power, PF, frequency, four quadrant active, reactive and apparent power & energies, THD & Individual voltage & current harmonics indications. MFM shall be suitable for harmonic measurement & display up to 31st harmonic.

9) MFM with Modbus RTU protocol shall be looped with shielded wire for communication. Max 8 devices per loop shall be considered. All looping to be brought to one panel where RS 485 to Ethernet converter shall be installed for external connection to SCADA/ Automation system through Ethernet switch.

Thedetailsof metering requirement are elaborated below. This shall be utilized to finalize the metering requirement during detailed engineering.

Sl No	Type of feeder	Protection
1	Incomer/ Buscoupler/	• Analog Ammeter with ASS -1 Nos • Analog Voltmeter with VSS-1 Nos • Digital Multifunction meter-1 No,
2	Outgoing feeders	• Analog AmmeterwithASS- 1 No

13.0 Circuit Breaker

13.1 Operating Mechanism

1) Air break, gang operated, motor operated spring charging, trip free mechanism.
2) Spring charged stored energy mechanism to ensure high speed closing and tripping independent of operating forces.
3) Closing spring charged through universal motor with provision for manual charging through handle, insertion of handle to decouple the motor. Motor shall be automatically disconnected when the spring is charged. Spring charging motor shall operate between 85-110% of the specified voltage.
4) Spring charging motor to automatically charge the closing spring for next closing operation when the breaker is closed.
5) Closing and tripping initiated through AC operated coils designed to operate at 85-110% and 70 - 110% of rated control voltage respectively. Additional provision for closing and opening without electric power by mechanical means shall be provided.
6) Trip free feature for all means of closing. Anti pumping feature to be provided
7) Non-reset type operation counter to be provided for each breaker.
8) Mechanically operated close and trip push button (shrouded to prevent accidental operation) acting directly on the trip bar.
9) Mechanical indication shall be provided to show:
   - Breaker ON,OFF & TRIP
   - Closing spring charged & discharged.
   - Service and test position

13.2 Drawout Features

1) Distinct fixed positions viz SERVICE, TEST and ISOLATED.
2) Latching facility for the fixed positions inside the panel
3) Provision to move the breaker from one position to another through a detachable device from outside without opening the door.
4) Power connections - Self-aligning, plug-in type. type tested design

13.3 Safety Interlocks

1) Breaker cannot be closed in any intermediate position other than the fixed positions.

2) With the breaker closed, it cannot be moved from any of the position to another.

3) Automatic safety shutters to prevent accidental contact with live parts when the breaker is withdrawn. Insertion of breaker into `Service' position not possible if safety s are not free.

4) Mechanical stopper to prevent accidental falling while withdrawing.

5) Rack in / out of circuit breaker from isolated to test as well as test to service position and vice versa shall be allowed only with door closed. Door interlock shall have defeat feature.

6) It shall not be possible to open the circuit breaker enclosure when the breaker is ON or to have access to any part of the draw out assembly which is live when the circuit breaker is in the service position.

7) Remote closing of breaker not permitted with door open.

13.4 **Microprocessor based releases**

1) General

a) The micro processor based release unit shall be interchangeable on site for adaptation to changes in the installation.

b) Sensors used shall be non-magnetic or of the Rogosky type for accurate current measurements. This will have tapping match the actual load current

c) The release shall measure the true RMS value of the current.

d) The release shall have thermal memory to store temperature rise data in the event of repeated overloads or earth faults. It shall be possible to disable this function if necessary.

e) The display on the release shall be functional even after failure of complete power supply to the power bus. For this, either inbuilt rechargeable cells or external UPS supply shall be used.

2) Protection

The release shall offer the following protection functions as standard. The tripping curve shall be site selectable to achieve total protection discrimination.

a) Long-time (LT) protection with an adjustable current setting and time delay;

b) Short-time (ST) protection with an adjustable pick-up and time delay;

c) Instantaneous (INST) protection with an adjustable pick-up and an OFF position.

d) Earth-fault protection(G) with an adjustable pick-up and time delay shall be provided.

Current and time-delay settings shall be indicated in amperes and seconds respectively on a digital display.Acknowledgement that the setting change should translate to the trip threshold.

3) Communication

The circuit breaker shall be capable of communicating the following data on open protocol through the release:

a) Circuit-breaker status (open/closed, connected/ disconnected/ test, tripped on a fault, ready to close);

b) Release settings;

c) Tripping causes and tripping status data;

d) The measurements processed by the Release - current, voltage, frequency, power etc

e) It shall be possible to remotely control the circuit breaker through the release.

14.0 Current Transformer (CT)

1) CT's shall be nylon encapsulated window type.

2) Short time ratings and insulation level of CT's shall be similar to rating of associated breaker.

3) the metering CT's shall have 1.0 class of accuracy with ISF of <=5, unless otherwise specified.

4) The CT ratios & VA burden shall be finalized during detailed engineering as per the load requirement and burden calculation.

15.0 Potential Transformers (PT)

1) PT shall be of cast resin insulated type having insulation class B.

2) Accuracy class 0.5/3P shall be used unless specified otherwise.

3) VA burden shall be selected based on meters and relays connected with the PT and the same shall be finalized during engineering.

4) PT shall be provided on line side and on bus for implementation of auto change over and momentary paralleling scheme

5) PT shall be protected by MPCB on primary side and MCB on secondary side.

16.0 Annunciation Schemes and Annunciators

1) Minimum 6 window annunciator shall be provided for outgoing feeders and 12 window annunciator shall be provided for all incomers and buscoupler.

2) Annunciation signaling (as applicable) on individual panels shall be provided:

   i) All transformer warning / signaling conditions

   ii) All feeder protection faults

   iii) Control supply failure

   iv) PT fuse failure / MCB tripping

   v) Bus-coupler failed to close on auto-changeover

   vi) Any other signal as decided during detailed engineering

3) Annunciator shall be of microprocessor based facia window type, programmable and suitable for NO/NC potential free contacts.

4) Two different audio signals for trip and alarm.

5) Test, accept and reset facilities (with push button) shall be provided for each Annunciator.

6) 20% spare fascias shall be provided subject to minimum 2 windows. Spare annunciation points shall be wired upto terminal blocks.

7) Clustered LED's with high light intensity shall be used in the Annunciator window.

8) All trip signal facia shall have red color and non trip signal white color.

9) The cover plate of facia shall be flush with panel.

10) It shall be capable to receive simultaneous signals.

11) It shall be capable to receive signal during testing mode.

12) It shall be ensured that spurious signals due to influence of external electromagnetic / electrostatic interference on the annunciation wiring and switching disturbances from neighboring circuits within panels does not affect the annunciation system.

Sequence shall be as follows

Description	**Visual**	**Audio**
On occurring of fault/ test	Flashing	On
On accepting	Steady on	Off
On reset (fault cleared)	Off	Off
On reset (fault persists)	Steady on	Off

17.0 Indicating Lamps

1) LED indication lamp shall be provided with Low voltage glow protection.

2) LEDs used shall be of the colour of the lamp

Color shall be as follows;

Type of lamp	**:**	**LED Colour**
On	:	Red
Off	:	Green
Trip on fault	:	Amber
Trip ckt. Healthy	:	White
Spring Charged	:	Blue
R,Y & B Phase	:	Red, Yellow & Blue

18.0 Control and Selector Switches

1) Control switches for circuit breaker ON/OFF control - 3 position spring return to neutral with lost motion device and pistol grip handle.

2) Other control and selector switches such as local-off-remote, Auto-manual changeover switch, Sync Selector switch, Trip selector switch etc as applicable - stay put type with wing type knobs.

3) Ammeter selector switches - 4 position, make before break type.

4) Voltmeter selector switches - 7 position unless specified otherwise

5) Contact Rating :

Continuous	10 amps
AC 11	4 amps, 240V
DC 11	0.5A, 110V, L/R - 40 ms

19.0 Push Buttons

1) Contact Rating :

Continuous	10 amps
AC 11	4 amps, 240V
DC 11	0.5A, 110V, L/R - 40 ms

2) Colour :

Accept	Blue
Reset	Black
Test	Yellow
Emergency Stop Push button (Mushroom head)	RED

20.0 Labels

1) Labels made on non-rusting metal, preferably Anodized Aluminium, with engraved inscription of black letters on white background and shall be riveted.
2) PCC designation nameplate at the center of the board with letters not less than 25 mm high.
3) Panel designation number on each panel, both in front and rear. (Min 10mm Height)
4) Inscription plate for each feeder, both in front and rear. (Min 5 mm height)
5) Door front mounted devices to have labels directly below them. (Min 3mm height)
6) Labels for equipment/component inside the cubicle shall be painted at base and sticker on equipment.
7) Label designation and size of lettering subject to approval.

21.0 Surface Treatment

All metal parts of the panel to undergo surface treatment that includes de-rusting, cleaning, chemically degreasing, pickling in acid, cold rinsing, phosphating and passivating followed by powder coating to shade RAL 7035 unless specified otherwise.

22.0 Auto Changeover and Momentary Paralleling Scheme

All the PCCs with sectionalized buses will be normally operated with the bus coupler breakers in open condition.

Auto / Manual / Independent changeover between the two normal incomers and their bus-coupler will be provided with the following features through appropriate selector switch. Necessary line under voltage and bus under voltage relays, timers etc for the scheme shall provided.

22.1 Auto Mode

For prolonged under voltage on any one of the bus sections, the respective incoming

breaker will trip and the bus coupler breaker will close provided the other bus section is healthy and bus coupler is selected for auto changeover. Total changeover time will be adjustable between 1 to 5 seconds. This auto changeover will be blocked if the incoming breaker had tripped on fault. In case bus coupler trips on auto closing, no further closing shall be permitted till the system is reset. Changeover back to the normal source of supply will be affected manually.

22.2 Manual Mode

Manual live changeover facility will be provided for all the PCCs. For planned outage of one of the normal incoming supplies, the respective selected incomer will be tripped automatically after the bus section breaker is closed manually. Also for restoration of normal power supply, the buscoupler will trip after the respective incoming breaker is closed. For this purpose, a trip selector shall be provided for selecting the breaker to be tripped and momentary paralleling shall be done after phase comparison of both the power supplies through check synchronization relay. Thus, depending on the selection made, the selected breaker will be tripped once all the three breakers are closed manually, thus maintaining continuity of supply for the complete PCC.

A timer with a time delay on pick up of 0.5. - 5 sec will be provided, for annunciation of the running breaker failing to trip within a preset time, (i.e. If the two sources remain paralleled for more than a preset time). Latest breaker tripping provision will be included in the changeover scheme for prolonged paralleling.

22.3 Independent Mode

Provision for manual independent (dead bus) closing of a bus-coupler after an intentional manual trip/ outage due to under voltage of any one incomer will be provided.

23.0 TESTS

For Testing Refer Testing chapter.

05.03.11 MOTOR CONTROL CENTRE(INTELLIGENT/NON-INTELLIGENT TYPE

	GENERAL	

1.0	Type	Non drawout type
2.0	Construction	Modular construction. Fully compartmentalized with metal / insulating material partition.
3.0	Enclosure class	IP54.
4.0	Type of execution	Single front.
5.0	Mounting	Floor mounting. Free standing with ISMC 75.
6.0	Installation	Indoor.
B. Constructional Features :-		
1.0	Sheet steel	
	Thickness	2.0 mm for load bearing members. 1.6 mm for non load bearing members.
	Material	CRCA
2.0	Cable entry	Incomer :- Bottom cable entry. Outgoing :- Bottom cable entry.
3.0	Design	Separate enclosed/isolated cable alley (minimum 275mm wide) for each vertical. Cable alley & module doors shall open opposite to each other. Extendable at both ends. Rear access through removable rear hinged cover door. All the components shall be accessible from front. Motor controller shall be flush mounted on the respective door. Interchangeable facility of same type of feeder modules in case of draw out design. Each module (draw out) to have covering at the bottom. ACB cubicle door shall also close when the ACB is

		in isolated position.
4.0	Interlocking & protection	Module door interlocked with main power isolating devices with defeat facility. Power circuit isolation device to have pad locking in the OFF position with door closed.
5.0	Operating height	Minimum :- 300mm.or as per type tested design conforming to IEC 61439 Maximum :- 2000 mm. Minimum 200mm vacant space shall be provided throughout the panel at bottom.
6.0	Gland plate	Undrilled removable bottom gland plates (3 mm thick).
7.0	Miscellaneous	Neosprene rubber gasket shall be provided for all the doors, removable covers & between adjacent covers. Lifting hooks for all the shipping sections. Doors shall have concealed hinges.
8.0	Labelling	Clear legible identification labels (anodized aluminium with white letters engraved on black background) with letter sizes of:- 25-50 mm for MCC panel in front and back side of the panel. 5 mm for components and module name plates. Danger board on front and rear sides in English, Hindi & regional language.
9.0	Earthing	Two separate earthing terminals shall be provided. Bolted joints with tooth spring washers for good earth continuity. Earth bus to run in all cable alley of the panel.
10.	Shipping length	To be limited to 2.4 M.
11.	Limiting dimensions	Width of MCC Vertical :- 775 mm (min) Width of Module :- 500 mm (min) Width of Cable alley :- 275 mm (min)

		Height of module :- 400 mm (min) for motor feeder, 300mm (min) for power supply feeders Depth of MCC :- 600 mm , maximum However depth of incoming ACB panel shall be 1200 mm (minimum). Can be accepted as per govt. acccridiated lab approved type test report and conforming to IEC-61439
12.	Panel space heater	In each panel with thermostat, DPMCB, switch.
C. Busbars		
(i) Main horizontal & vertical busbars		
1.0	Arrangement	Three phase & neutral. Bus Bar chamber on the top.
2.0	Material	High conductivity electrolytic aluminium alloy confirming to grade E91E as per IS-5082 -1981.
3.0	Phase Busbar Rating	Shall be able to carry continuously the connected load (considering diversity factor) plus a 25% margin. Minimum rating shall be same as incomer ACB/MCCB rating. Max. current density shall be:- 0.8 A/sq.mm for Aluminium. 1.5 A/sq.mm for Copper.
4.0	Neutral Busbar Rating	50% of phase busbar rating.
5.0	Short circuit rating	50 kA for 1 sec.
6.0	Busbar configuration	Red-yellow-blue from front to back or top to bottom or left to right as viewed from front.
7.0	Busbar insulation	Heat shrinkable PVC. R,Y,B coloured sleeves for phases.Black for neutral.
8.0	Busbar supporting insulators	Non-hygroscopic, Flame retarded. Track resistant.

		High strength. Sheet moulded compound or equivalent polysterfibre glass moulded type.
9.0	Max. temp. rise of bus	Not to exceed 40 deg. C. above ambient of 50 deg.C.
10.	Air clearance for bare busbar	Phase to phase :- 25.4 mm (minimum) Phase to earth :- 19.0 mm (minimum)
11.0	Joints and tap off points	Busbar joints and tap off points shall be shrouded and bolted (with cadmium coated bolts with plain and spring washers and locknuts). Bimetallic connectors for connection between dissimilar metals. Anti oxide grease for all bus connections.
12.0	Neutral bus isolation	Through disconnecting link.
13.0	Vertical busbar	Rear side.
(ii)	**Earth bus**	
1.0	Material	GI / Al.
2.0	Size	Minimum 50 x 6 mm at bottom of panel with extension at both ends.
(iii)	**Control bus**	
1.0	Material	Copper. (Control Bus on top Busbar chamber front side).
2.0	Size	Minimum 25 x 3 mm or equivalent.
3.0	Segment	Control bus shall be sectionalized and each bus shall be fed from control trafo of respective section. However selector switch in one module shall be available to select the feed of both sections of control bus from either of control trafo also.
4.0	Selector Switch	25A, 4 position (Trafo -1, Trafo -2, Individual, OFF) and as described above.

(iv)	**Power supply bus for motor controller (from UPS)-(Applicable for IMCC)**	
1.0	Voltage	240/110V AC, 50 Hz distribution through separate DP MCBs for each module.
1.0	Material	Copper. (Control Bus on top Busbar chamber front side).
2.0	Size	Minimum 25 x 3 mm or equivalent.
D.	**Insulation level**	
1.0	Rated insulation voltage	1100 V.
2.0	Impulse withstand voltage	4 kV as per IS-13947 (Part I) 1993.
3.0	One minute power frequency withstand voltage	2.5 kV for power circuit & 500 V for control circuit.
E.	**Pollution Degree**	
1.0	Pollution Degree	Pollution Degree 3 . As per IS-13947 (Part-1) : 1993;unless otherwise stated
F.	**Intelligent Motor Controllers (Applicable for IMCC)**	
1.	Type	Modular type.
2.	Wiring	All the potential transformer PT's, protection CT's (phase CT and neutral CT) shall be hard wired directly to the controller or the controller module shall have builtin CT and PT for protection & metering purpose.
3.	Control Power supply	Separate power supply source (240/110V AC) from UPS through DP MCB (for controller only). For coil of Contactors, relays, lamps etc. separate control power supply at 240/110 V AC from MCC control bus through DP MCBs.
4.	Inputs and outputs	Controller to be used as for Motor Protection, Metering & remote monitoring purposes through communication to L1 automation. For motor

		start/stop, feedback, interlocks etc. potential free contacts of Power contactors, aux. contactors, relays, breakers etc. shall be wired to Automation/PLC IO cabinet.
5.	Functions in controller	Protection, Metering&Annunciations and communicating to L1 automation for remote monitoring.
6.	Fault memory	Faults to be stored in memory on FIFO sequence.
7.	LED indications	Controller healthy Controller fault Controller power supply healthy
8.	Communication	Each motor controller unit shall communicate on the communication bus (Devicenet / Modbus / Profibus DP/Ethernet) with PLC/DCS directly for remote monitoring.
9.	Communication Port	1 nos.
10.	Communication configuration	Maximum of 20 numbers of controller shall be looped for communication to Plant PLC/DCS. For each group of 20 controllers, separate Y link/RLM shall be installed with IMCC inside a separate module at suitable location.
11.	Communication speed	Minimum 1.5 to 12Mbps.
12.	Control	Through L1 automation & from HMI (located in control room).
13.	Software	All the configuration and monitoring shall be done through inbuilt software. All the required software required for operation and communication shall be provided with latest version available.
14.	Protections	Thermal overload Adjustable overload pre-alarm Earth fault Stalling

		Unbalance Short circuit Single phase prevention Under current Too many starts Under voltage Under voltage lockout Breaker or contactor failure alarm Trip failure alarm Over temperature Winding and bearing temperature (if applicable for motor).
15.	Display Unit with LCD (to be mounted on Module door)and through communicationwith HMI at control room	Voltage, Frequency Power factors Power consumption, KW Thermal capacity Temperature Phase and average Amp. Earth fault current % motor load % unbalance Peak current during starting Starting time Pre trip values
16.	Fault / alarm history description	No. of trips No. of operations (Forward / reverse) Hours run Hours run last start Kilowatt hours

		Kilowatt peak demand Alarm / trip history (with date and time) Alarm / trip description Reference start curve (in graphics) Start curve (in graphics) Time to trip / reset
G. Feeder arrangement		
Incomers and Buscoupler		
1.0	Isolating Equipment	3 Pole MCCB upto 630A. Above 630A, 3 pole ACB motor operated spring charging. 4 pole ACB in case of DG source as second Incomer. All MCCBs/ACBs shall be microprocessor based with LSIG releases. Each incomer shall be provided with one Control transformer of minimum 500VA rating with auto changeover, MPCBs at primary side & DP MCBs at secondary for control & indication lamps for incomers.
2.0	Quantity	Two incomer
3.0	Bus coupler	Required.
4.0	Interlocking	Required. Normally only one Incomer shall be ON. After incoming power failure of any Incomer or ACB trips, second Incomer shall be made ON manually.
5.0	Interlocking type	Electrically. Mechanical (through castle key).
6.0	Indication Lamps	LED cluster type indicating lamps for:- Incoming Power ON: R / Y / B.

		MCCB/ ACB ON/OFF/TRIP/SPRING CHARGED etc.
7.0	Meters and selector switches	96 sq.mm size voltmeter with 4 position selector switches. 96 sq.mm size ammeter with 4 position selector switches.
8.0	Current transformer	3 numbers for protection. 3 numbers for metering. 1 number neutral CT. 1 number interposing CT (if required).
9.0	Potential transformer	1 number
H. Outgoing feeder arrangements		
(i) Motor Starter feeders		
1.0	Circuit breaker	Three pole Motor protection MCCB (or MPCB upto 45 KW).
2.0	Power contactor	AC3/AC4 as per requirement. 3 pole. Minimum 25 A at AC-3 duty. Contactor coil rating for 240/110 V AC. 2NO + 2NC auxiliary contacts. Electrically & Mechanically interlocked for reversible drives.
3.0	Auxiliary contactors	Required nos. as per scheme.
4.0	Protection	For conventional MCC (NIMCC) – EOCR for all motor feeders as per specification of Major components given under clause No.10.0. For IMCC - Intelligent motor controller with communication for all motor feeders as per specification given above under F.
5.0	Control supply isolation device	DP MCB

6.0	Test PB	Inside module for testing of power contactors when the module incoming power breaker is OFF.
7.0	Space heater power provision	For motor feeders of 45 KW and above:- Through separate DP MCB and interlock with main power contactor.
8.0	Ammeter in LCS	Interposing CT (middle phase) shall be provided in the feeder module for motor rating 45 KW and above.
9.0	Indication lamps (LED)	ON/OFF/TRIP for DOL, FON/RON/OFF/TRIP Open/Close/Open Torque/Close Torque for valves etc. for RDOL/Valve as applicable.
10.0	Ammeter on Feeder Module	In case of conventional MCC, an Ammeter with selector switch for 3 phase current shall be provided for all Motor feeders above 15 kW.
11	Selection of Power Components	As per Appendix-1 (Table -1A) attached.
(ii) Power supply feeders		
1.0	Circuit breaker	3 Pole with neutral link MCCB, microprocessor based with LSIG release. In case earth fault release is not available with smaller rating MCCB, same shall be through external CBCT.
2.0	Indications	ON/OFF/TRIP indication lamp.
I. Panel wiring		
1.0	Power / current transformer circuit	1.1kV grade single core, black colour PVC insulated, stranded copper conductor of minimum size 2.5 sq.mm. For feeder rating 100A and above all the power circuit shall be through rigid busbar.
2.0	Control and potential circuit	1.1kV grade single core. Black colour PVC insulated. Stranded copper conductor of minimum size 1.5 sq.mm.

3.0	Ferrules	Numbered plastic/ceramic ferrules. Self locking type. Ferrule numbers of wires connected to Terminal shall have same as TB number.
4.0	Marking	Wiring shall be properly marked as per relevant IS.
5.0	Spare contacts	All spare contacts of relays, selector switches & contactors shall be wired upto the terminal block. Each components shall have at least one potential free spare contacts.
6.0	Terminals	Power & control terminals shall be segregated by insulating material like hylam/bakelite sheet. Power terminals shall be stud type. Control terminals shall be single tier, non-breakable Clip On type suitable for connecting two cores of 2.5 sq.mm wires. Minimum 20% spare terminals shall be provided. The minimum rating of control terminal shall be 10 Amps. CT Terminals shall be disconnecting type with shorting links. Ferrule numbers shall be same as TB Numbers.
7.0	Cable glands	Double compression cable glands for receiving external power and control cables.
J. Control Supply		
1.0	Control transformer	1 number of 415V/240/110V control transformer of minimum 2.5 KVA in each section. **(For Mining areas & Beneficiation/any Process Plant at Mining area)** 110V, AC using suitable control transformers having secondary mid point earthed. **Common** Secondary unearthed.

		Control supply for each module shall be through DP MCBs inside respective module. Control supply ON lamps with earth fault test PB to be provided.
2.0	Input and output side isolation device	Input side :- MCCB/MPCB Output side :- DP MCB
3.0	Control supply changeover system	Manual changeover through selector switch (Selector switch shall have a contact rating of 25 A at 240/110 V AC). Power contactor of 25A (AC3) duty to be provided with each control transformer module for interlocking of control supply with Bus Power.
K. Space Heater Supply		
1.0	Space Heater Power supply	240/110V AC power supply for Space heater/panel illumination shall be arranged by tapping from phase & neutral side of both incomers by providing MPCB at incomer side, auto-change over arrangement, power contactor, DP MCBs, thermostat etc.

Note: MCCs shall be Non Intelligent Type in general. However if Process requires then the MCC shall be Intelligent Type . In case of Non Intelligent Type the MCC shall be communicate with PLC through RIO panel.

05.03.12 POWER DISTRIBUTION BOARD(PDB)/AC DISTRIBUTION BOARD(ACDB)

415V, 3 phase, 4 wire, 50 kA (short time rating for 1 sec.) indoor type.

Board shall be single front, metal clad, front matched dust and vermin proof, fully compartmentalized and extendible on both sides, IP52 type enclosure.

It Shall have base channel of size ISMC 75.

Unless specified in TS the PDB shall have two incomers with Bus coupler with castle key interlock.

It Shall have isolated busbar chamber for main busbars at the top, running throughout the length of the board. Chamber shall have removable cover. The board to be extendible on both sides.

Cable alley (minimum 300mm wide) shall have sufficient space for aluminium power cables and bottom cable chamber shall be left free completely isolated from the vertical busbars. Each vertical panel shall be provided with separate cable alley. Module door & cable alley shall open in opposite directions.

Busbars shall have same cross section throughout the length. Rating of the neutral busbar shall be 50% of the main busbar. Earth bus bar shall run in bottom chamber throughout the length of the panel.

Shall have MCCB triple pole, air break type with independent manual quick make and quick break type. MCCB shall be capable of breaking rated current at .3 pf at rated voltage. MCCB shall withstand the fault current envisaged for 415V system.

Incomers shall have analogue type of Voltmeter & Ammeter with selector switches. All outgoing feeders shall have analogue type Ammeter with selector switches. All feeders shall have ON/OFF/TRIP lamps.

Incomers of board and outgoing shall be MCCBs. However in case of incomer of 630 Amps or above, ACB shall be used.

All MCCBs, ACBs, shall be microprocessor based, 50KA for 1 second with LSIG releases. In case, integral earth fault protection is not available with MCCB for earth fault protection, CBCT & relay shall be provided.

Operating handles of MCCBs shall be interlocked with module door with defeat & padlock facilities. Minimum module height shall be 300mm.

Each incomer shall be provided with minimum rating of 1000VA, 415V/240V control transformer with auto changer for control power supply for indication lamps etc.

DP MCBs shall be used in indication circuits.

Maximum operating height 1800mm and minimum operating height shall be 300mm. 200mm vacant space shall be provided at bottom.

For Single Phase Power Supply required nos and rating of DP MCBS shall be provided in single or two modules .

For General, Constructional features, Busbar details, Wiring, Feeder arrangement etc. Specification given for Main Lighting Distribution Boards shall be followed.

05.03.13 DC SYSTEM (BATTERY, BATTERY CHARGER AND DC DISTRIBUTION BOARD)

One set of complete DC system shall be provided . The DC system shall be consisting of the following:

- DC battery set
- Identical Dual Float Cum Boost Charger (FCBC)
- DC distribution switchgear (1 set with 2 sections)

- All interconnecting cables/wiring with connection accessories and other required items to make the system complete.

Normally the chargers connected to the battery shall supply the DC load and also keep the battery under float charge. On failure of supply from charger, the battery shall be taken over without any interruption.

When the battery requires boost charging, the charger will operate on boost charge mode while the second battery will supply the DC load on float mode through changeover arrangement.

Interfacing of DC system with DCS/PLC of the respective unit shall be done by the Bidder. Separate DCS/PLC cards shall be provided in each of the chargers to convert output voltage and current into 4-20 mA current signal.

The DC distribution switchgear shall feed the power from the charger/battery to the various consumers of the plant.

Battery and accessories

Nominal voltage is 110 V DC. The no. of cells shall be chosen accordingly. Battery cell shall be Plante Type. Ampere hour capacity (minimum) shall be as per requirements of the plant plus 30 % cushion for purchaser's use subject to minimum. However minimum rating of battery shall be 300 AH .The discharge test of all the batteries at the rate of 10 hours to the end cell voltage 1.85V per cell as per IS shall be carried out by the Bidder at site.

The battery bank shall be single tier formation only.

Following accessories shall be supplied

- Battery stand
- Acid for first filling
- Cell testing voltmeter 3 - 0 - 3 volts complete with leads
- Cell booster for charging 1 to 5 cells
- Level indicator
- Copper cell connectors (5 nos.)
- Bridging clamps for cutting out individual cells in the event of defect
- First aid box
- Torgue wrench
- Wash basin with water connection in the battery room

Battery Chargers

Float cum boost chargers for each battery shall be comprising of the following;

- MCCB, line contactor and overload relay on the AC side
- 3 phase full wave semi-controlled rectifier bridge complete with free wheeling diode, high speed protection fuses and snubbers
- Dry type double wound rectifier transformer with copper conductor and class `B' insulation
- Filter circuit at the output
- MCCB on DC side
- Control and protection circuits

In float mode, the charger operates with a constant voltage controller and the output voltage of the charger shall be maintained within + 1% of the set voltage for + 10% input AC voltage variation, or 0 - 100% load variation, or both occurring simultaneously. The output voltage required can be set externally through potentiometers in the range 90-120% steplessly.

In boost mode, the charger shall be suitable to operate in a constant current as well as constant voltage mode with manual selector arrangement, controller suitable for two-rate charging. The charging current shall be externally adjustable from 20 to 100% steplessly. However, the design of float & boost chargers shall be identical such that they can be interchangeable.

Provision of charging with manual control of output voltage shall also be provided. Electronic current limit, adjustable between 85-105% of rated current shall be provided. During boost charging, the charger shall be cut-off as soon as over voltage occurs. Ripple content in the charger's output voltage shall not exceed 0.5% in float mode and 3% in boost mode.

Provision shall be provided to isolate the battery from the chargers. MCB may be provided for this purpose.

The supply to the charger will be at 415V $\pm$ 10%, 50 Hz. Charger shall be suitable for frequency variation as per IS.

Charger shall have a separate over voltage relay with a variable setting from 100 % to 120 % in steps of 5 % of V_n.

DC Distribution board

The DC distribution board shall have double bus bar arrangement. The DCDB shall be provided with all the instruments, AC/DC meters, indicating lamps, relays and other accessories.

The following relays shall be provided:

- AC input supply to charger failure
- Earth fault
- Float bus over and under voltage
- Boost bus over voltage
- Boost over current for each charger circuit
- All relays shall be in drawout cases and with mechanical hand reset operation indicator.

Above relays shall be provided to detect fault in any of the feeders. A separate over volage relay shall also be provided in DCDB. Over voltage setting of the O/V relays shall be variable type with range of 117 – 125 V.

The following indications shall be provided.

- AC supply ON (for 3 phases separately) for each charger
- DC supply ON for charger
- Boost/float mode ON for charger
- Supply ON for each outgoing distribution feeder

Each outgoing circuit shall be connected to bus bars. Each outgoing circuit shall have MCCB. The no. of outgoing circuits shall be as per the requirement plus 10 nos. for purchaser's use and 20 % spare.

The following measurement shall be provided;

- AC input voltage and current of each charger (through voltmeter/ammeter S/S)
- DC output voltage and current of each charger
- Battery charging/drain current of each charger with necessary shunt
- Battery trickle charging current (through amplifier)
- DC bus voltage (through selector switch) to measure between Positive to Earth, Negative to Earth & positive to negative.

DC voltage and DC current transducers (4-20 mA) shall also be provided as per requirement of the DC system. DC Voltmeter range 0-160V shall also be provided with a selector switch to measure +/earth and -/earth voltages.

Static type annunciation shall be provided for the following;

- AC supply failure to charger
- Battery earth fault (+ve&-ve separately)
- Float bus over/under voltage
- Boost bus over voltage
- Boost over current for each charger
- Failure of thyristor/diodes for each charger
- Failure of blocking diode
- Output MCCB open for each charger
- Battery MCCB open
- Battery room exhaust fan OFF
- D.C.Voltage Low
- D.C.Voltage High
- A.C.Input Under Voltage

One repeat alarm point for all above annunciations shall be provided to facilitate annunciation of "Fault in Charger" in control room.

Switch board shall be floor mounting type sheet steel enclosed with degree of protection IP 52 or better. Board shall be compartmentalized design.

All power wiring shall be done through single core PVC insulated copper wires/buses. All control wiring shall be done through single core, PVC insulated copper wire of 2.5 sq. mm. All connections external to the panel/switch board shall be terminated in suitable terminal blocks. Inter panel wiring shall be only between terminal blocks.

05.03.14 UNINTERRUPTED POWER SUPPLY

1.0	**Basic particulars for design:-**	
(i)	Input Voltage	415 V AC +10% /- 15% , 3-Phase,4 wire, grounded neutral system with a symmetrical fault level of 50 KA RMS.
(ii)	Input Frequency	50 Hz. (In design it is +/-3%)

(iii)	Output Voltage	UPS output voltage shall be 240V AC.
(iv)	Output Voltage tolerance	+/- 1%
(v)	Output Frequency	50 Hz. +/- 0.1%-0.5%.
(vi)	Output Voltage wave form	Sine wave
(vii)	Harmonic Distortion	Less than 2% for linear loads. Less than 3% for Non linear loads (individual). Less than 5% for total harmonics distortion.
(viii)	Voltage Distortion	Less than 3% for 100% linear loads. Less than 5% for nonlinear loads.
(ix)	Phase Displacement	120 deg. +/- 1deg. for balanced load. 120 deg. +/- 3deg. for unbalanced load.
(x)	Transient recovery	Shall return to steady state condition in less than 100 msec. after a disturbance.
(xi)	Ambient	50 deg.C.
2.0	**Basic details**	
(i)	Duty type	Online continuous.
(ii)	Reference standard	Features and performance in line with IEEE 446.
(iii)	Overload	125% of the rated output for minimum 10 minutes. 150% of the rated output for 60 sec.
(iv)	Configuration	With isolating transformer, rectifier, inverter unit, Bypass and necessary DC batteries.
(v)	Power device	Inverter power circuit shall comprise of IGBT using PWM control technique.
(vi)	Redundancy	The system shall be of parallel redundant type with bump less transfers.
(vii)	Static bypass	Automatic static bypass and individual DC battery.

		The load shall normally be fed from the inverter. In addition to static bypass switch, a manual changeover switch of adequate rating shall be provided to supply the load directly (bypassing the rectifier/charger, inverter, and static transfer switch) from the mains instead of through the UPS system. The bypass circuit shall be through Constant Voltage Transformer of adequate rating (at least 125% of UPS KVA rating).
(viii)	Battery bank	Battery shall be SMF type, either Lead acid type or Ni-Cad or Gel VRLA type. Separate Battery bank shall be provided for each UPS.Rating of each battery bank shall be 100%. The batteries shall be housed in a separate battery cabinet/Racks&located in air conditioned room/Glass enclosure not very far from UPS panel. Battery cells shall preferably be mounted on slide-out trays for ease of maintenance. A battery disconnect circuit breaker with undervoltage release (UVR) shall be included for isolation of the battery pack from the UPS module. The UPS shall automatically be disconnected from the battery by opening the breaker when the battery reaches the minimum discharge voltage level. Casters and leveling feet shall also be provided with the battery power pack cabinet for ease of installation.
(ix)	Battery backup	Each Battery shall be suitable to maintain the power supply for at least 30 minutes in the event of mains failure with rated capacity of the UPS at full load.
(x)	Battery management system	UPS shall have latest 'Battery Management System' to charge / discharge the entire battery automatically.

(xi)	AC DB	Necessary distribution board for distribution of power from UPS output to individual consumers. Incomer of ACDB shall be MCCB. Out going feeders of ACDBs shall be DP MCBs of adequate rating. Incomer side shall be provided with Voltmeter, ammeter, indication lamps for power ON/OFF/TRIP.
(xii)	Loading capability	UPS shall be capable of taking 100 % non linear loads.
(xiii)	Interchangeability of sub assemblies	The UPS shall be constructed of replaceable subassemblies. PCB's shall be plug-in type. Like assemblies and like components shall be interchangeable.
(xiv)	Noise level	Maximum noise level shall be less than 60 dB at a distance of 1 m from the body of the UPS.
(xv)	Efficiency	The efficiency values of UPS under 50% unbalanced load & 100 % linear loads shall be as near as possible to normal efficiency.
(xvi)	Isolation transformer	The isolation transformer shall be of dry type and shall be provided on both input and output side of the UPS.
(xvii)	Grounding	The AC output neutral shall be electrically isolated from the UPS chassis. The UPS chassis shall have an equipment ground terminal. Provisions for local bonding shall be provided. Component mounted doors shall be separately earthed through 2.5 sq.mm PVC insulated green/green-yellow color flexible copper wire.
(xviii)	Communication port	The UPS shall have inbuilt RS 485/serial communication port for display of online status of UPS on HMI.
3.0	**Rectifier**	• Rectifier unit shall be suitably designed, selected &rated for supplying both inverter load and battery charger load. Boosting device, Converters should not be used in between battery

		bank & DC Bus except isolating device. • Rectifier unit shall consist of minimum six pulse bridge connection.
4.0	**Protective features**	• Maximum current limiting. • Automatic reduction of current limit in the event of cooling fan failure. • Boost charging and float charging current limiting.
5.0	**Inverter**	• With input circuit consisting of battery contactor, battery filter and smoothing reactor. • DC/AC converter for voltage control. • Inverter proper and control electronics. • Series reactor and parallel filter. • Output transformer.
6.0	**Protection**	• Abnormal output voltage (over voltage & under voltage). • Abnormal link voltage. • Over current on output. • Over current on input or commutating failure. • Low battery voltage. • High transformer temperature. • Auxiliary supply failure. • Fan failure. • Logic failure. • Clock failure. • Fast acting HRC fuse for inverter circuit and control circuit. • Reverse power protection for parallel inverters.
7.0	**Static by-pass switch**	• Static switch automatically switches the load to

		the reserve power supply for the mains whenever there is failure in inverter supply to the load. • Fast acting inverter contactor shall connect the inverter output to the load. High speed fuses shall be provided for protecting the thyristor against accidental overload.
8.0	**Indicating meters on panel**	• Input voltmeter with selector switches • Input ammeter with selector switches. • DC voltmeter with selector switches • Centre zero type DC ammeter for measurement of charging/discharging current from the battery. • AC output voltmeter with selector switch. • Separate frequency meter to see Input and Output frequency. • AC output ammeter with selector switch. • AC voltmeter with selector switch for bypass circuit. • AC ammeter with selector switch for bypass circuit. • Frequency meter for bypass circuit.
9.0	**MIMIC on UPS panels**	• MIMIC of the system power flow diagram as single-line diagram of the UPS shall be provided on UPS panels front door with long-life LED's integrated within the single line diagram to indicate the operating status of different components/sections of the UPS.
10.0	**Display and Operating system**	• The UPS shall be provided with a microprocessor based keypad and display unit mounted on UPS panels front door for operating and viewing the UPS status for convenient and reliable user operation. • The monitoring functions such as metering, status and alarms shall be displayed on an

		alphanumeric LCD display. Additional features of the monitoring system shall include: • Menu-driven display with text format. • Real time clock (time and date). • Alarm history with time and date stamp (minimum upto 16 faults in memory with FIFO sequence). • Battery back-up memory.
11	**Metering**	The following parameters shall be displayed: • Input AC voltage line-to-line and line-to-neutral for each phase. • Input AC current for each phase. • Input frequency. • Battery voltage status. • Battery charge/discharge current. • Output AC voltage. • Output AC current. • Output frequency. • Percent of rated load being supplied by the UPS. • Battery time left during battery operation.
12	**Alarm Messages**	• Input power out of tolerance. • Input phase rotation incorrect. • Incorrect input frequency. • Charger in reduced current mode. • Battery charger problem. • Battery failed test. • Low battery voltage warning or blown battery fuse.

		• High battery voltage. • DC bus overvoltage. • Bypass frequency out of range. • Load transferred to bypass. • Excessive retransfers attempted. • Static switch failure. • UPS output not synchronized to input power. • Input power single phased. • Input voltage sensor failed. • Inverter leg overcurrent in X-phase. • Output undervoltage. • Output overvoltage. • Output overcurrent. • System output overloaded. • Load transferred to bypass due to overload. • Fan failure. • Overtemperature shutdown. • An audible alarm shall be provided and activated by any of the above alarm conditions.
13	**Status Messages**	• Normal operation • Load on maintenance bypass • Load on UPS • Load on static bypass • System shutdown • UPS on battery
14	**Controls**	• UPS start-up / shutdown shall be done by push button / rotary control switch. • Normal operation / bypass operations shall be

		done by a single rotary control switch. • An advisory display and menu-driven user prompts writeup sticker (pasted inside the panel door) shall be provided to guide the operator through system operation without the use of additional manuals. • Pushbuttons shall be provided to display the status of the UPS and to test and reset visual and audible alarms.
15.0	**Constructional features**	
(i)	**Isolation devices**	• MCCB (upto 630A),50KA fault level as incomers for each UPS &Bypass. • DP MCB (of adequate rating) in outgoing side. • Power circuit isolation device to have pad locking in the OFF position with the door closed.
(ii)	**Installation**	• Metal clad, indoor installation
(iii)	**Mounting**	• Floor mounting with base channel of ISMC-75.
(iv)	**Enclosure protection**	• Totally enclosed dust and vermin proof. • IP – 42.
(v)	**UPS housing**	• Each UPS system shall be housed in a separate cubicle, complete with an individual front and back access door with concealed type hinges. • For UPS panel all the switches, indication lamps and meters shall be flush mounted on the respective compartment door. • For ACDB panel the input MCCB's and output MCB's shall be operated from outside the panel door.
(vi)	**Back access**	• Each panel shall have a door on back side. All the doors shall have neosprene gasket. • Natural rubber gasket shall be provided between

		adjacent panel doors and removal covers.
(vii)	**Lifting hooks**	• Lifting hooks for each panel shall be provided
(viii)	**Designation plate for UPS**	Inscription plate for each panel:- • Name plate shall be provided at top centre of the UPS panel. • Name plates shall be of AnodisedAluminium with white letters engraved on black background and in English language. • Letter height for UPS designation plate shall be in the range of 25-50 mm. • Individual components shall be identified with identification plate and shall match with the identification tags mentioned in the drawing. • Danger board shall be provided on front and rear side of the UPS both in Hindi , English & regional languages.
(ix)	**Thickness of sheet steel (CRCA)**	• Load bearing members : 2.0 mm • Non load bearing member : 1.6 mm
(x)	**Door earthing**	• Hinged door at front and back with flexible earthing connection.
(xi)	**Cable entry**	• Incomer :- Bottom cable entry • Outgoing :- Bottom cable entry
(xii)	**Gland plates**	Undrilled removable bottom gland plates(3 mm thick).
(xiii)	**Cooling of panels**	• Panels shall have fan installed vertically at top for forced air draft and louvers with screen protection in bottom. • Fans shall be powered from UPS output. Low velocity fans shall be used to minimize audible noise output. • The UPS shall be installed in air conditioned

		environment.
(xiv)	**Bolts , nuts & cable glands**	• All bolts and nuts for terminations shall be cadmium coated. • Double compression cable glands for receiving external power & control cables.
(xv)	**Indicating lamps**	• All indicating lamps shall be of LED high density type.
(xvi)	**Finish**	• Exterior :- RAL 7035
(xvii)	**Terminal block**	• Terminal block for incoming cable shall be located in back side and outgoing cables shall be in front side of the ACDB panel. • All incoming terminal blocks shall be fully insulated for the working voltage. • The terminal blocks shall be sleeved color coded Red, Yellow , Blue , Black for R,Y,B,N respectively using heat shrinkable PVC sleeve. • All outgoing terminal blocks shall be sleeved color coded Red and Black for line and phase respectively using heat shrinkable PVC sleeve. • All the terminal blocks shall be shrouded. • Not more than two connections shall be made at one terminal. • Terminal blocks shall be suitable to connect two cores of 2.5 sq.mm. • There shall be 20% spare terminal blocks.
(xviii)	**Minimum air clearance for bare busbars .**	• Phase to phase :- 25.4 mm • Phase to earth :- 19.0 mm
(xix)	**Earth bus**	The main earth bus shall be of 50 x10 mm GI with extension at both ends of switchboard for connection to safety grounding network. Earth busbar shall run continuous throughout the UPS

		panel at bottom.
(xx)	**Panel internal wiring**	The panel internal wiring shall be carried out by 1100V grade, single core, black color PVC insulated , stranded copper wire of following size; • Current transformer circuit :- 4.0 sq.mm • Control and potential circuit :- 2.5 sq.mm • Identification of wire shall be numbered by plastic/ ceramic ferrules. • Ferrules shall be self locking type.
(xxi)	**Incoming Feeders**	• Each UPS shall be with separate incoming power supply from different sources. Bypass circuit shall be with separate power supply All incomers to be equipped with following:- • 3 pole MCCB. • Ammeter with 4-position selector switch (three phases & OFF). • Voltmeter with 4-position selector switch and fuses (three line-line & OFF). • Current transformers (for metering). • 3 nos. indicating LED type lamps (R,Y,B). • 3 nos. indicating LED type lamps (CB ON-Red, CB OFF- Green, CB TRIP - Amber) • Following protections are required for the MCCB controlled; • Incomers :- - Overcurrent releases. - Short circuit. - Earth fault.
(xxii)	**Outgoing Feeders**	• Each outgoing feeder shall have followings:- • Outgoing feeders shall have DP MCB.

		• MCB of 09 kA rating with Thermo-magnetic releases.
(xxiii)	**Testing**	• All routine tests shall be as per IS-8623 (Part-II) 1993. • Type test certificate shall be submitted for similar rated UPS.

05.03.13 LOCAL CONTROL STATION

1.0	Material	Sheet steel (CRCA) 2 mm thick
2.0	Mounting	Wall / structure mounted.
3.0	Enclosure class	IP-54 (for indoor installation). IP-55 with canopy (for outdoor installation).
4.0	Door opening	Hinged type front door opening .
5.0	Cable gland	Removable undrilled, To be provided on bottom.
6.0	Internal wiring	2.5 sqmm, single core, stranded, black PVC insulated copper conductor.
7.0	No.of components like ON/OFF PB's , selector switches etc.	As per scheme requirement.
8.0	Contact details of components .	All Push buttons - 2NO + 2NC contacts & selector switches of 10 A rating. 1 NO & 1 NC contacts of PBs &polesof Selector switch shall be potential free for PLC inputsas per control circuit design.
9.0	Emergency Stop PB	RED in colour. Mushroom headed. Press to lock and turn to release type. 2NO + 2NC contacts.
10.0	Start/Open/Close push button details	Start push button shall be GREEN in colour.

	Additionally for VFD motors Speed Increase/ Speed decrease/if required Stop. For RDOL motors Forward start / Reverse Start	Shrouded type. 2NO + 2NC contacts.
11.0	Lamp details (if any)	High density LED type.
12.0	Location of selector switches	Local/ Remote selector switches shall be installed in the LCS.
13.0	Terminal blocks	- Shall be able to terminate wires of 2.5 sq.mm size. - Not more than two wires shall be terminated in a single terminal block. - Shall be mounted on D-channels. - 30 % spare terminals shall be provided. - Colour of TBs for different voltages shall be different. - Single tier, non-breakable, clip on type. - Ferrule numbers of wires shall be same as TB numbers.
14.0	Miscellaneous	LCS may be used for termination of maximum one number of additional 7 core control cable for field switches, if required.
15.0	Provision of ammeter.	For motors ratings of 45kW and above, Ammeters on middle phase shall be provided. For motor rating 110kW & above, ammeter with selector switch shall be provided for three phase current.
16.0	Earthing	Earthing studs shall be provided on two opposite sides. Internally the earthing studs shall be connected with the body through green colour PVC insulated copper flexible wire.

05.03.15 HT VFD PANEL FOR COMPRESSOR

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1.0 INTRODUCTION

The input voltage for the Compressor shall be at 6.6 kV. Major equipment for Electrics of Gas Compressor shall include panel with metering, protection& control, integrated Drive Transformer, Air cooled MV drive, HT Motor, Local Control Station etc. as mentioned in schedule of quantities.

2.0 STANDARDS

The design, manufacture, performance & testing of Electrical items covered under this specification shall in general, comply with the latest issue of applicable Standards and Codes of Practices published by IEC, Bureau of Indian Standards, OISD norms, Indian Electricity Act & Indian Electricity Rules and other relevant standards.

In case the Tenderer is not in a position to comply fully with certain IEC/BIS specifications, or in respect of certain items for which there are no IEC/BIS specifications, the Tenderer may base his proposals on other reputed national or international standards .

3.0 SCOPE OF WORK

Scope of work for Electrics of Compressor Motor includes the following:

a) **6.6kV HT VCB CICO Panel** with protection, metering & control dedicated for this drive system. This shall be utilized for integrated Drive transformer protection and start/stop control of Compressor motor through Air cooled MV VFD. The configuration of the panel shall be Cable in Cable out (CICO) having two verticals. DC control supply for this panel shall be derived using suitable rated capacity DC Power pack or DC power supply tapped from DCDB.

b) **Dry type, Indoor duty, Integrated Drive transformers** (at 6.6 kV Primary Voltage) for Air cooled MV VFD drive. Secondary voltage shall be selected matching with VFD. This Transformer will be placed inside the panel along with Drive Lineup.

c) **Air Cooled MV VFD drives(in IP-52 enclosure)** suitable for Compressor application with minimum 12 pulse or above configuration. It is preference to have 6.6 kV Motor and accordingly drive output voltage as 6.6kV.Drive shall communicate on **Industrial Ethernet based communication (Profinet/Ethernet**

IP/Modbus over TCP-IP) with Plant Automation. & PLC system Accordingly necessary hardware shall be inbuilt in the drive.

It shall provide all the parameters like peak transient voltage, rise time and dV/dt etc, which are essential to be taken care in the design of Compressor motor for matching with VFD. Tenderer should limit his harmonics to minimum possible values so that IEEE-519-2014 values for THD can be met effectively at plant level Point of common coupling (PCC).

d) **HT squirrel Cage Induction Motor** matching with above VFD. Preferred Motor rated voltage is 6.6kV.The approximate kW of each motor shall be as per Technological & Process requirement . However exact kW & poles of the motor shall be considered as per Compressor Manufacturer design data as approved. Bearing oil lubrication of motor shall be taken care by Compressor manufacturer. Accordingly appropriate flow and pressure for forced oil lubrication shall be informed in priority. Similarly data shall be provided for inlet water for secondary cooling of windings. All hardware provisions for interfacing for lubrication and water cooling shall be provided at motor's end.

e) **Local control Station** for the Compressor Motor. This shall have analog display of current and speed with Local/Remote selection, Start, Stop, Emergency stop push buttons, speed increase and decrease push buttons. Local Control station shall be Ex-d type.

f) **Vibration monitoring system** including Vibration probes and vibration monitors for motor at field. Vibration probes shall be terminated suitably by Tenderer in Vibration Monitoring Panels near the motor. Vibration Monitors shall provide local display of parameters. 4-20mAmps output signal from these monitors shall be taken to upstream VFD for monitoring and control. VFD shall communicate the same to Plant DCS over communication bus.

g) **Cable schedules and termination schedules** for Power cables, Control cables, Instrumentation cables, Communication Cables shall be considered with upstream 6.6 kV HT Switchboard, PLC/DCS, UPS, MCC DCDB shall be considered.

4.0 SPECIAL CONSIDERATIONS

a) All Auxiliary low voltages AC/DC shall be generated within the drive. Only external UPS supply shall be considered.

b) Any specific requirement for Motor bearing lubrication during Power failure conditions shall be indicated during detail engineering. Motor bearings shall be designed to take lubrication till natural stop of compressor & Motor system due to inertia without the need for an external uninterrupted power distribution for lubricating pumps for the motor.

5.0 PAINTING

Painting of panels shall be carried out using minimum 7-tank process. Finish of all Panels shall be electro statically powdered coated. Interior & Exterior color shade of all panels shall be **RAL-7035. Other paint shades are indicated in Technical specification of items.**

6.0 SPARES

Tenderer shall guarantee for supply of spares for their equipment for at least 10 years.

7.0 TECHNICAL SPECIFICATION

7.1 Rating Selection of MV VFD

1. Continuous current rating of Compressor MV drive shall be **minimum 115%** of the motors full load rated current.
2. Current rating of MV drive shall be calculated after de-rating to specified ambient temperature (50 degree C).

7.2 Rating Selection of Drive Transformer

Drive transformer sizing shall be done based on Motor rating & considering the following modifying parameters.

1. Motor efficiency, drive efficiency & drive power factor
2. Harmonic loading on the transformers due to the MV VFD drive.
3. Ambient temperature as 50 deg C.
4. Design Margin of 20 % shall be considered over and above the calculated rating (including harmonics loading) for reaching final kVA rating of the drive transformer.

7.3 VCB CABLE IN – CABLE OUT (CICO) PANEL

7.3.1 TECHNICAL PARTICULARS AND DESIGN PARAMETERS

The CICO Breaker Panel Technical specification shall be followed 6.6 kV Switchboard specification in addition to mention in the following portion.

Sl. No.	PARTICULARS	HT SWBD
1.		Metal Enclosed, Floor Mounting, Free standing, natural air cooled type Indoor Construction. 1) This shall comprise of two verticals having line PT in incoming cable vertical and VCB in the outgoing cable vertical. 2) Integral manual earth switch shall be provided on the outgoing side. 3) All the provisions for necessary signals and interlocks as per the signal exchange diagram given in this TS shall be provided. 4) Battery based power pack having stored energy for 3 close-open operations in a span of one hour and having capacity to feed the control supply of the CICO panel for one hour shall be provided. This power pack shall be fed from UPS or DC Battery Power 5) This panel shall have provision for industrial Ethernet communication for connection of protective relays to Automation system, for future use. 6) **Manufacturer of the HT switchboard panel shall be same as the manufacturer of Circuit Breakers.** **7)** The panel shall be internally arc compliant (IAC) tested for AFLR configuration in line with IEC 62271-200 for the specified rating and duration. Type test report for the same shall be submitted during drawing approval stage. 8)The panel shall be constructed with CRCA sheet steel or Aluzinc sheet steel. For Aluzinc construction, doors and covers shall be painted as per the approved colour. For CRCA construction, complete panel shall be painted. The sheet steel thickness shall be as per the IAC & IP type tested design. 9) Over-Current and Earth fault Protection (50,51,51N,50N) shall be provided for Transformer feeder and Flagged aux relays shall be provided for transformer faults 10) Fast response current, voltage, power transducers, wherever specified

Sl. No.	PARTICULARS	HT SWBD
		8) Response time shall be maximum 20millisecond 9) Accuracy shall be +, - 0.5% 10) Distortion factor < 0.2% 11) Output shall be 4-20mA 12) Frequency shall be 50 Hz 13) Input shall be 1A for Current and 110V for voltage 14) Transducer shall be suitable for ambient condition inside panel

7.3.2 General requirement

7.4 DRIVE TRANSFORMER

a) Copper wound Transformers shall comply with the relevant Standards.
b) Indoor Installation
c) Duty: Continuous
d) Service: Converter Duty
e) Transformer shall be Core type VPI insulation.
f) Insulation Class shall be Class H with temperature rise of winding limited to B.
g) Insulation level shall be designed according to the voltages specified as applicable and as below.

Sl. No.	Description	6.6kV System
1	Nominal system voltage (kV)	6.6
2	Max. system voltage (kV)	7.2
3	One minute power frequency withstand voltage (kV)	20
4	Peak impulse test withstand voltage (kV)	60

h) Overload capacity of the transformer shall be as per IS 6600 - 1972 unless otherwise specified.
i) Permissible maximum temperature at rated output and principal tap at the ambient temperature of 50°C.

Windings (by resistance method)	120°C

Core and other adjacent parts of winding	120°C
Core and other parts not adjacent of winding	Within safe limits of core and adjacent materials

j) Winding Material shall be electrolytic grade copper with 99.9% purity.
k) Transformer shall be provided with a rating plate giving the details as per IS.
l) Noise level shall be low and shall be within limit depending on the rating of the transformer as per IEEE-141.
m) Drive integrated transformer shall be in a dedicated panel having four loading points which will be supported through structural support from bottom.
n) Transformer panel shall have sufficient space for 6.6kV (UE) cable bending & termination.
o) Transformer shall have necessary dedicated temperature element/device for providing winding temperature alarm & trip contacts.

7.5 MEDIUM VOLTAGE AC VARIABLE FREQUENCY DRIVE

The MV AC drives covered under the specification shall be state of art in the area of control and regulation technology for AC drives. Same shall be suitable for Process Compressor application considering the following

S.N.	Parameters	Description
1.	Basic design particular & Type of connection	**Basic design particulars:** • Digital control technology with vector control technique • Suitable for Variable torque applications as per Process Fan requirement, • Harmonic control as defined by IEEE 519-2014. • Fuseless Design **Type of connection** **Converter section** • Rectifier for 12 pulse or higher pulse design with respect to harmonics control as defined by IEEE 519-2014 **Inverter section** • IGBT/IGCT based Sine coded PWM control • The inverter shall be with multi level topology. • VFD shall be designed to reduce motor terminal dv/dt and allow longer cable length from drive to motor. **The distance between VFDs to**

		compressorsshall be as per approved layout, suitable dv/dt filter shall be provided at VFD output. • VFD shall have provision to communicate to automation system on system communication bus preferably Industrial Ethernet.
2.	Reference Standards	IEC61800-2, ANSI 2 DIN VDE IEEE 519-1992
3.	Overload capacity	110% of the rated current for 1 minute (in cycle of 5 min) for variable torque applications.
4.	Drive Power factor	Greater than 0.95
5.	Efficiency	More than 97% or better at full speed and full load.
6.	Torque accuracy	Shall commensurate with Process Fan application
7.	Speed control accuracy	Shall commensurate with Process Fan application
8.	Cooling medium & Ventilation	Air Cooled.
9.	Load side components	• Sine wave Filter, if applicable • Output reactor (if required as per distance indicated above).
10.	Meters	• Input voltmeter and ammeter with selector switches • Output Voltage, current & frequency in addition to input parameters shall be available through Operator Panel. kW, kWH, Power factor shall also be available through the same. • **Online Harmonic Analyzer for harmonics at input side.**
11.	Selector switches	• Local , Remote. • Auto , Manual.
12.	Pushbuttons	• Trip reset, Start, Emergency stop and others as per scheme requirements
13.	Lamps	• Drive ready • Drive trip • R , Y , B phase power ON • Control supply ON Any other lamps as per scheme requirement. All the lamps shall be of cluster LED type
14.	Remote control facilities	• Shall have transducer to monitor the outputs like motor speed at LCS • Facility to accept speed reference from HMI, engineering station through communication bus.
15.	Communication Bus	Industrial Ethernet (ProfiNet, Ethernet IP, Modbus over

	suitability.	TCP/IP)
16.	Analog Inputs	VFD shall have provision to receive analog inputs from Motor RTD and BTD, Vibration Monitors at field. These values will be further communicated to Plant DCS on Industrial Ethernet.
17.	Drive Features	• Flying Start • Resonance frequency bypass
18.	Signal exchange between Plant PLC and VFD	The VFD will need to accept inputs from the Plant PLC i.e. Start Permissive, speed reference, Fan Shutdown Interlock and Plant E-Stop. VFD will in turn give Drive Ready, Running, and Fault inputs to the Plant PLC. VFD will also receive inputs from vibration & temperature monitoring system. These are minimum requirements of signal exchange. **Please refer Signal exchange diagram included in this TS for the complete drive system.**
19.	Operator panel	• Advance Operator panel • Shall be mounted on the front door of the unit. • All adjustments to be made with the door closed. • Status and Power LEDs viewable through the cover
20.	LCD display	• Display shall be back lighted, enabling viewing in extremes of lighting conditions • Display shall be in alphanumeric (in English only)
21.	Construction features	• Enclosure protection IP-52or better. • Floor mounted, free standing, modular design, Suitable to withstand vibrations. • Sheet steel clad, Minimum 2.0 mm thick for panels. Minimum 2.0 mm thick for doors and side covers. • Metal or glass barriers shall be provided between each vertical section and between the low voltage compartment and the power cell. • Microprocessor based control logic board with their power supply system shall not be exposed to high voltage. • Enclosures shall be sealed to provide environmental protection and to eliminate radio frequency interference • Enclosures shall be designed to avoid harmonic and inductive heating effects.

		• Power module shall be short circuit proof. • Cubicles with illumination lamps, door switches, space heaters and adequate sockets for soldering. • All control blocks plug–in-type with necessary test sockets.
22.	Startup and Maintenance Module handling tools	• Easy to use PC software tool for startup and maintenance of drives is included in Tenderer's scope. • Provision of drive module handling tools is included in Tenderer's scope. • All the tools, instrumentation used for drives commissioning and maintenance for power devices replacement shall be in offered by the Tenderer separately with list.
23.	Remote Monitoring & Online service back up.	• Remote Monitoring of drive with online service back up support for next 3 years from date of successful commissioning shall be decided mutually with Purchaser.

One set of Laptop with programming software and other accessories i.e. programming software licenses, connecting cables, latest edition of Windows software etc shall be provided. Laptop shall have 15'' screen, 16 GB RAM, Intel Core i7 processor, upto 1 TB of storage with Ethernet & USB ports shall be provided.

7.6 HIGH VOLTAGE INVERTER DUTY SQUIRREL CAGE INDUCTION MOTORS

For VFD driven motors shall be **HIGH VOLTAGE INVERTER DUTY SQUIRREL CAGE INDUCTION MOTORS . The specification has mentioned in elsewhere in the specification.**

7.7 LOCAL CONTROL STATION

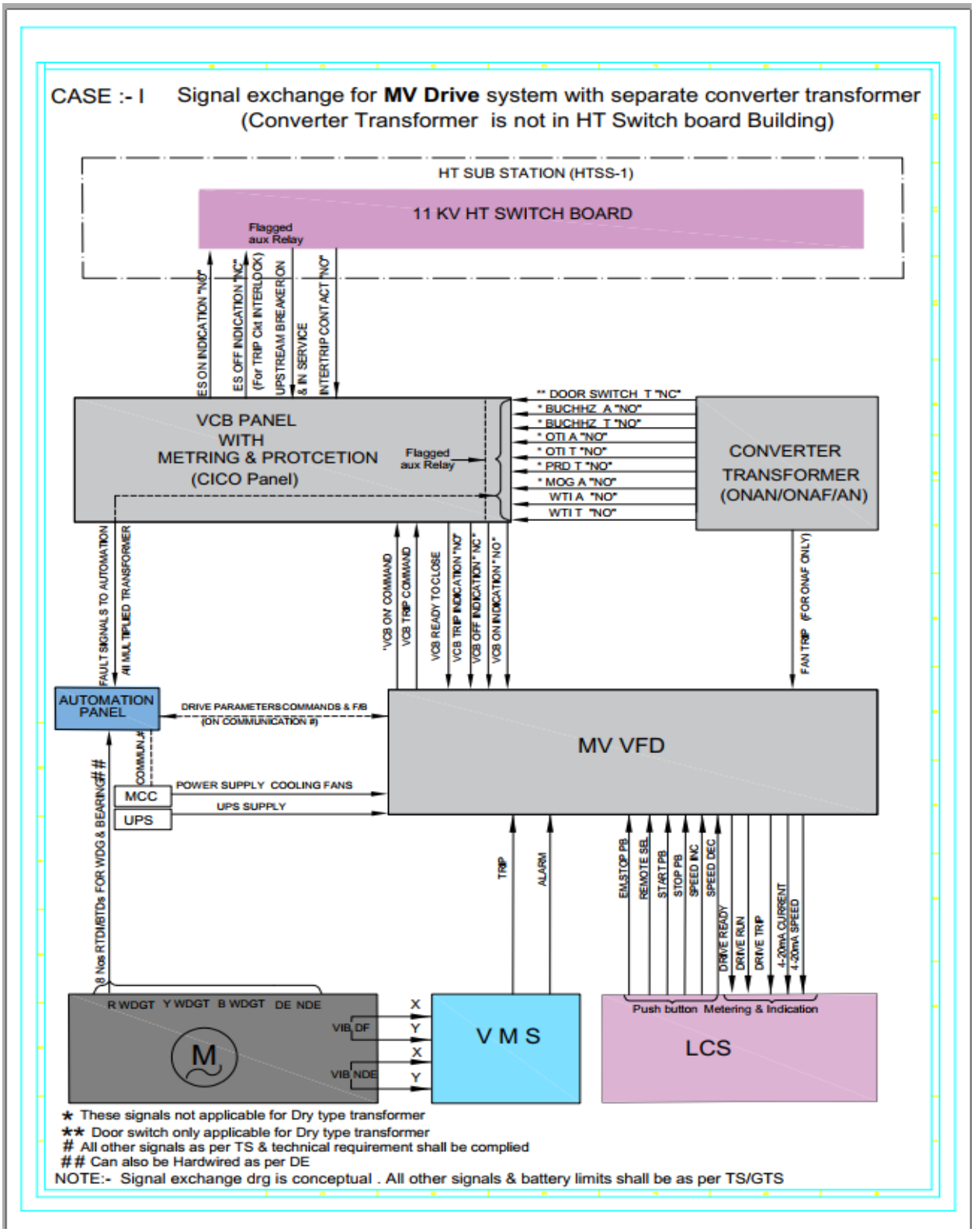
One no Flame Proof LCS shall be provided for the Each Compressor Motor as per Flame Proof standard.

7.8 BRIEF SPECIFICATION OF SUB COMPONENTS

A) **MOULDED CASE CIRCUIT BREAKER (MCCB), MOTOR PROTETION CIRCUIT BREAKER, AC CONTACTORS ,INDICATING INSTRUMENTS CONTROL TRANSFORMERS PUSH BUTTONS INDICATING LAMPS MINIATURE CIRCUIT BREAKERS (MCB) ,SELECTOR SWITCHES**

7.9 SIGNAL EXCHANGE DIAGRAM:

Typical Signal Exchange is indicated below. However, same shall be decided during engineering as per applicability.



7.10 BRIEF SCHEDULE OF QUANTITIES

S. N.	EQUIPMENT DESCRIPTION	UNIT	QTY
1.	**Electrics for Compressor including**		
a)	VCB CICO Panel as per TS	Nos	1
c)	Air Cooled AC Variable Frequency MV Drive with integrated Drive Transformer for Compressor as per TS	Set	1
d)	High Voltage Inverter Duty Squirrel Cage Induction Motor for Compressors as per TS	Nos	1
e)	Local Control Station for Motor as per TS	No.	1
f)	Vibration Monitoring System for Motor as per TS	Set	1
g)	Laptop as per TS	No.	1
h)	Miscellaneous items (cabling ,Earthing ,interconnections etc)	Lot	1

05.03.16 ILLUMINATION

1.0 General

The lighting system inside and outside plant units shall be designed based on the desired minimum illumination levels specified below. Where the areas are not indicated below but are required, lux level recommendation by latest issue of Indian Standards IS:-3643(Part-1)-1992 & IS6665-1972 and OISD-149 shall be followed.

For all high rise buildings/in high bays, walkway shall be provided for maintaining light fittings. At other places suitable ladder/platform/approach shall be provided for maintaining/replacement of light fittings.

IS 16105-2011 shall be followed for all LEDs /Fittings. Whereas for the other light fittings IS-3646 & national lighting code shall be followed.

2.0 The minimum level of illumination, type of fittings, maintenance factor to be considered is as given below:

Sl.No.	Area	Type of Light Fittings& Lamps	Lux level (min)	MF
1	Control rooms	Decorative type luminaries fixture with diffuser for recessed mounting with energy efficient LED lamps (Philips Type RC240B LED36-4000 PSE-OD WH or equivalent)	400	0.75
2	Electrical rooms having HT Panels, , PCC, PDB, MLDBs, MCC without false ceiling	Surface mounted/Suspended luminaries with energy efficient LED tube. (Philips type SP824P LED 36-4000 PSE W30L120 OD GR OR equivalent.	200	0.7
3	Electrical rooms having VFD panels, PLC, UPS with false ceiling	Decorative luminaries for recessed mounting with energy efficient LED lamp (Philips type RC869B LED 36-4000 PSE W30L120 D6 GR OR equivalent).	200	0.7
4	Office buildings, Office rooms, Conference rooms, Library, Lab buildings, Computer centers, Management buildings, without false ceiling	Surface mounted/Suspended luminaries with energy efficient LED tube. (Philips type SP824P LED 36-4000 PSE W30L120 OD GR OR equivalent.	300	0.75
5	Office buildings, Office rooms, Conference rooms, Library, Computer centers, Management buildings, Officers/GM/ED/MD rooms with false ceiling	Decorative luminaries for recessed mounting with energy efficient LED Lamps (Philips type RC869B LED 36-4000 PSE W30L120 D6 GR OR equivalent).	300	0.75
6	Corridors without false ceiling	Surface mounted/Suspended luminaries with energy efficient LED tube. (Philips type SP824P LED 36-4000 PSE W30L120 OD GR OR equivalent.	70	0.75

7	Corridors with false ceiling	Decorative luminaries for recessed mounting with energy efficient LED Lamps (Philips type RC869B LED 36-4000 PSE W30L120 D6 GR OR equivalent).	70	0.75
8	Battery Room	Wall mounted Flame proof light fitting with IP65 enclosure.	150	0.6
9	Transformer Room, Civil Staircases of plant buildings	General purpose batten luminaire with energy efficient LED tube (Philips type BN208C LED40/NW L1200 FR with AC208C MB S (mounting bracket) OR equivalent).	100	0.6
10	Staircases (steel) of plant complex and cable tunnels/ cellars/ Overhead cable galleries	Industrial well-glass integral type luminaire with LED lamps (Philips type BY200P LED 27S CW PSU S1 PC OR equivalent). Note-Flameproof light fitting for hazardous area shall be considered.	70	0.6
11	Pump house, compressor shed, hydraulic cellers, (Having height less than 8mtr)	Industrial well-glass integral type luminaries with LED Lamps (Philips type BY200P LED 27S CW PSU S1 PC OR equivalent) Note-Flameproof light fitting for hazardous area shall be considered.	200	0.5
12	Flood lighting/ Open-Process area / heat exchanger / pipe racks / cooling tower /pig launching area	Weather proof flood light fittings with LED Lamps of Philips TEMPO LED or equivalent. Note-Flameproof light fitting for hazardous area shall be considered.	70	0.5

13	Main Technological areas, Work Shops, Central Stores, Repair shops, hydraulic cellers, etc. (Having height 8mtr or more)	High bay/Medium bay integral type light fittings with LED Lamps (Philips type BY688P LED 140 NW/CW PSD wide beam /narrow beam as per requirement or Crompton Model No. LHBBX- 150-CDL OR equivalent).Note-Flameproof light fitting for hazardous area shall be considered.	200	0.5
14	Platforms of all Technological areas/ Cable Floors/Cable basements etc. (Having height less than 8mtr)	Industrial well-glass integral type luminaire with LED Lamps (Philips type BY200P LED 27S CW PSU S1 PC or Crompton OR equivalent). Note-Flameproof light fitting for hazardous area shall be considered.	150	0.5
16	Toilets/Wash place, Store,	General purpose batten luminaire with energy efficient LED tube (Philips type BN208C LED40/NW L1200 FR with AC208C MB S (mounting bracket) OR equivalent)..	100	0.6
17	Aviation obstruction	Aviation obstruction light fittings, flame retardant type LED module, without flashing module, steady in red colour, having omni directional capability and shall be suitable to deliver maximum light output in the zone between 70 deg above and 10 deg below the horizontal with a maximum of condition at 20 deg above the module. Philips type XGP 400 1xLED		

		– K2/RD 240 V OR equivalent.		
18	Plant Roads	Street light luminaire with LED Lamps (Philips GreenlineXtra OR Equivalent). Note-Flameproof light fitting for hazardous area shall be considered.	30 Flame Proof area as per OISD	0.5
19	General Area lighting	30mtr./ 20 mtrHight Mast with LED Lamps. Note-Flameproof light fitting & control gear shall be considered for hazardous area.	30	0.6
20	Hazardous Areas	Flame Proof, HPSV Lamps	Lux level as described above	
21	Areas Having Acid Vapours	LED Lumminaire, enclosed type linear polycarbonate Philips type WT550C LED35S CW PSU SI PC or equivalent.	100	0.5
22	Scale fume tunnel	24V Bulk head with LED, IP65 or better	100	0.5
23	Lawns, Garden, Landscape Lighting	LED Post Top	1 number at interval of 5m.	

24	Auditoriums, Conference Halls, Entrance lobbies, Control rooms, Computer centres, Training Centres, Officers/GM/ED/MD rooms	LED fitting Philips Type GreenSpace/GreenLEDi/LU XSpace HE or equivalent.	Suitable numbers to be provided for aesthetic in addition above at Sl.No.5.

Note:- Wattage of LED Lamps shall be decided so as to provide minimum Lux level specified against each area/premises. The models of the light fittings may changed during detailed engineering.

3.0 **Area Lighting:-**External area lighting including street/road lighting / High Mast lights shall be fed from Outdoor type Feeder Pillar located at suitable places. Automatic switching ON/OFF of these circuits shall be done through timers. Street light/High mast/Flood light towers shall be fed through 415/240V, 3 phase, 4 wire circuit with individual fittings distributed at 240V, single phase, with control and protection located at bottom of each tower. DP MCB in a sheet steel box shall be provided near each fitting to facilitate removal of lamp in off position.

4.0 **Lighting Power distribution:** The distribution of lighting power supply for the individual areas shall be done at 415V, 3 phase, 4 wire bus system through Main Lighting Distribution Boards (MLDB) for the area. **The Each incomer of MLDB shall be fed through separate lighting transformers.**Two nos. (minimum) MLDB shall be provided in Sub-station building. The MLDB shall have DoubleIncomer(One Incomer from normal power supply & other Incomer from DG source of Power Supply) The outgoing feeders of the MLDB shall feed the required numbers of Sub Lighting Distribution Boards (SLDB) for lighting. Each SLDB shall receive power at 415V AC, 3 phase, 4 wire and distribute it into 240V, 1 phase circuits for connection to the lighting fixtures and 240V receptacles. The SLDBs shall be located in the rooms, bays, shop units, junction housesetc preferably near entry/exit. covering the respective zone. The SLDBs shall be located in the electrical rooms in the respective area.

The transformer shall be panel mounted with IP42 enclosure, dry type, class F insulation located either in field or in Electrical room

Following guidelines shall be followed for designing the Lighting Power distribution system:-

a) All Control rooms, office rooms/buildings, Conference rooms, Laboratory buildings,

Computer buildings, Management buildings, Data centres, Control room building, Administrative buildings, Entry gate complex, Workers rest room, Canteen building shall be provided with concealed wiring with modular type switch boards flushed with wall with switch socket points for controlling each point (light/socket). Each light fittings, fan points,occupancy and daylight sensor, dimmer, socket points shall have separate modular switches for ON/OFF. All rooms of these buildings shall be provided with adequate numbers of 5/15A switch socket points.

b) Electrical Panel rooms/buildings, Cable floors, light fittings shall be made ON/OFF through SLDB out going feeder DP MCB directly. In this case, all fittings in one circuit shall be made ON or OFF. However, any office rooms, shift office, store rooms, toilets, wash place, pantry etc. with these buildings, light fittings, fan points, socket points etc. shall be controlled with concealed wiringthrough Switch board modular switches individually.

c) In case open type Technological areas/premises (open to sky type without shed/cover/roof/side sheeting), incomer of SLDB shall be provided with Power contactor with Timer and auto manual provision for ON/OFF of light fittings.

d) In case covered Technological areas, (not open to sky type but covered with shed/cover/roof/side sheeting), incomer of SLDB shall need not be provided with Power contactor with Timer and auto manual provision for ON/OFF of light fittings. In this case, light fittings shall be made ON/OFF directly through incomer MCB or through out going MCB.

e) In case Area lighting, Road lighting, High Mast lighting, incomer of Feeder Pillar/SLDB shall be provided with Power contactor with Timer and auto manual provision for ON/OFF of light fittings.

f) Number of SLDBs shall be planned judiciously for ease of control of light fittings. Generally, one SLDB shall be provided for maximum of two floors/platforms of any building/shop/units. However, for smaller size floors/plat forms one SLDB can be used for more than two floors/platforms, case where platform/floor sizes/heights are small and considering convenience of ON/OFF of light fittings from SLDB.

In case of Electrical buildings, Substation& Control rooms, Lab buildings, Office buildings For Building level (Electrical building, Control room, Switchgear room) SLDB, Shall be provided at suitable location as per the detail engineering, which shall further feed to per phase isolation MCB DB for further distribution of light fixture and power sockets. Separate MCBDB shall be envisaged for lighting and Air conditioning and Power sockets.

For Administration building and Control room building Energy meter shall be provided

for measurement of lighting and HVAC load measurement as per GRIHA requirement. The SLDB shall have two incomer one for normal power and other incomer for PV solar electric system in control and administration building.

For Pump house, DG shed, Storage shed, workshop control of light fittings may be provided directly from SLDB.etc. each floor shall be provided with one SLDB located near exit/stair case. In case one SLDB is considered due to smaller area, then power from SLDB shall be taken to DP MCB DB Box mounted on the floor from where power shall be fed to each.Each circuit of SLDB shall be connected with maximum of 1000W load. Block diagram for power and lighting distribution boards shall be prepared with EMDB & ELDB distribution also for ease of understanding to bidder.

5.0 Emergency lighting

Normally all the Light fittings shall be fed from Dual Source(Grid Supply& DG Supply)

Dedicated &separate Emergency lighting SLDBs shall be provided for indoor & outdoor areas as per requirement to feed emergency lighting circuits which shall be through Local Battery & Inverters.

Emergency lights can continue to glow 20% to 25% lights shall be connected through Emergency SLDBs in Control Room,Substation, Admin Building, outdoor area (FLP/Non-FLP), compressor shed (FLP), Gate complex etc as required during detail engineering.

Only FLP type Portable Emergency lighting including built-in battery& lamp, battery charger shall be provided in strategic areas like control room,staircases, entry of cable Gallery, escape routes, compressor shed etc. for safety.

The SLDBs and it's connectivity with the respective buildings shall be in the scope of bidder. Necessary Equipment in this regard shall be considered.

6.0 <u>BUILDING ILLUMINATION& ENERGY MONITORING</u>

Administration building, Control room, Canteen, Gate complex, Worker rest room shall be design to complaint with Energy building code 2017.

Lighting control system shall be consider in Admin building, Control room, Canteen, Gate complex and Worker rest room :

Automatic lighting shutoff:

90% of interior lighting fittings in building or space of building larger than 300 m2 shall

be equipped with automatic control device. Within this building all office area, business, conference rooms, habitable space enclosed by walls of (area less than 30 mm2), storage space (more than 15mm2) shall be equipped with occupancy sensor. Public toilets more than 25 m2, controlling at least 80 % of lighting fitted in the toilet. 70% of the light fitting of corridor shall be provided with auto controlling device.
The lighting fixtures, not controlled by automatic lighting shutoff, shall be uniformly spread in the area.

The occupancy / PIR sensor shall have the following specifications

1. Passive infrared
2. Angle of detection 30deg.
3. Loading current – 10A
4. Operating temperature 0 to 40 deg C
5. Material Flame retardant PC/ABS
6. Maximum mounting height 2.5 to 3.5 mtr.
7. Detection range 7 mtr diameter at height of 2.5 mtr..
8. IP rating IP-42
9. EMS and RoHS Compliant.
10. Adjustable off delay timing 1-90 min.

Light fixtures controlled by occupancy sensors shall have a wall-mounted, manual switch capable of turning off lights.
Space control:
Each space enclosed by ceiling wall shall have atleast one control device to control the general lighting within the space.
It shall control a maximum of 250 m2 for a space less than or equal to 1,000 m2, and a maximum of 1,000 m2 for a space greater than 1,000 m2.
Control in Daylight Areas:

Luminaires in day lighted area shall be equipped with manual control device to shut off the light and also an automatic control device to shut off /dim the luminaires, installed within day lit area, during potential daylit time of a day.

Dimmable daylight sensor with PIR sensor:
In addition to above occupancy sensor following characteristic shall be included:

1. Adjustable lux level 100-1000 lux
2. 01-10V Analog dimmable control with min. 15 ballast

Metering:
Digital meters shall be provided at IGGL compressor Complex main source for monitoring;

- Utility grid
- PV solar electric Generation
- DG Set

In addition to above, digital meters shall be provided at each Admin and Control building to monitor energy and water consumption for following services:

- Heating, ventilation and air conditioning system
- Split AC's
- Lighting (indoor and outdoor)

Multi Function Meters / Energy meter:

Multi Function Meters for Energy monitoring shall be provided at control Room & Substation and Administrative Building for Energy monitoring as per GRIHA requirementhave the following as basic requisites – All the meters shall be of digital type and shall conform in all respects to International standards – IEC 61557-12, IEC 62053-22, IEC 62053-23 or the
relevant Indian standards with latest amendments thereof.
Multi-Functional Meter should be capable of multi measuring and monitoring of electrical parameters, energy metering, and transmission of this information via RTU/Protocol Converter to the SAS (Substation Automation System) network.

7.0 Maintenance lighting

For maintenance lighting, power supply shall be fed from 240/26.5V small capacity step-down transformers to the 24V socket outlets.

8.0 Outdoor lighting

Flood lights for area lighting shall be mounted at suitable height poles with bracket/stand for mounting flood light fixtures.
High masts shall also be considered for the area lighting, refer high mast sections mentioned in this TS.

Street/road lighting and boundary wall lighting shall be provided with LED lamp fittings mounted on poles of 9m height.

8.0 Power factor improvement

Power factor of all the light fittings shall be improved so that it is not less than 0.90. Power factor shall be improved by providing capacitor banks with discharge resistor in

the light distribution or by providing capacitors with individual fittings.

9.0 Lighting Transformer

Sl.No.	Parameter	Description
1.0	Type	Dry Type, Class F insulation, Protection - IP42 or better.
2.0	Power Rating	100 KVA
3.0	Primary Voltage	415 V
4.0	Secondary Voltage	415 V
5.0	Connection	Star – Star
6.0	Tap at primary	+/-2.5% & +/-5%

10.0 Main Lighting Distribution Board (MLDB)

A. General		
1.0	Type	- Metal clad. - Non drawout type. - Type tested design
2.0	Construction	- Modular construction . - Fully compartmentalized with metal / insulating material partition.
3.0	Enclosure class	IP52
4.0	Type of execution	Single front.
5.0	Mounting	- Floor mounting. - Free standing with ISMC 75.
6.0	Installation	Indoor.
B. Constructional Features:-		

1.0	Sheet steel	
	Thickness	- 2 mm for load bearing members. - 1.6 mm for non load bearing members.
	Material	CRCA
2.0	Cable entry	- Incomer :- Bottom cable entry. - Outgoing :- Bottom cable entry.
3.0	Design	- Separate bus alley and cable alley on opposite side of the outgoing modules. - All the components shall be accessible from front. - Each module to have covering at the bottom. - Minimum 200mm shall be left blank at bottom through the length of panel.
4.0	Interlocking & protection	- Module door interlocked with main power isolating devices. - Power circuit isolation device to have pad locking in the OFF position with door closed.
5.0	Operating height	- Minimum :- 300mm - Maximum :- 2000 mm.
6.0	Gland plate	Undrilled removable bottom gland plates (3 mm thick)
7.0	Miscellaneous	- Neosprene rubber gasket shall be provided for all the doors , removable covers & between adjacent covers . - Lifting hooks for the panel . - Doors shall have concealed hinges .
8.0	Labelling	Clear legible identification labels (anodized aluminium with white letters engraved on black background) with letter sizes of :- - 25-50 mm for MLDB panel - 5 mm for components and module name plates.

		- Danger board on front and rear sides in English, Hindi and local language .
9.0	Earthing	- Two separate earthing terminals shall be provided. - Bolted joints with tooth spring washers for good earth continuity. - Earth bus to run in all cable alley of the panel .
10.0	Shipping length	To be limited to 2.4 M.
11.0	Limiting dimensions	Width of MLDB Vertical :- 800 mm (min) Width of Module :- 500 mm (min) Width of Cable alley :- 300 mm (min) Depth of MLDB :- 600 mm Height of MLDB :- 2400 mm (max) Width of Bus alley :- 300 mm (min) Height of module :- 300 mm (min)
C. Busbars		
(i) Main horizontal & vertical busbars		
1.0	Arrangement	Three phase & neutral. Bus Bar chamber on the top.
2.0	Material	High conductivity electrolytic aluminium alloy confirming to grade E91E as per IS-5082 –1981.
3.0	Phase Busbar Rating	- Minimum rating shall be same as incomer MCCB rating - Shall be able to carry continuously the connected load (considering all derating factors) plus a 25% margin . - Max. current density shall be - 0.8 A/sq.mm for Aluminium - 1.2 A/sq.mm for Copper .
4.0	Neutral Busbar Rating	50 % of phase busbar rating

5.0	Short circuit rating	50 KA for 1 sec.
6.0	Busbar configuration	Red-yellow-blue from front to back or top to bottom or left to right as viewed from front.
7.0	Busbar insulation	Heat shrinkable PVC - R,Y,B coloured sleeves for phases - Black for neutral.
8.0	Busbar supporting insulators	- Non-hygroscopic - Flame retarded - Track resistant - High strength - Sheetmoulded compound or equivalent polysterfibre glass moulded type .
9.0	Max. temp. rise of bus	Not to exceed 35 deg. C. above ambient of 50 deg.C.
10.0	Air clearance for bare busbar	Phase to phase :- 25.4 mm (minimum) Phase to earth :- 19.0 mm (minimum)
11.0	Joints and tap off points	- Busbar joints and tap off points shall be shrouded and bolted (with cadmium coated bolts with plain and spring washers and locknuts). - Bimetallic connectors for connection between dissimilar metals . - Antioxide grease for all bus connections .
12.0	Neutral bus isolation	Through disconnecting link .
13.0	Vertical busbar	Rear side/Front side (Type tested)
(ii)	**Earth bus**	
1.0	Material	GI/AL at bottom through the panel lenght.
2.0	Size	Minimum 50 x 6 mm with extension at both ends .
(iii)	**Control bus**	
1.0	Material	Copper.

2.0	Size	Minimum 25 x 3 mm or equivalent.
3.0	Emergency operation	Availability of control supply in case of failure of normal power shall also be provided so that Bus-coupler & Incomer operation for emergency can be done.
D. Insulation level		
1.0	Rated insulation voltage	1100 V
2.0	Impulse withstand voltage	4 KV as per IS-13947 (Part I) 1993.
3.0	One minute power frequency withstand voltage	2.5 KV for power circuit & 500 V for control circuit.
E. Feeder arrangement		
Incomers		
1.0	Isolating Equipment	3 pole microprocessor based MCCB (for rating upto 630 A) with LSIG protection.
2.0	Quantity	Two incomers & One Bus coupler
3.0	Autochangeover	- Through Power contactor logic with suitable timer and auto manual selector switch. - Power Contactors of AC3 rating same as incoming MCCB.
4.0	Indication Lamps	LED type indicating lamps for:- - MCCB ON/OFF/TRIP. - Power ON R / Y / B.
5.0	Meters and selector switches	- 96 sq.mm size voltmeter with 7 position selector switches - 96 sq.mm size ammeter with 4 position selector switches
6.0	Current transformer	3 numbers for metering .
Outgoing feeder arrangements		
1.0	Circuit breaker	Three pole microprocessor based MCCB with LSIG release.

2.0	Indications	ON/OFF/TRIP indication lamp.
F. Panel wiring		
1.0	Power / current transformer circuit	1.1Kv grade single core, black colour PVC insulated , stranded copper conductor of minimum size 2.5 sq.mm.
2.0	Ferrules	- Numbered plastic/ceramic ferrules. - Self locking type.
3.0	Marking	- Wiring shall be properly marked as per relevant IS.
4.0	Terminals	- Power & control terminals shall be segregated by insulating material like hylam / bakelite sheet. - Power terminals shall be stud type. - Control terminals shall be clip on type suitable for connecting two cores of 2.5 sq.mm wires. - Minimum 20 % spare terminals shall be provided. - The minimum rating of control terminal shall be 10 Amps.
5.0	Cable glands	Double compression cable glands for receiving external power and control cables.

11.0 SUB LIGHTING DISTRIBUTION BOARD (SLDB)

A. General:-		
1.0	Type	- Metal clad. - Shall be suitable for 415/240V, 3 phase and neutral.
2.0	Construction	- Totally enclosed, Dust& vermin proof. - Welded back and sides.
3.0	Enclosure class	IP54/IP 55 (with canopy) for outdoor installation. FLP/Non-FLP type as per the area classification

4.0	Type of execution	Single front.
5.0	Mounting	Wall mounting.
6.0	Installation	Indoor/ Outdoor (with canopy).
B. Constructional Features:-		
1.0	Sheet steel CRCA	
	Thickness	2 mm.
2.0	Cable entry	- Incomer :- Bottom cable entry. - Outgoing :- Top / Bottom cable entry.
3.0	Design	- One/ Two Incomer and outgoings. - Two nos. incomer shall be envisaged in admin and control building (to accommodate power from PV system) - Separate compartment for incomer & separate compartment for out goings. - All the components shall be accessible from front. - Access to the operating handle of the incoming isolating switch shall be from the front of the cubicle without opening the front door. - Operating knobs of outgoing MCBs shall be accessible only after opening the front door of the cubicle. - Protective insulated cover plate (3 mm thick bakelite sheet) shall be provided inside the cubicle to shroud all the live parts. - For Hazardous area switchgear shall be four pole break type shall be provide. Neutral link is not acceptable.
4.0	Gland plate	Undrilled detachable gland plates (3 mm thick) shall be provided at the top and bottom with suitable gaskets for cable entry.
5.0	Miscellaneous	- Neosprene rubber gasket shall be provided for all the doors , removable covers & between

		adjacent covers . - Suitable locking devices. - Doors shall have concealed hinges .
6.0	Labelling	Clear legible identification labels (anodized aluminium with white letters engraved on black background) with letter sizes of :- - 5 mm for components and module name plates. - Danger board on front and rear sides in English, Hindi and local language .
7.0	Earthing	Two separate earthing terminals shall be provided.
8.0	Limiting dimensions	- Width of SLDB :- 900 mm - Depth of SLDB :- 300 mm - Height of SLDB :- 800 mm (min)
C. Busbars		
1.0	Arrangement	Three phase & neutral.
2.0	Material	High conductivity electrolytic aluminium alloy confirming to grade E91E as per IS-5082 –1981.
3.0	Phase Busbar Rating	- Shall be able to carry continuously the connected load (considering all derating factors) plus a 25% margin. - Max. current density shall be; - 1.0 A/sq.mm for Aluminium. - 1.5 A/sq.mm for Copper.
4.0	Neutral Busbar Rating	50 % of phase busbar rating.
5.0	Short circuit rating	25kA for 1 sec(or higher as per system requirement).
6.0	Busbar configuration	Red-yellow-blue, black for neutral.
7.0	Busbar insulation	Heat shrinkable PVC; - R,Y,B coloured sleeves for phases. - Black for neutral.

8.0	Busbar supporting insulators	- Non-hygroscopic - Flame retarded - Track resistant - High strength - Sheet moulded compound or equivalent polysterfibre glass moulded type.
9.0	Air clearance for bare Busbar	Phase to phase :- 25.4 mm (minimum) Phase to earth :- 19.0 mm (minimum)
D. Feeder arrangement		
Incomers		
1.0	Isolating Equipment	• 3 pole ELCB/RCCB with 30 mA sensitivity with IsolatorAC23 duty ELCB/RCCB shall be of AC 23 duty category conforming to IS: 13947-1993 having fully shrouded contacts. • For AdminBldg, Substation& ControlBldg, 3 pole+ neutral MCCB shall be provided as incomer
2.0	Quantity	One/Two
3.0	Indication Lamps	LED type indicating lamps for:- - Power ON R / Y / B .
Outgoing feeder arrangements		
1.0	Circuit breaker	TP/DP MCB with meter for measuring of energy consumption of HVAC and Lighting circuits in Admin and control building. It shall further connect to MCB DB having MCB + RCCB /RCBO as incomer and SP MCB as outgoing. MCBDB shall be recess/ surface mounted type For other area DPMCB shall be provided
E. Panel wiring		
1.0	Power / current transformer circuit	1.1kV grade single core, black colour PVC insulated, stranded copper conductor of minimum size 2.5 sq.mm.

2.0	Ferrules	- Numbered plastic/ceramic ferrules. - Self locking type.
3.0	Marking	Wiring shall be properly marked as per relevant IS.
4.0	Terminals	- Power & control terminals shall be segregated by insulating material like hylam / bakelite sheet. - Terminals shall be ELMEX type suitable for connecting two cores of 2.5 sq.mm wires. - Minimum 20 % spare terminals shall be provided. - The minimum rating of control terminal shall be 10 Amps.
5.0	Cable glands	Double compression cable glands for receiving cables .
6.0	Labelling	Clear legible identification labels (anodized aluminium with white letters engraved on black background) with letter sizes of:- - 25-50 mm for panel. - 5 mm for components and module name plates. - Danger board on front and rear sides in English, Hindi and local language.
9.0	Earthing	- Two separate earthing terminals will be provided. - Bolted joints with tooth spring washers for good earth continuity. - Earth bus to run at bottom.
10.0	Shipping length	Individual Panel
11.0	Limiting dimensions	- Width of Panel :- 1100 mm - Depth of Panel :- 450 mm - Height :- 1200mm

12.0 OUT DOOR FEEDER PILLAR (NORMAL AREA)

For Mining areas & Beneficiation/any Process Plant at Mining area, each incomer of Out Door Feeder Pillar shall be provided with 415V/240V transformers with secondary midpoint earthed having 30% spare capacity (minimum 25kVA rating). The transformer shall be mounted inside the panel (feeder pillar), dry type, class F insulation.

A. General		
1.0	Type	- Metal clad. - Non drawout type.
2.0	Construction	- Fully compartmentalized. - Separate compartment for incoming MCCB, Bus Bar, Meters etc. - Separate common compartment for out going TPN MCBs Power isolating devices.
3.0	Enclosure class & Doors	IP55 with Double Door arrangement and with Top Canopy.
4.0	Maintenance/Type of execution	From Front only.
5.0	Mounting	- Floor mounting. - Free standing with ISMC 75.
6.0	Installation	Out Door - Mounting on Platforms made up of Civil/RCC approx. 400mm above Road levelwith steel wire fencing all around feeder pillar
B. Constructional Features :-		
1.0	Sheet steel	
	Thickness	- 2 mm for load bearing members. - 1.6 mm for non load bearing members.
	Material	CRCA
2.0	Cable entry	- Incomer : - Bottom cable entry. - Outgoing: - Bottom cable entry.
3.0	Design	- Incoming Compartment to house Bus Bars on Top part with shrouding. - Incoming MCCB, CT with ammeter, voltmeter with selector switches shall be

		mounted inside incoming compartment, where asout going MCBs shall be mounted in separate out going compartment. - All the components shall be accessible from front.
4.0	Interlocking & protection	- Incoming MCCB handle shall be interlocked with 2nd Door with defeat facility and Pad locking facility
5.0	Operating height	- Minimum :- 300mm from bottom of Panel - Maximum :- 1200 mm.
6.0	Gland plate	Undrilled removable bottom gland plates(3 mm thick).
7.0	Miscellaneous	- Neosprene rubber gasket shall be provided for all the doors, removable covers & between adjacent covers. - Lifting hooks for the panel. - Doors shall have concealed hinges.
8.0	Labelling	Clear legible identification labels (anodized aluminium with white letters engraved on black background) with letter sizes of:- - 25-50 mm for panel. - 5 mm for components and module name plates. - Danger board on front and rear sides in English, Hindi and local language.
9.0	Earthing	- Two separate earthing terminals will be provided. - Bolted joints with tooth spring washers for good earth continuity. - Earth bus to run at bottom.
10.0	Shipping length	Individual Panel.
11.0	Limiting dimensions	- Width of Panel :- 1100 mm - Depth of Panel :- 450 mm

		- Height :- 1200mm
C.	**Busbars**	
1.0	Arrangement	Three phase & neutral.
2.0	Material	High conductivity electrolytic aluminium alloy confirming to grade E91E as per IS-5082 –1981.
3.0	Phase Busbar Rating	Current density shall be; - 1.0 A/sq.mm for Aluminium - 1.5 A/sq.mm for Copper . - Minimum Size – 30mmx10mm
4.0	Neutral Busbar Rating	50 % of phase busbar rating.
5.0	Short circuit rating	25 KA for 1 sec.
6.0	Busbar configuration	Red-yellow-blue from front to back or top to bottom or left to right as viewed from front.
7.0	Busbar insulation	Heat shrinkable PVC; - R,Y,B coloured sleeves for phases. - Black for neutral. - Complete Shrouding to be provided.
8.0	Busbar supporting insulators	- Non-hygroscopic. - Flame retarded. - Track resistant. - High strength. - Sheet moulded compound or equivalent polysterfibre glass moulded type.
9.0	Max. temp. rise of bus (if applicable)	Not to exceed 35 deg. C. above ambient of 50 deg.C.
10.0	Air clearance for bare Busbar	Phase to phase :- 25.4 mm (minimum) Phase to earth :- 19.0 mm (minimum)
11.0	Joints and tap off points	- Busbar joints and tap off points shall be shrouded and bolted (with cadmium coated bolts with plain and spring washers and locknuts).

		- Bimetallic connectors for connection between dissimilar metals. - Antioxide grease for all bus connections.
12.0	Neutral bus isolation	Through disconnecting link .
13.0	Vertical Busbar	NA
(ii)	**Earth bus**	
1.0	Material	GI.
2.0	Size	Minimum 50 x 6 mm with extension at both ends.
(iii)	**Control bus**	
1.0	Material	NA
2.0	Size	NA
3.0	Emergency operation	NA
D.	**Insulation level**	
1.0	Rated insulation voltage	1100V.
2.0	Impulse withstand voltage	4 KV as per IS-13947 (Part I) 1993.
3.0	One minute power frequency withstand voltage	2.5 KV for power circuit & 500 V for control circuit.
E.	**Pollution Degree**	
1.0	Pollution Degree	Pollution Degree 3. as per IS-13947 (Part-1) : 1993;unless otherwise stated.
F. Feeder arrangement		
Incomers		
1.0	Isolating Equipment	TPN MCCB (100A) microprocessor based with LSIG release (minimum 25KA for 1 sec). In case E/F protection is not available with MCCB of rating, same shall be provided using CBCT, E/F relay.

2.0	Quantity	One incomer
3.0	Automatic operation	Incoming shall be provided with 100A (AC-3) rating Power contactor-4 pole. Selector switch for Auto/manual selection to be provided. Under Auto mode, Power contactor shall be made on with the help of Timer. Under manual mode, Power contactor shall be made on using Start/stop PB mounted on 2nd Door.
4.0	Indication Lamps	LED type indicating lamps for:- - Power ON R / Y / B.
5.0	Meters and selector switches	- Ammeter & Voltmeter. - 96 sq.mm size with selector switches.
6.0	Current transformer	3 numbers for metering.
Outgoing feeder arrangements		
1.0	Circuit breaker	Three pole MCB .- 32A with removable neutral link-15Nos minimum. DP MCB- 32A with removable neutral link-15Nos minimum (For Mining areas & Beneficiation/any Process Plant at Mining area).
2.0	Indications	NA
3.0	Protection	All the equipment inside the boards shall be covered in front with a 3 mm thick bakelite sheet. Only the operating knobs of the equipment shall be projected outside the bakelite sheet and 2nd Door for safe operation.
G. Panel wiring		
1.0	Power / current transformer circuit	1.1kV grade single core, black colour PVC insulated, stranded copper conductor of minimum size 2.5 sq.mm.
2.0	Ferrules	- Numbered plastic/ceramic ferrules. - Self locking type.
3.0	Marking	- Wiring will be properly marked as per relevant IS.
4.0	Terminals	- Power & control terminals shall be segregated by insulating material like hylam / bakelite

		sheet. - Power terminals will be stud type.
5.0	Cable glands	Double compression cable glands for receiving external power and control cables.

13. a) Flame Proof LDB/SLDB/Feeder Pillar

1.0	**Construction**	The enclosures of the lighting and power panels shall be made of cast light metal alloy and shall be free from frictional sparking hazard. The magnesium content in the alloy shall be as per IS-13346. The temperature of external surfaces shall be limited to 200^0C, unless otherwise specified. The enclosures shall be sized to facilitate easy maintenance and heat dissipation. The panels shall be suitable for use in outdoor open location and shall have IP-55 degree of protection. They shall preferably be provided with integral canopy can be accepted. The separate canopy shall be made of at least 14 SWG (2mm) galvanised sheet steel or FRP. The canopy shall be suitable for providing protection against rain from top and two sides. The lighting and power panels shall be provided with gaskets made of non-in flammable and self-extinguishing material.
2.0	**Painting**	The enclosures shall be treated and prepared for painting with two coats of epoxy paint with final colour shade both internal and external) as below: - Flame proof (Gas group IIA/IIB) : Dark admiralty grey shade 632 of IS -5 - Flame proof (Gas group IIC) : Light yellow shade 355 of IS-5
3.0	**Inscription /Caution Marking**	A warning inscription “Isolate power supply elsewhere before opening” shall be provided on each enclosure. The warning inscription

		shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning plate shall be of nickel plated brass or stainless steel.

14.0 Control Room Switchboard

1.0	Location	Control room for controlling the lighting fixtures
2.0	Type	Flush mounted type
3.0	Construction	Fabricated from 14 SWG MS sheet with 6mm thick bakelite cover Shall have conduct knockouts on the sides.
4.0	Switch mechanism	Modular switches shall be provided
5.0	Power source	The switchboards shall be fed from SLDB of respective area.

15.0 Transformer for 24V AC Sockets

1.0	Type	Dry type Step-down transformer Air-cooled
2.0	Rating	Minimum 2500VA
3.0	Primary / secondary voltage	240V /26.5 V AC , single-phase
4.0	Construction	The transformer shall be enclosed in industrial wall mounting stainless steel (2 mm thick) box having separate chambers for the transformer, incoming and outgoing MCB's.
5.0	Cable entry	Suitable knock-outs shall be provided at the top and bottom for cable entry through GI pipes.
6.0	No. of winding	Two winding

7.0	Protection	SPN MCB's on primary and secondary side incorporating overload and short circuit releases.
8.0	Utility	Power supply to 24V repair network
9.0	Location	On structural platforms

16.0 240V SWITCH SOCKET OUTLET (For use at Shop Floors/Technological areas, Panel rooms, cable floors etc.)

1.0	Type	1 pole, 5 pin with third pin earthed industrial type receptacles . non-reversible, metal-clad, dust proof, industrial type suitable for horizontal insertion.
2.0	Rating	240 V AC , 5+15A,
3.0	Construction	Metal clad gasketted construction, weatherproof All socket outlets shall be supplied with heavy-duty type plug and cap with chain.
4.0	Isolation Switch	rotary type switch mounted flush in the socket outlet box. The isolating switches shall be manually operated industrial type of category AC 22.
5.0	Protection	Operating handle of the rotary switch shall be fixed in such a manner that it shall not be possible either to insert or withdraw the plug without switching off the supply.
6.0	Cable entry	Suitable for cable entry through 20mm dia. conduit.
7.0	Mounting	Wall / column mounting.
8.0	Inscription	Inscription plate shall be provided indicating the voltage and current rating of the switch socket outlet.
9.0	Miscellaneous	In hazardous area, flame proof switch socket outlet shall be provided.

17.0 240 V SINGLE/ DOUBLE POLE SWITCHES (For use at Shop Floors)

1.0	Application	The switches are intended for controlling lighting circuits.
2.0	Type	Weather and dustproof and industrial type.
3.0	Design	The rotary or toggle switches provided shall be of sturdy design.
4.0	Standard	As per IS : 6875 (Part-3) – 1980.
5.0	Housing	The unit shall be housed in cast iron or cast aluminium box having gasketted, screwed front cover plate, fixing lugs and suitable provision for terminating conduit/cable at the top, bottom or sides as specified.
6.0	Mounting	DIN Channel mounting. Single phase MCBs mounted adjacent to each other and connected to different phases shall be provided with adequate insulated phase barriers.
7.0	Terminal suitability	Terminals suitable for aluminium conductor cables.

18.0. Lighting

Fixtures and Accessories

01 All the luminaires shall be designed, manufactured and tested in accordance with the Indian Standards as far as they are applicable.

02 All the luminaires shall be industrial type with LEDwithminimum burning time of 50,000 hours with no toxic content with a colour temperature (CCT)>=5400 - 4000K & CRI above 80.Power factor shall be more than 0.9 and driver efficiency more than 86%.Junction Temperature shall be kept as low as possible so as to increase performance and life time of LED and ensure that the luminaires are as heat efficient as possible. LED Light fittings shall be suitable for operation at an ambient temperature of 50 Deg. C. Heat sink temperature rise above ambient shall be limited as per relevant available IS/IEC. For all out door fittings, surge arrestors shall be provided.

All the lighting fixtures shall be complete with all parts along with LED lamps/tubes, drivers and accessories for installation and efficient performance whether specifically

mentioned in the specification or not.

LED fittings shall be selected so as to provide correct colour appearance and rendering to enable workers to see & judge quickly and accurately, details of their work such as colour, brightness, shape form etc.

03 Individual light fittings shall be provided with suitable gland arrangements for 3x2.5 sq.mm armoured copper cable entry unless otherwise specified. Terminals of all fittings shall be suitable for taking 3x2.5 sq.mm, copper conductor PVC insulated and PVC sheathed cable.

04 All fittings shall be supplied with all interconnections made and fully wired upto the terminal block.

05 All live parts shall be provided with suitable sleeves to prevent accidental contacts. The earthing terminal in the fitting shall effectively earth the body of the entire luminaire.

06 Dust and vapour tight fittings shall have the enclosures suitably designed to withstand the heating effect.

07 The fixing arrangement of various components shall be in such a way that the maintenance and replacement jobs can be easily carried out.

08 All flameproof equipment shall be provided with flameproof plugs.

09 Flame proof fittings and control gearboxes shall be provided as per relevant IS in hazardous area. Flame proof light fittings shall have approvals from statutory CMRI-Dhanbad, CCoE-Nagpur, DGMS-Dhanbad& DGFASLI-Mumbai.

19.1. ILLUMINATION FITTINGS

1.0 OUTDOOR LIGHTING FITTINGS.

All road lighting fittings shall be mounted on steel tubular poles with single/ double or triple outreach brackets having LED lamps.

For lighting of open areas, self-supporting steel towers shall be provided with flood light fittings with LED Lamps.

2.0 LED FITTINGS

2.01 DECORATIVE LED LIGHT FITTING

Decorative type light fitting suitable for energy efficient tubular LED lamps with diffuser and CRCA body, IP20 or betterfor recessed mountingaccommodating all electrical accessories pre wired upto a terminal block. It shall have optimum glare control and shall be aesthetically appealing with distinguished looks.

2.02 INDUSTRIAL TYPE LED LIGHT FITTING

Energy efficient industrial type LED tube fitting, the fitting shall have channel and reflector with white cover plate, CRCA body/housing with powder coated finish & with diffuser for glare free light distribution. The fitting shall be complete with all electrical accessories and pre wired upto a terminal block.

For battery rooms, Acid plants, Chemical plants, luminaries shall be polycarbonate housing, MS gear tray dully pre-wired with accessories and transparent cover of polycarbonate similar to IPFC112LT16/20 or equivalent complete with 2 numbers of LED tubes

All types of LED fittings shall be suitable for mounting on wall/ceiling/conduit suspension.

2.02.1 WELL GLASS FITTINGS

Industrial type, Integral well glass luminaire with IP 65or better protection with die cast housingsuitable for use with LED lamp. The luminaire shall be complete with controlgear, driver & surge protector, heat resistant cover, wire guard preferred in case available adjustable mounting bracket, cable loop-in loop-out arrangement etc.

2.02.2 FLOOD LIGHT FITTING

Weather proof Flood light luminaire with LED lamp, IP 65 or better, integral type with aluminium die cast housing.The luminaire shall be complete with controlgear, driver & surge protector, heat resistant cover, prewired up to terminal block.

2.02.3 STREET LIGHT FITTING

LED based, energy efficient type and Street light fittings, suitable for outdoor duty in weatherproof enclosure class with IP65 protection, integral starting/control gear complete with controls/starter pre-wired to a terminal block. LED fixture housing shall be made up of high grade pressure die cast aluminium with powder coating to provide excellent resistant to corrosion. The fittings to be provided with heat resistant & toughened glass cover. The fittings shall be suitable for direct mounting on poles having extended arm. LED Light fittings shall be suitable for operation for outdoor installation. Heat sink temperature rise above ambient shall be limited as per relevant IS/IEC as available.

LED shall be provided with secondary lens optics to achieve effective light intensisty distribution.

2.02.4 FLAME PROOF FITTINGS

Flame proof type fittings shall be well glass type luminaries suitable for use with HPLN 250W (High pressure Mercury Vapour)/60W FLP Well glass LED light fixture with

separate/integral control gear complete with copper ballast, power factor improvement capacitor, terminal block enabling loop-in-loop out connection. Both fittings & control gear shall be of cast Aluminium alloy LM6 or cast iron stove enamel, Grey hammertone finish outside and white inside.

For integral type control gear LED FLP well glass fixtures, a separate 4-Way FLP/Non-FLP (as per area classification) type junction box shall be provided for loop in and loop out of cables.

The material for cable gland shall be brass/stainless steel/aluminium alloy LM6 and shall be double compression type suitable for indoor/outdoor use. These are must for every flameproof fittings and accessories.

All Electrical equipment shall be suitable for Flameproof area Zone -1 & 2 (Gas IIA and IIB) -class T3. Control station equipment shall have minimum flame proof Ex-d protection enclosure for Zone-1 and 2. Equipment will be certified by CIMFR or equivalent testing agency (NABL accredited) and valid PESO license shall be available.

FLP (CMRI, PESO approved) type double-compressionnickel-platedbrass cable glands, tinned-copperlugs,clampingmaterialetc.forcabletermination.

3.0 STREET LIGHTING POLES

Lighting poles shall be fabricated from GI of specified section with joints swaged together when hot and bevelled on outside edges. A weatherproof sheet steel junction box shall be provided at the bottom of the pole and contain DP MCB, bolted type terminals, grounding stud etc. The bolted type terminals shall be suitable for receiving 4 x 16 mm2 AYFY cables with loop-in-loop out arrangement GI conduits shall be embedded in the muff for incoming and outgoing cables.

The street light poles of 9 M height shall be conforming to 410-SP-29.

All erection consumables like bricks, sand, cement stone chips etc. for foundation of poles shall be supplied & erected.

4.0 High Mast Lighting Tower

4.01 Mast Proper

The mast shall be 20/30 meterhigh and designed in such a manner that it is capable of withstanding external forces exerted by wind pressure as per IS: 875 (Part 3)-1992 along with load of the lantern carriage assembly.

4.02 Mast Construction

The mast shall be fabricated from special steel plates conforming to BS 4360 cut and folded to form number of polygonal sections, giving a continuous tapered profile for stability and aesthetics, Silicon content in steel should not exceed 03% for good quality galvanisation. Bottom section shall be provided with plate welded to it for anchoring the mast to a reinforced concrete foundation block. To increase the strength, gussets shall be provided.

The bottom section shall be accommodate winch, electric drive etc. and for the safety of the same a vandal resistant and weather proof door shall be provided with locking arrangement.

The fabricated and welded mast sections as detailed above shall be hot dip galvanised with a minimum thickness of coating 90 microns conforming to IS 4759-1996, IS: 2629-1990 & IS: 2633-1992, both internally and externally.

After the delivery of the mast at site, these shall be jointed by slip stressed fit method with necessary stressing equipment. No site welding or bolted joints shall be accepted. Earthing terminal shall be provided on the mast base and feeder pillar-box as per relevant ISS.

The mast shall be provided with suitable aviation obstruction lamp.

4.03 Head Frame

The head frame designed to be a capping unit of the mast shall be of welded steel construction, galvanized internally and externally after assembly.

The head frame assembly shall accommodate specially designed LM 6 die-cast pulleys to accommodate the wire ropes and cable. Pulley construction shall ensure that wire rope does not jump out of the grooves.

The suspension arrangement for lantern carriage shall be with three ropes of stainless steel running on three on three pulleys for superior stability. There shall be a separate pulley for running the electric supply cable.

The pulleys shall run on stainless steel shaft/spindles and shall be self lubricating type.

The whole head frame assembly shall be covered and protected by steel canopy, hot dip galvanized internally and externally and secured to frame by stainless steel hardware.

4.04 Lantern Carriage

It shall be of mild steel construction and hot dip galvanized internally and externally. The lantern carriage shall be so designed and fabricated to hold designed number of flood light fittings and their control gearboxes, radically symmetrical. All junction boxes, Controlgear, fittings etc. mounted on the lantern carriage shall be on non-corrodable material with class of protection IP 55.

At the top docking position, combined guides and stops shall ensure concentricity between the lantern carriage and the masthead. The stops shall also help to ensure proper levelling and positioning of the lantern carriage at its top position. All the lower docking position, the lantern carriage shall rest firmly at a maintainable height from the ground level with the help of stoppers for ease of maintenance.

During lowering/raising operation the design shall ensure that there is no damage caused to the mast surface and any other parts installed.

4.05 Winch Assembly

The winch shall be self sustaining and self lubricating type specially designed without the need of breaks, springs or clutches, and shall consist of two drums fabricated from steel with machined grooves and mounted inside the mast at a convenient height from the base.

The wire rope shall be wound on the drum with one end attached to the lantern carriage while the other end is clamped to the winch drum. The design shall ensure no inter winding of the fitting ropes.

At least four turns of rope shall remain on the drums when the lantern carriage is fully lowered.

4.06 Support Ropes

The support ropes shall be of stainless steel and shall be capable of safely handling the lantern carriage load.

4.07 Supply cables.

Power supply cables shall be class B insulated with required number of cores provided with multi-pin heavy duty locking type male/female connectors at the end. Pulley assembly shall accommodate extra cable for emergency supply.

Test load shall be of 5-meter length 5-core 2.5-mm2 copper conductor cable with multi-pin heavy duty locking type male/female connectors at the ends. Under no circumstances the test lead shall travel through the mast.

4.08 Foundation

The design and construction of foundation for high mast lighting tower shall be included in the scope of the contractor.

The Contractor shall submit the design drawings for approval of MECON for high mast based on soil bearing capacity and wind speed. The Contractor shall be responsible for safe & efficient erection of the mast.

4.09 Electric Drive & Fittings

The drive shall be 3 phase, 415 volt, 50 Hz, class B insulated,induction motor/geared motor with suitable torque limiter.

The motor shall be mounted on MS hot dip galvanised plate inside the mast with a possibility of adjusting its position. The drive shall be capable of taking the load of whole lantern carriage with luminaries, control gearboxes, aviation obstruction light mounted on it.

Manual handle shall be supplied along with power tool for operating the winch manually in case of power failure. Reversible type starters for motor, contactors for lighting circuit, MCB isolator switch etc. shall be provided in a weatherproof enclosure for safe area. For high mast mounted in hazardous area Motor and control panel shall be flame proof type Ex-d temp class-T3.

4.10 Light Fittings

The light fittings shall be of integral type flood light type with LED lamps. The quantity,wattage, mounting position/angle and optical characteristics shall be decided on the basis of the following illumination requirement.

Minimum 30 lux illumination shall be achieved at a horizontal distance of 30 meters from the bottom of the mast all around. Illumination level of 10 lux shall be sufficient at plant boundary wall, parking area, Administrative Building, etc. Minimum of 3-5 lux is required to be achieved at a horizontal distance of 125 Metre from the bottom of the mast towards all area. Minimum 20 lux shall be achieved in the areas adjoining at the perimeter of 40 meter (approx.) radius considering the mast base at the centre.

All lighting performances shall be checked holding the lux meter in horizontal plane at ground level.

05.03.18 SUBSTATION AUTOMATION SYSTEM FOR POWER DISTRIBUTION

A) GENERAL

The power distribution network consists of 33 kV MRS & 33/6.6kV HT main substation & LT Substation. The SLDs/ Feeder details for HT switchboard/LT switchboard network are enclosed.

The proposed SAS under this specification shall be installed at SAS room to be located in Control room building. It shall have monitoring & control HT switchboard view all alarms, events, trends and disturbance system analysis.

The monitoring of auxiliary system like, PCC, PDB, ACDB, DCDB, FDA etc shall also be done from SAS system.

The monitoring of voltage and current of Battery, DCDB and Charger shall be done from SAS system.

One remote monitoring console needs to be provided at the office of In charge. The console shall fetch data by extending LAN from SAS room over CAT-6E cable. All necessary networking devices required shall be in the scope of the bidder.

a) The proposed system shall have following functionalities.

- Remote / local Control & monitoring
- Reports
- Trends and Historical.
- Alarms
- Event logging
- Fault Analysis
- All mimics of all switchyard transformer bays control room building equipment will be available at SAS system.

B) SYSTEM DESIGN

Scope of work

The Bidder shall refer relevant SLDs & Protection for number of feeders of HT switcboards and control room equipment for deciding BOQ and architecture for the SAS system.

The bidder's scope of SAS shall cover following:

SAS Component :

The SAS will consist of independent IEC-61850 based ring for monitoring and control of all the sub-station equipment. The interconnectivity among all substations shall be through OPGW/OFC cable.

1. Control unit, protection & metering of IED of all 33kV & 6.6kV feeders as per SLD of substation.
2. Monitoring & Control of transformer RTCC panel for power transformers.
3. Metering of IED of all LT switchgear panel feeders.
4. Monitoring of DCDB, ACDB, FDA, Fire fighting and other panels.
5. Industrial Ethernet switches IEC-61850 compliant shall be supplied.
6. Data Concentrator/Server (Main and Hot Stanby) conforming, IEC 61850, IEC 60870-5-104 and Modbus-RTU Protocols.
7. Engineering & Operator Work stations.
8. A3 cum A4 size color Printer cum scanner.
9. CAT-6E Cable and communication cables.
10. Dual power supply for switches.
11. Necessary networking components.

SAS system will be capable of handling minimum 10000 tags.

Detailed Scope of Supply, erection, testing & commissioning for SAS:

At Control Room	Redundant data concentrator/Server (Main and Hot Standby). Engineering work stations Operator Work stations. A3 cum A4 size color Printer cum scanner. One no. Lap top computer.

	Managed L2 Ethernet fiber/cu industrial switches and necessary networking components. All necessary hardware, software. Power Cables/Communication cables (Cu). OPGW/OFC cables with LIUs.

Notes:

1) All equipment under SAS shall be supplied in line with the state of the art technology. The Bidder will furnish the detailed technical specifications and data sheets of each system, being offered. The details will include configuration of the system such as processor, memory size, storage devices, communication ports, back up devices, operating system.

C)SYSTEM HARDWARE

General

The bidder will provide redundant sub-station SAS System in hot standby mode.
It will be capable to perform all functions for entire substation requirements as indicated in the SLD. It will use industrial grade components. Processor and RAM will be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used.
The capacity of hard disk will be selected such that the following requirement should occupy the following:

1. Storage of all necessary software.
2. 2 TB space for OWNER'S use.

a)Server (Main and Hot Standby)

The Server should present an open, expandable and future-proof system, by taking into account latest standards, such as e.g. modular system concept, etc.
RTU should be having redundant power supply, redundant communication processor and redundant central processor. These cards shall be accommodated within same rack and panel. Communication Processor will be connected to LAN Switch for communication with HMI and IEDs. The protocol for two way communication between all the numerical relays, data concentrator/server and HMI should be IEC 61850.
The communication processor is responsible to communicate all data from meters and numerical IEDs to HMI. The communication processor should have the capability to integrate Modbus-RTU. Communication Processor will be connected to LAN Switch for communication with HMI.
Digital Inputs: All Inputs should be suitable for 110V DC. They will be connected to potential free contact from field.
Digital Outputs: All Outputs should be suitable for 110V DC. They will be connected to potential free contact in field.
Analog Inputs: Analog signals are to be configurable as 4-20mA as required.
Control Voltage: Voltage converter to be provided by bidder for converting control DC

voltage to required DC in case the control voltage is different from station supply.
Sizing & Scalability: The system shall be scalable and shall be able to add more feedersin future.
The server shall be suitable for operation in Substation or High Electromagnetic Interference environment.
Data Concentrator shall be mounted in cabinets of following specification:

- All Panels shall be Powder Coated & conforming to IP 52.
- All I/O of RTU shall be properly terminated in Field Termination boards.
- Cabinets shall be of approved make with proper Door Lock & Key facility.
- Cabinets shall have Front & Rear Doors.

b)Operator/Engineering Workstation

The Operator Workstation will show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a color display. All event and alarm annunciation will be selectable in the form of lists. Operation will be by a user friendly function keyboard and a cursor positioning device. The user interface will be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, de-cluttering etc.

c)Operator Workstation Monitor

These will have high resolution and reflection protected picture screen. High stability of the picture geometry will be ensured. The screen will be at least 24" diagonally in size and capable of color graphic displays.

d)Printer

The printer will have in built testing facility. Failure of the printer will be indicated in the Station HMI. The printer will have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.
All reports and graphics prints will be printed on colour Inkjet printer. Laser printer will be used for hourly log printing.

e) Mass Storage and Back up device

The mass storage unit will be built-in to the Station HMI. All operational measured values and indications will be stored in a mass-storage unit. For back up purposes DVD-R/RW with 1TB or more capacity will be provided. The unit should support at least Read (48X), Write (24X), and Re-Write (10X) operations. The monthly back up of data will be taken on disc. The facility of back up of data will be inherent in the software.

f) SAS SOFTWARE

Software for proper operation of Operating work station (OWS) and Engineering work station EWS with licence shall be provided for adequate number of tags to meet system

requirement.

The software license provided in this project should not be computer specific and they should be reusable on another computer, as and when required, provided only one computer is active in the system.

Configuration Software shall be provided for protection relays and metering devices.

- For 33kV and 6.6kV Switchboard –Data access shall be taken directly from relay for control and monitoring, and from meter for metering. Alternatively server shall be used to fetch the data from relays and meters for control and displaying the same on OWS and EWS.
- For Auxiliary System (LTPCC/ACDB/DCDB/Battery/FDA and Fire Fighting system) – Data access shall be taken directly from relay for monitoring, and from meter for metering. Alternatively server shall be used to fetch the data from relays and meters for control and displaying the same on OWS and EWs.

Bidder shall supply all the necessary softwares for complete operation & maintenance of the system inducting the following:

a) Antivirus (4 Clients)
b) MS Office (4 Clients)
c) Other software (as required) to make the system complete

The whole system shall be configured & integrated with the relay network wherever applicable to carryout following function as a minimum:

- Power System logging, fault recording, Relay monitoring & measurement of various electrical parameters through relay.
- Software to display SLD along with metering data from relays of entire stations.
- Relay Supervision (Self-diagnostic status with annunciation).
- Time Check & Synchronization at pre-defined regular intervals by user.
- Event/Alarm handling.
- Report generation as per requirement.

Operational and maintenance manuals including drawings shall be provided.

D) SYSTEM ARCHITECTURE

The SAS system will be based on a centralized architecture and on a concept of Feeder oriented, distributed intelligence.

Each /IED will be independent from each other and its functioning will not be affected by any fault occurring in any of the other feeder control units of the station.

The data exchange between the electronic devices on bay and station level will take place via the communication infrastructure.

The switches will be connected in a dual ring structure, so that an alternate route is available in case of any problem or failure. Necessary alarm will be generated in the SAS in case of any communication problem.

E)SYSTEM LEVEL FUNCTIONS

a) Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., will be supervised continuously. Every detected change of

position will be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list and a hard copy printout will be produced. Alarms will be initiated in the case of spontaneous position changes.

The switchgear positions will be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which will give ambivalent signals. An alarm will be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

b) Measurements

Analog inputs for voltage and current measurements will be taken directly from the measuring instruments to the SAS system. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (V) and current (I) will be calculated.

The measured values will be displayed locally on the station HMI. The abnormal values must be discarded.

Threshold limit values will be selectable for alarm indications.

c) Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They will be recorded in an event list in the station Operator work station. Alarms will be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms will also be printed out on an event printer.

d) **SAS DISPLAY DESIGN PRINCIPLES**

Consistent design principles will be adopted with the HMI concerning labels, colors, dialogues and fonts. Non-valid selections will be dimmed out.

The object status will be indicated using different status colors for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state

F) COMMUNICATION SYSTEM

The bidder shall furnish detailed communication system topology with all equipments, hardware and softwares along with the offer. The bidder shall also indicate the list of equipments to be supplied under the project.

Switched Ethernet Communication Infrastructure:

The bidder will provide the redundant optical Ethernet communication infrastructure for SAS using managed switches.

Input/ Output (I/O) modules

The I/O modules will form a part of the IED and will provide coupling to the substation

equipment. The I/O modules will acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current will be from the secondaries of instrument transformers. The digital inputs will be acquired by exception with 1ms resolution. Contact bouncing in digital inputs will not be assumed as change of state

Extendibility in future

Offered substation automation system will be suitable for extension in future for additional feedersF. During such requirement, all the drawings and configurations, alarm/event list etc. displayed will be designed in such a manner that its extension will be easily performed by the Purchaser. The bidder will provide all necessary software tools & protocol details along with source codes to perform addition of feeders in future and complete integration with SAS by the user. These software tools will be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional equipment which will be added in future.

G) POWER SUPPLY

The entire electronic component shall be designed to suite the specific substation environment as far as EMC constraints. Power for the SAS will be through UPS supplied under the project scope and individual substation automation system will be from substation 110V DC and 240V AC (Wherever required). The UPS for SAS will have 2x20KVA capacity. The UPS will be of DUAL redundant type with two nos rectifiers, two nos invertors and one set VRLAbattery bank with 1hr back up time.

H) FACTORY ACCEPTANCE TESTS:

The supplier will submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual feeder level IED s applicable type test certificates will be submitted.

The manufacturing phase of the SAS will be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Bidder has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy will be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. If the FAT comprises only a certain portion of the system for practical reason, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system.

SAT (Site Acceptance Test)

The integrated system tests and SAT will be performed as detailed in subsequent clauses as per following configuration over whole system supplied at site as per mutually agreed and approved SAT document:

Hardware & Software Integration tests:

The operation of each item will be verified as an integral part of system. Applicable

hardware diagnostics will be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration. The equipment expansion capability will also be verified during the hardware integration tests.

I)SPARE PHILOSOPHY

Min. 30% Spare ports for Cu ports and one spare port for FO port shall be provided in each type of eathernet switches. Also, 20% spare cards (Analog and Digital) of total used cards shall be provided in Data concentrator and other IEDs. Each card shall have min. 30% I/O spare capacity.

J) **TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES**

Training Exclusive training for purchaser/ consultant personnel will be provided by the bidder.

Bidder personnel who are experienced instructors and who speak understandable English will conduct training. The bidder will arrange on its own cost all hardware training platform required for successful training and understanding in India. The Bidder will provide all necessary training material. Each trainee will receive individual copies of all technical manuals and all other documents used for training. These materials will be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, will become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training will utilize equipment identical to that being supplied to Employer.

K) Computer System Hardware Course

A computer system hardware course will be offered, but at the system level only. The training course will be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects will be covered:

- System Hardware Overview: Configuration of the system hardware.
- Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipment.
- System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
- System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
- Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques

and procedures. Classes will include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment will be taught in detail.

- Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training will be provided on Employer equipment, or on similarly configured systems.

L) Computer System Software Course

The Bidder will provide a computer system software course that covers the following subjects:

- System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.
- Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures
- System Initialization and Failover: Including design, theory of operation, and practice.
- Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,
- Software Documentation: Orientation in the organization and use of system software documentation.
- Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

Application Software Course

The Bidder will provide a comprehensive application software courses covering all applications including the database and display building course. The training will include:

- Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.
- Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.
- Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.
- Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

M)MONITORING REQUIREMENTS

Minimum following parameters shall be monitored in SAS. All control, signal, fiber cabling, media converter, LIU etc.are included in scope of work.

- Switchgear/switchboard status indication
- Measurements (V, I, P, Q, f)
- Event
- Alarm
- Winding temperature of transformers
- Ambient temperature
- Status and display of 110V DC system
- Acquisition of alarm from protection relays
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc
- Tap-position and temp parameters of Transformer

List of Inputs

The indicative list of input for typical bays/Feeders is as below:-

Analog inputs

i) For line
- Current: R phase, Y phase, B phase
- Voltage: R-Y phase, Y-B phase, B-R phase

ii) For transformer (Oil type)
- Current: R phase, Y phase, B phase
- OTI, WTI (for transformer)
- Tap position (for transformer only)

For transformer (Dry type)
- WTI (for transformer)

iii) Bus coupler
- Current: R phase, Y phase, B phase

iv) Common

a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicable
- Voltage: R-Y phase, Y-B phase, B-R phase

b) Frequency for Bus-I and Bus-II
c) Ambient temperature (switchyard).
d) LT system
i) Voltage of 110V DC Bus-I
ii) Voltage of 110V DC Bus-II
iii) Current from 110V Battery set-I
iv) Current from 110V Battery set-II

Digital Inputs

The indicative list of input for various bays/system is as follows:

1. CICO FEEDER
i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) Main bkr auto recloser operated
ix) Tie/transfer auto recloser operated
x) A/R lockout
xi) Tie/transfer bkra/r lockout
xii) O/V STAGE I operated
xiii) O/V STAGE II operated
xiv) 110V DC-I/II source fail

2. Transformer FEEDER
i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REF OPTD
ix) DIF OPTD
x) OVERFLUX ALARM (Pri)
xi) OVERFLUX TRIP (Pri)
xii) OVERFLUX ALARM (Sec)
xiii) OVERFLUX TRIP (Sec)
xiv) OTI ALARM/TRIP
xv) PRD OPTD
xvi) OVERLOAD ALARM
xvii) BUCHOLZ TRIP

xviii) BUCHOLZ ALARM
xix) OLTC BUCHOLZ ALARM
xx) OLTC BUCHOLZ TRIP
xxi) OIL LOW ALARM
xxii) back-up o/c (HV) optd
xxiii) back-up e/f (HV)optd
xxiv) 110V DC-I/II source fail
xxv) TAP MISMATCH
xxvi) GR-A PROTN OPTD
xxvii) GR-B PROTN OPTD
xxviii) Back-up o/c (MV) optd
xxix) Back-up e/f (MV)optd

All transformer alarm/warning signals will be interfaced with BCU and all trip signals will be wired to the protection relays .

3. Busbar Protection

i) Bus bar main-I trip
ii) Bus bar main-II trip
iii) Bus bar zone-I CT open
iv) Bus bar zone-II CT open
v) Bus transfer CT sup. Optd
vi) Bus transfer bus bar protnoptd
vii) Bus protection relay fail

4. Auxiliary system

i) 415V Incomer-I On/Off, TRIP
ii) 415V Incomer-II On/Off , TRIP
iii) 415V Bus-I/II U/V
iv) 415V bus coupler breaker on/off
v) LT transformer-I WTI Alarm & trip
vi) LT transformer-II WTI Alarm & trip
vii) Time sync. Signal absent
viii) Alarm/ trip signals as listed in Section
ix) Battery and Battery charger
x) 110V dc-I earth fault
xi) 110V dc-II earth fault
xii) Alarm/trip signals as listed in Section
xiii) Fire protection system

The exact number and description of digital inputs will be as per detailed engineering requirement.

At Substation Level battery voltage and current and DC earth fault relay, DC under voltage and DC over voltage etc. will be interfaced with SAS. Battery Charger current will also be monitored.

2.1.1 Bill of Quantity (Tentative):

Item	Item Description	Unit	Quantity
1.0	SAS Redundant Server (Main and Standby, Rack Based)	No.	2
2.0	L2, Ethernet switch with 4 FO (Single Mode) , 16 Cu ports for LAN for Control Centre LAN	Lot	1
3.0	LIU with FO Ports	Lot	1
4.0	Laptop Loose Supply (Latest Model)	No.	1
5.0	Operator Workstation with 24 " LED display	No.	2
6.0	Engineering Workstation with 24" LED display	No.	1
7.0	Laser Printer cum Scanner A4/A3 Size B&W	No.	2
8.0	Panel Cabinet	Lot.	1
9.0	2 PC table, 5 Revolving Chair , 2 Printer Table and 2 Filing cabinet & 2 steel racks, 1 semi circular central master control table	Lot	1
10.0	FO Patch cord, UTP cable, Connector as per site requirement	Lot	1
11.0	SAS software, DBM software	Lot	1
12.0	Large Video Display System (LVDS) 70" with all acessiries	No	1

A) Tentative Technical specification of Hardware components:

SAS Servers		
Sr. No.	**Required Features**	**Feature Details**
1	**Motherboard**	Intel(R) Core(TM) i7 of Xeon
2	**Features :**	
a	Processor	Intel(R) Core(TM) i7 of Xeon
b	Processor Sockets	2-Processor Slot, 1no. Installed Processor.
c	CPU/ Clock Speed	4.2 GHz
d	RAM	DDR-3, 16 GB ,1066 MHz; Expandable upto 128GB

e	Hard Disk	Installed 2 x 1TB SAS (10K rpm) 2.5in, Hot Pluggable HDD; RAID-1 configured
f	Maximum Internal storage (provision)	Chassis with up to 16, 2.5 Hard Drives
g	Storage Drive	DVD+/-RW ROM, SATA, Internal
h	Supports both IPv4 and IPv6	Yes
i	Supports SNMP v1/ v2/ v3	Yes
3	**Interfaces :**	
a	I/O Ports	1 x DB-9 Serial Port,
b	USB Ports	USB 2.0/3.0 Ports - 6 total: 4 rear, 2 front
c	Ethernet Port	4 x 1000Mbps Ethernet ports on Board
d	Expansion Slots	2 x PCIe 3.0 slots
e	RAID Controller	supports RAID
4	**Power supply**	Dual, Hot-plug, Redundant Power Supply (1+1), min 500W, Hot Swappable
5	**Power Cord**	Deskside Power Cord, 230V,2M (Nepal, Sri Lanka, India)
6	**Environmental Aspects :**	
a	Temperature	Operating :05° to 40°C (41° to 104°F)
		Non-Operating : -30° to 60°C (-22° to 140°F)
b	Relative Humidity	Operating :10 to 90% Rh
		Non-Operating : 5 to 95% Rh
7	**Physical Specifications :**	
a	Form factor	2U Rack, Rack Mounted
d	Mounting Rail	ReadyRails Sliding Rails With Cable Management Arm
Description : Software		
1	**Operating System**	Windows Server 2012R2 Standard Edition,Factory Installed, No Media,, 64 bit SP2, Standard Ed. (Eng) - SAS / Web Server Application

Laptop

Sr.No	Features	Feature Details
1.0	**Motherboard**	Intel(R) Core(TM) i7 of Xeon
2.0	**Display**	22" or above UHD, Anti-glare LED Panel
3.0	**RAM**	16GB 1333MHz DDR3 SDRAM
4.0	**Cache**	6MB Cache
5.0	**HDD**	2TB 5400rpm Hard Drive
6.0	**DVD Drive**	8X DVD+/-RW Drive
7.0	**Mouse**	Yes
8.0	**USB Port**	USB 2.0 (1)/USB 3.0 – 2 USB/eSATA combo

9.0	**Interface**	Network connector (RJ-45),10/100/1000 Gigabit Ethernet
10.0	**Power Consumption**	90W AC Adapter
11.0	**Power Supply**	230V AC +/- 15%, Freq 50Hz +/- 3%
12.0	**Wireless & Bluetooth**	Dell Wireless 380 Bluetooth Module
13.0	**Battery**	6-cell (60Wh) Primary Battery
14.0	**Power Cord**	Yes
15.0	**Serial Port**	USB to Serial Convertor
Description : Software		
1.0	**Operating System**	Genuine Windows(R) 10 Professional 64-bit

Server Panel		
Sr.No	**Description**	**Feature Details**
1.0	**Deg. of Protection**	IP-5X (Standard for Data Conc. panels)
2.0	**Panel Description**	**42U Rack** with Aluminium Vertical Profile frame with Steel End-Frames. All other parts of formed sheet steel
3.0	**Panel Size**	800W x 800D x 2200H (42U Size)
4.0	**Top cover**	With 4 x cut-outs for Fan mounting
5.0	**Bottom cover**	With 2 x cut-outs for cable entry
6.0	**Front Door**	Fully Perforated Steel Doors
7.0	**Rear Door**	Fully Perforated Steel Doors
8.0	**Side Panel**	Screw Fixed,1200mm Deep 2 Nos
9.0	**FAN Plate**	Plate for Cooling Fans
10.0	**Plinth Size**	600W x 1200D x 100H. mm.
11.0	**Rack Colour**	RAL 9005 Jet Black
12.0	**Plinth Colour**	RAL 9005 Jet Black
13.0	**Finish**	Power Coated as per above mentioned colour
14.0	**Mounting Frame**	19" L type punch section 4 Nos.
15.0	**Bulk Head Light**	1 No. of CFL
16.0	**Locking System**	Minimum 3 point ergoform lock
17.0	**Power Socket**	5/15A Socket strip with 10 sockets with double pole MCB per Power Strip RAL9005 Finish - 2 No.
18.0	**FAN Details**	230 VAC 600Wt Fan - 4 Nos
19.0	**Earth Strip**	Copper 15 x 5 x 450 mm earth bus
20.0	**Lifting Hook**	4 Nos. of eyebolt

Operator / Engineering Work Station		
Sl.No.	**Feature**	**Details**
1	**General Features :**	
a	Motherboard	Intel® i7® processor
b	Processor	Intel® i7® processor
c	CPU/ Clock Speed	Based on Intel i7 processor
d	RAM	16GB (2x 8GB), 1600 MHz , DDR3 ECC;

e	HDD Drive	1TB (SATA) 7200RPM
f	Storage Drive	16X max SATA DVD+/-RW with Dual Layer Write Capabilities
2	**Interfaces**	
a	Supports both IPv4 and IPv6	Yes
b	I/O Ports	1x serial port, 1xparallel port
c	Ethernet Ports	2 x 100/1000 Ethernet ports
d	LTP Port	24 Pin LTP port for dotmatrix printer connectivity
e	I/O Interface	Front: 3 No. USB 2.0, 1 No. USB 3.0, 1 No. Microphone, 1 No. Headphone; Internal: 3 No. USB 2.0, 4 No. SATA/SAS 3.0GB/s, 2 No. SATA 6.0GB/s (reserved for optical drive(s)); Rear: 5 No. USB 2.0, 1 No. USB 3.0, 2 No. PS2, 1 No. Serial, 1 No. RJ45
3	**Power Supply**	
a	Power Supply	240V AC +/- 15%, Freq 50Hz +/- 3%
b	Power Consumption	400W, 90%, Efficient power supply
4	**Environmental Aspects :**	
a	Temperature	Operating :40° to 95°F (5° to 35°C)
		Non-Operating : -40° to 140°F (-40° to 60°C)
b	Relative Humidity	Operating : 8% to 85%
		Non-Operating : 8% to 90%
5	**User Interface :**	
a	Monitor	24" Monitor, HP/DELL/IBM
b	Keyboard	USB Keyboard
c	Mouse	USB Optical Mouse
d	Speakers for audible alarms	USB powered external speakers, HP/DELL/IBM, Compact Speakers Model No-UC-238, Speaker Wattage-40W
Description : Software		
Operating System	Windows 10 Professional 64bit	

Note: -
The above mentioned specifications are indicative and minimum technical requirement. However, the equipment shall be finalized during detailed engg Stage with state of the art technology.

05.03.19 FLAMEPROOF ELECTRICAL ACTUATORS

All control valves in which shall be motorized electrically operated with manual operating handles.

The actuator shall be designed for operation on 415V, 3 phase, 50 Hz system. The actuators shall consist of motor, torque/ position limit switches, clutch, hand wheel, position indicator, space heater. The actuator enclosure shall be comply with hazardous area Zone-2 be totally enclosed dust tight, water proof used for

Hydrocarbonhandlingareashavebeengenerallyclassifiedaszone1&2,gasgroupIIA/IIBas perIS:5572,APIRP-500,OISD-113andIPRules.The installed actuators inthese areasshallbesuitableforthearea classification withtemperature classT3(200^{0}C),CMRI testingand approvedbyCCOE,DGFASand havingBISlicense.

Two torque limit switch one for each direction and four for end of travel limit switch (two for each direction) shall be provided. Emergency manual operation shall be provided and hand wheel shall de-clutch automatically when motor is energised.

Position transmitter, potentiometer type shall be provided for remote indications wherever required.

Internal wiring shall be of 1.5 sq.mm copper wire, however, terminals for external connections shall be suitable for 2.5 sq.mm.

05.03.20CABLES

a) HT XLPE POWER CABLE(3.3kV to 33 kV Grade)

A.	**Applicable Standards** List is given below, latest revision/ version of standard applicable during engineering shall be followed.	
	Standard	**Description**
1	IS–7098-Part-II, 2011	Specification for Cross-linked polyethylene insulated PVC sheathed cables – Part–II: For working voltage from 3.3kV upto and including 33kV.
2	IS: 8130 – 2013	Conductors for insulated electric cables and flexible cords.
3	IS: 5831 – 1984	PVC insulation and sheath of electric cables.
4	IS: 3975 – 1999	Low carbon galvanized steel wires, formed wires, and tapes for armouring cables.
5	IS: 10418 – 1982	Drums for electric cables
6	IS: 10462 (part-1) – 1983	Fictitious calculation method for determination of dimensions of protective covering of cables: Part-I Elastomeric and thermoplastic insulated cables.
B.	**Technical Particulars**	
	Description	**Requirement**
1.	Voltage grade	6.6 kV(UE) used for Resistance Earthed System 33 kV(E) used for Solidly Earthed System

	Application suitability	Suitable for laying in trays, trenches, ducts and conduits and for underground buried installation with backfill and possibility of flooding by water and chemicals.
2.	Conductor	Stranded and compacted circular aluminium (AL) conductor of grade H2 or H4 & class 2 as per IS.8130
3.	Conductor Screen	Non-metallic extruded semi-conducting compound. (Min thickness 0.3 mm)
4.	Insulation	Extruded cross-linked polyethylene (XLPE) as per IS-7098. The insulation and sheath materials will be resistant to oil, alkali and will be strong enough to withstand the mechanical stresses during installation.
5.	Insulation Screen	Non-metallic extruded semi-conducting compound. (Min thickness 0.3 mm).
6.	Extrusion process	The conductor screen, XLPE insulation and insulation screen shall all be extruded in one operation to ensure perfect bonding between the layers.(Triple extrusion process)
7.	Curing process for triple extruded core	Dry curing in CCV or VCV line
8.	Metallic Screen	Wrapped copper screen together with semiconducting tape over semiconducting insulation screen. Overlapping shall be min 10%. Calculation in support of selection of the size of copper screen shall be submitted during engineering
9.	Copper Screen rating	1kA for 1 Sec.(3 phase together for 3 core and each phase for single core)
10.	Inner Sheath	Extruded PVC compound confirms to ST-2 as per IS-5831 over laid up cores stranded together with holding tape and necessary fillers. For single core cables, there shall be extruded inner sheath between insulation metallic screen and

		armouring
11.	Armour	Galvanized steel strip armour as per IS-3975 for 3 core cable For single core cables, the same shall be with hard drawn aluminium round wire.
12	Outer Sheath	Extruded FRLS PVC compound confirming to ST-2 as per IS-5831, Black in colour and suitable chemicals will be added into the PVC compound of the outer sheath to protect the cable against rodent and termite attack
13	Length & ISI Marking	Sequential marking of the length of the cable in meters and ISI marking will be provided on the outer sheath of the cable at every one meter. The embossing / engraving will be legible and indelible
14	Core Identification	With coloured strips or by numerals applied on core in line with IS - 7098.
15	Drum type	Steel Drum.
16	PVC / Rubber end caps	To be supplied for each drum with a minimum of eight per thousand meter length. In addition, ends of the cables will be properly sealed with caps to avoid ingress of water during transportation and storage.
17	Special Requirement	FRLS PVC Outer Sheath with UV protection and anti rodent
18	FRLS Cable	**FRLS cables shall also meet the requirements as listed specifically for FRLS cables in subsequent clauses.**

SN	**Requirement**	**Value**
1	Oxygen Index as per ASTMD-2863	minimum 29
2	Temperature Index as per ASTMD-2863	minimum 250^0C
3	Smoke density as per ASTMD-2843	minimum average light transmission

		of 40 %
4	Acid gas generation limit as per IEC 60754-1	Hydrochloric acid gas release, maximum 20% by weight
5	Ignition resistance and flame propagation	conform to IEC 60332-1
	Fire resistance test	conform to IS 5831
6	Flammability test	conform to IEEE 383
7	flammability test on group of cables	Confirm to IEC 60332-1
8	Swedish chimney test	Confirm to SS-424-14-75 class F3
D	**Documentation**	
	For Approval	Guaranteed Techncial Particulars (GTP)
	For Reference	1) Cable cross section with label 2) Cable Drum Diagram 3) Fictitious calculation

1) Water swellable tape shall be considered additionally at appropriate layer for cables directly buried in ground.

3) HT XLPE CABLE shall be 3 CX240 Sq mm generally however as per OEM recommendation Single Core may be acceptable for case to case basis

B) 1.1kV GRADE XLPE LT CABLE

Sl.No.	Parameter	Description
1.0	Voltage Grade	1.1 kV grade
2.0	Duty type	Heavy duty
3.0	No. of cores	3.5 / 4 coresXLPE

4.0	Neutral Conductor	- For conductor size beyond 50 sq.mm, the fourth core used as neutral conductor shall be of reduced size as per IS: 7098 part-I
5.0	Reference standard	IS:8130 – 1984 IS:5831 – 1984 IS:3975 – 1988 IS:3961 (Part-II) - 1967. IS:7098 Part-I
6.0	Conductor type (Material, Size & Shape)	- Copper conductor – Min Cross sectional area 2.5 sq mm. - Aluminium conductor- Min Cross sectional area 6sq mm. - All power cables shall have compact **circular** stranded (rm/V) or circular stranded (rm) conductors as applicable. - The Aluminium conductor shall be H2 or H4 grade.
7.0	Standard Sizes	- Power cables shall be selected from core sizes of 2.5, 4, 6, 10, 16, 25, 50, 70, 95, 120, 150, 185, 240 sq.mm (Aluminium conductor).
8.0	Insulation type	- XLPE insulation. - The insulation compound shall be conforming to IS:7098 (Part I) - 1988.
9.0	Inner sheath	- For armoured / unarmoured cables extruded,PVC, Type ST2 as per IS 5831. - Black in colour.
10.0	Armour	- Galvanised steel round wire armour / Galvanised flat steel wires (strips)

		armour as applicable as per IS:7098 (Part I) 1988 - Single core armoured cables shall be provided with non-magnetic armour consisting of hard drawn round aluminium wires.
11.0	Outer sheath	- For armoured/ unarmoured cables a tough outer sheath of PVC compound (Type ST2 as per IS 5831) . - Black in colour .
12.0	Temp. rise	Shall be limited to 90 deg.C.
13.0	Cable & Core identification	Cable identification shall be provided by embossing on the outer sheath the following: ➢ Manufacturer's name & trade mark ➢ Voltage grade ➢ Year of manufacture ➢ Type of insulation ➢ R, Y, B for phases. ➢ Black for neutral (fourth core)

C) Control Cable

For control circuits, PVC insulated and FRLS PVC sheathed multi-core cables with copper conductors having a minimum cross-sectional area of 2.5 sq.mm per core shall be used. The number of cores may be standardized as 2,3,4,5,7,10,14,19,24.Each core of control cable with 7 core and above shall be numbered at every 1 meter intervals. In multi-core control cables, the following minimum reserve cores shall be kept at the engineering stage;

Up to 7 cores	-	One reserve core
Up to 10 cores	-	Two reserve cores
Up to 14,19 cores & above	-	Three reserve cores

Sequential length marking shall be provided in outer sheath of all power and control

cables.

PROPERTIES FOR FLAME RETARDANT LOW SMOKE (FRLS) CABLES

Sl.No.	Parameter	Description
Following properties shall be included for cables, wherever FRLS cable is specified in TS		
1.0	Reference standard	Category AF as per IS : 10810 ASTM-D 2863 (Critical Oxygen Index) ASTM-D 2863 (Temperature Index) ASTM-D 2843 (Smoke density) IEC 754-1 (Acid gas generation) IEEE-383 (Flammability test on group of cables) Swedish chimney test SS 424175, class F3. (Flammability test) IEC 332-1 (Flammability test) IEC 332-3 (Flammability test) IS 5831 (Fire resistant test)
2.0	Sheath	Specially designed with thermoplastic or thermosetting materials , superior resistance to ignition and flame propagation with smoke emission and toxicity or corrosive characteristics Flame retarded Oil resistant
3.0	Test values	
1	Oxygen Index as per ASTMD-2863	minimum 29
2	Temperature Index as per ASTMD-2863	minimum 250^0C
3	Smoke density as per ASTMD-2843	minimum average light transmission of 40 %

4	Acid gas generation limit as per IEC 60754-1	Hydrochloric acid gas release, maximum 20% by weight
5	Ignition resistance and flame propagation	conform to IEC 60332-1
	Fire resistance test	conform to IS 5831
6	Flammability test	conform to IEEE 383
7	flammability test on group of cables	Confirm to IEC 60332-1
8	Swedish chimney test	Confirm to SS-424-14-75 class F3

D) HT Cable termination & joints

All high voltage cable terminations shall meet the test procedures and requirements stipulated in IEEE 48-1990 as class-I termination.

Following type of cable termination and joints shall be used for HT cables in indoor and outdoor applications:

Heat shrinkable type

Heat Shrinkable type system

The stress control and grading wherever necessary shall be by means of semi conducting heat shrinkable tubing. Environmental sealing between heat shrinkable material and cable surfaces shall be achieved by using hot melted sealants or adhesives.

Where such sealants or adhesives shall be exposed to high electrical stress, same shall be track resistant type.

Cold Shrinkable type System
In Hazardous Area Cold Shrinkable Type Cable Joints shall be used

E) Specifications for miscellaneous materials

Connectors

Cable termination shall be made with aluminium/ tinned copper crimped type solder less lugs of approved make for all aluminium conductor and stud type terminals.

Cable identification

Cable tags shall be of 2 mm thick, 20 mm wide aluminium strap of suitable length to contain cable number as per cable schedule.

Ferrules

Ferrules shall be approved interlocked type & size to suit core size mentioned and shall be employed to designate the various cores of control cable by the terminal numbers to which the cores are connected, for ease in identification and maintenance.

Cable Glands

Cable glands to be supplied shall be nickel-plated brass double compression type. Glands for classified hazardous areas shall be certified by CIMFR and approved by PESO/CCOE, Nagpur.

Cable clamps

All cables shall be clamped with metal clamps and single core cables shall be clamped with trefoil clamps made of aluminium.

Cable trays

This shall be a prefabricated hot dip galvanized sheet steel tray. Runner size shall be 50x50x6 and rung size shall be 25x5 at every 250 mm. At one meter interval two rungs shall be provided side by side to facilitate clamping. Galvanizing content shall be 86 microns.

Following sizes of prefabricated GI cable trays shall be used;

- 100 mm
- 300 mm
- 450 mm
- 600 mm
- 750 mm
- 900 mm

Cable trays

GI ladder type factory fabricated cable trays made from 2.5 mm thick hot welded steel sheets grade ‘o’

as per IS : 2062. Hot dip galvanizing of 75 micron thick as I Rev IS-2629,IS-4759, IS- 209 Trays shall be of standard length of 3 m.

Cable Termination Accessories

Cable glands & lugs :

- Double compression, Brass glands for all outdoor equipment.
- Single compression, Brass glands for all equipment installed inside electrical rooms.
- All lugs shall be Tinned copper Type.

05 .03.21 EARTHING AND LIGHTNING PROTECTION

1.01 Earthing - General

Entire system shall be earthed in accordance with the provisions of the relevant IS code of practice IS 3043-1987/ IEC recommendations and Indian Electricity Rules, OISD-147 Rules.

Parts of all electrical equipment and machinery not intended to be alive shall have two separate and distinct earth connections each to conform to the stipulation of the Indian Electricity Rules and apparatus rated 240 V and below may have single earth connections.

All shops and buildings as well as the electrical sub-stations and electrical rooms shall be provided with a ring main earthing system each. Individual ring main earthing systems shall again be interconnected as a network.The earthing system shall be provided to have overall network earthing resistance less than one ohm. Soil resistivity test through approved agency shall be carried out by the contractor at each location and the system shall be designed accordingly.

The ring earthing system around each building shall be laid at a distance of approximately 1.5 m from the building and at a depth of approximately 0.8m. The ring shall be bonded below the ground at intervals to the building steel structures, reinforcement of building columns and also to pipes, wherever they are crossing as far as possible. The earth ring shall further be connected at intervals to earthing electrodes as per the requirement to achieve a combined earth resistance of less than one ohm.

For the purpose of dimensioning the earthing lines/conductors for main earthing ring/earthing grid, the duration of the earth fault current shall be taken as 1 sec.

For different floors within a building, localized ground mats shall be formed and connected to the ground earthing ring through vertical risers. The earthing mat shall be common to both power and lighting installations. The ground mats so formed shall be covered with floor finish.

For protective earthing separate conductor shall be used for flow of earth fault current as elaborated below.

The LV side neutrals of the Power and distribution transformers shall each be connected to two separate earthing electrodes.Both the earth electrodes shall also be interconnected with GI earth Strip under the Ground. They shall also be connected with the neutral bus of the corresponding switchboard. The armour of all cables as well as fourth core of motor feeder cable and all conduits for cables shall also be connected to the earthing mains. A continuous earth strip shall be run on both side in case of cable tunnel/ overhead structural cable gallery and on one side in case of cable ducts and trenches.

The fourth core of the main power supply feeders shall be connected to the solidly earthed neutral bar in the substation switchgear as well as at the neutral bars in MCC/distribution boards. For MCC feeders and feeders to motors, fourth core shall be connected to the earth bus on either side of the panel.

Earthing connection to equipment subject to vibration and shocks, shall be through flexible stranded conductors.

1.02 Earthing of electrical equipment on cranes and travelling machines:

Every electrical equipment shall have double earthing.A ring earthing system shall be provided within the crane/machine to which every electrical equipment shall be connected at least at two places.

The earth ring on the crane/machine shall be connected to the plant earthing system through the gantry rails. Two sets of earth collector brushes shall be provided on each side of crane/machine to connect its earth ring to the gantry rails.

Each end of each gantry rail shall be bonded to the plant earthing system.In addition, intermediate earthing bond shall also be provided on the rails at every 60 m in case of longer tracks.Flexible copper bonds shall be provided across any gap in the running gantry rails.

For mobile equipment with flexible cables/ trailing cable/ Reeling drum, one separate copper conductor of adequate size shall be provided for earthing.

1.03 Conductor sizes for ground connections:

For equipment ground connections, the minimum conductor sizes used should be as follows:

S.N.	System / Equipment	Minimum Conductor Sizes
1.	Main earthing rings around the building and risers	75 x 10 mm GI Flat
2.	High voltage systems, HT switch-boards,	
3.	Transformers Earthing and neutral	
4.	LT PCC	
5.	Main earthing ring for MCC room, in shop units/plant buildings	50 x 6 mm GI flat
6.	Aux. LT Switchboards and other equipment protected by circuit breakers.	
7.	LT MCC, PDB, MLDB, Bonds to crane gantries	
8.	HT motors	
9.	Motors and starters over 45 kW	
10.	Cable trays all around	
11.	Motors and starters above 15 kW, and upto and including 45 kW Control desks, cabinets, Welding socket outlet, Isolators, LDBs.	25 x 3 mm GI flat
12.	Motors and starters above 3.7 kW and upto and including 15 kW. Local Control Box/station	16 Sq. mm Stranded GI wire:

13.	Instruments and miscellaneous small items protected by fuses of ratings not exceeding 15A.	6 Sq.mm Stranded GI wire
14.	Motors and starters upto and including 2.2kW, Light fitting, JBs, etc	6 Sq.mm Stranded GI wire

1.03 Earthing electrodes

The earthing electrodes for treated earth pits shall be of GI pipes 50 mm dia and minimum5 mm thickness in one piece provided with connection bar, water filling device and other accessories in line with IS-3043 latest edition.

1.04 Elecronic earthing system

Separate electonic earthing system shall be provided for all electronic equipment like PLC/SCADA, weighing panel, computer etc. Elecronic earthing shall be distinct and separate from the power and lighting equipment earthing system. Electronic earthing system shall be provided with copper plate earth electrodes and the same shall be connected to the equipment by insulated conductor.

1.05 Lightning protection

All buildings and plant structures vulnerable to lightning strokes owing to their height or exposed situation shall be protected against atmospheric flash-overs and lightning strokes in such a manner as to eliminate any danger to the personnel and equipment employed therein.

Stipulations of IS/ IEC :62305–1 to 4: 2010 shall be followed for lightning Protection system & components used for lightning protection shall be confirming to the respective parts (IS/ IEC : 62305 – Part 1 to 4) & OISD norms .

Electrical & Other Panels

Lightning zone shall be calculated as per IEC:62305 and Type-1 SPD shall be provided for equipment in Zone1 and Type-2 SPD shall be provided in Zone-2 equipment. All PLC, RIO panel, SCADA panel, UPSDB, Battery charger shall be provided with Type -2 surge protection device (SPD). Type-1 SPD shall be envisaged in LTPCCetc panels.

Lightening protection level of minimum level-II shall be provided a for the structure / buildings at risk. Considering Zone-1,Zone-2 lightning Protection Layout drawing shall be prepared and accordingly coordinated layout for SPD shall be designed.

For the instrumentation, Surge Protection Devices shall be installed for the following:

Control room / Remote I/O Modules:

SPDs shall be provided for all analog signals from field. Protection from switching surges suitable for voltage protection level of 0.15 KV and a Surge current of 10 kA (8/20 micro Seconds wave shape) with response time of < 1 ns. shall be supported.

COMMUNICATION LINES:

SPDs shall be provided for communication lines (RS 422 / RS 485) to field. Protection from switching surges for voltage protection level of < 100 V and a Surge current. of 20 kA (8/20 micro Seconds wave shape) with response time of < 1 ns shall be supported.

SPDs shall be provided communication lines (Ethernet / twisted pair) to field. Protection from switching surges suitable for voltage protection level of < 30V and a Surge current of 7.5 kA (8/20 micro Seconds wave shape) with response time of < 1 ns. shall be supported.

Surge Protectors for UPS Distribution:

Surge protection devices are also envisaged to prevent surges and transient over voltages through inductive or galvanic coupling due to lightning for the power supply distribution lines to various buildings / areas to protect equipment connected to the supply.

Air termination network should cover all salient points of the structure. All metallic chimneys, ducts and the like above the roof of the structure shall be bonded to and form part of the air termination network.

Down conductors shall follow the most direct path possible between air termination and earth electrodes avoiding sharp bends. Down conductor shall have a testing point adjacent to the earth electrode. Each down conductor shall have an independent earth electrodes. All earth electrodes shall be interconnected below ground level.

Earthing electrodes and grid for lightning protection shall be **distinct separate** from the earthing system for earthing of electrical equipment over the ground.The lightning protection grid and the equipment earthing grid shall be **inter connected** below the ground level.

The termination of strips to the equipment shall be done by bolting and the wires shall be terminated by compression lugs. Jointing of strips shall be done by welding for proper continuity. All contact surfaces shall be thoroughly cleaned of dust and oil and after jointing, the joints shall be given bitumen paint.

1.06 Guidelines for installation of Earthing Conductor

Earthing conductors run on walls/floors/cable and equipment structures etc. shall be supported at suitable intervals and painted with black oxide paint.

All joints in all kind of Earthing conductors except at earthing electrode shall be welded and painted black with bitumen paint.

At road /rail crossings earthing strips shall be laid through conduits /concrete ducts.

Eqarthing& Lightning protection shall be ensure for Equi potential earthing .

05.03.22 REPAIR NETWORK

General

A repair network shall be laid to cover all the units/buildings of plant for providing power to maintenance tools, tackles and telphers.

a) Switch socket outlets (for Welding) In Normal Area

Welding switch socket outlets shall be provided at every 60m distance in conveyer galleries. The number of welding socket outlets for main technological plants/platforms/junction houses/units shall be decided based on requirement, approach etc. Generally the welding socket outlets shall be provided in such a manner so that using 30m flexible cable with welding set, total plant area can be covered.

- 415V, 100 A, 3 pole load break switch.
- 3 phase and one earth pin socket
- Switch socket interlocked so as to prevent insertion or withdrawal of plug when switch is "ON".
- Facilities for terminating two cables of minimum size 3.5 x 70 sq. mm aluminium cables.
- All the switch socket outlet shall be fed from PDB directly.
- Maximum of 3 sockets can be looped from one feeder.

b) 15 A + 5A, 240 V industrial switch socket outlets normal area shall also be provided. At least one socket outlet shall be provided in electrical panel rooms within a distance of 30mtr. In case of conveyor galleries/platforms/junction houses/shop floors, cable tunnel, cable floor/basement etc. atleast one socket outlet shall be provided

covering a distance of 60mtr.

240 V switch socket outlets shall be fed power from Lighting circuits, i.e from SLDB or MCBDB. Multiple sockets can be looped from nearest LDB.

C) Flame Proof Sockets

Flame Proof 63 A sockets shall be used and Exd Construction and installedinthese areasshallbesuitableforthearea classification withtemperature classT3(200^0C),CMRI testingand approvedbyCCOE/ PESO,CIMFRDGFASand havingBISlicense.

D) Flame Proof Pushbutton station

Flame Proof 63 A sockets shall be used and Exd Construction and installedinthese areasshallbesuitableforthearea classification withtemperature classT3(200^0C),CMRI testingand approvedbyCCOE/PSO, CIMFR,DGFASand havingBISlicense.

05.04 GUIDELINE FOR ERECTION OF ELECTRICAL EQUIPMENT AND ACCESSORIES

05.04.01 General

All the electrical equipment shall be installed with proper care and as per layout drawings. Minor modifications required at site shall be made by the contractor with approval of purchaser /Consultant for installation of the equipment. Care shall be taken for proper handling of equipment and undue vibrations shall be avoided particularly in case of sensitive (instrument mounted on panels) equipment.

The contractor shall have valid electrical contractor's license and supervisory license valid for working in the state where work is being carried out. He shall have in his employment sufficient number of electricians and supervisors holding valid licenses for HV and LV installations as applicable. It shall be the responsibility of the Contractor to get the installation cleared and relevant drawingscertified/approved by Electrical Inspectors, Factory inspectors, Insurance agencies and other statutory authorities. The Govt. fees and necessary commercial aspects shall be taken care by the Contractor.

Manufacturer’s technical expert/their authorized expert shall be available at site during erection, testing and commissioning of the critical equipment e.g HT switchboard, Transformers, MV VFD, PLC/ DCS system, Battery system etc. Apart from these equipment, if the purchaser/ consultant feels the need for calling the manufacturer’s technical expert for any other equipment, the same shall be done by the contractor without any cost implication to the client.

05.04.02 Rotating machines

The erection work of motors shall include checking of all motors before installation including thorough cleaning and checking of bearings, replacement/rectification of defective items, greasing of bearing, if required, making minor modifications in its mounting arrangement, wherever required, assembling and its mounting on the motor base plate or on mechanical equipment, as the case may be, including levelling and alignment, checking insulation resistance and improving the same, if necessary, checking of internal connections etc.

All work associated with revisioning of motor shall also be included such as uncoupling and removing of motor from mechanical equipment, disassembling, cleaning, checking of insulation resistance and improving the same, if necessary, regreasing and replacing defective items/bearings on foundation, wherever required, reassembling, placing, levelling, aligning and fixing of coupling of the revisioned motor with mechanical equipment.

The contractor shall check different parts and assemble the motor at site in correct sequence wherever the motors are delivered in a dismantled state i.e. base frame, bearing pedestals, armature, field frame etc. in separate packages.

Erection, alignment and securing shall be done under expert technical supervision. Optical equipment/instruments shall be used for alignment.

The height of the shaft of the motors shall correspond to the machine to be driven, if discrepancies are encountered these shall be compensated by inserting machined metal simplates under the supports of the motor.

The motors mounted on the movable base frames/base plates shall be connected via intermediate terminal boxes with flexible cables.

After the complete installation of the motors, all bolts and bolted joints of the mechanical and electrical equipment shall be checked to ensure that they are done up tightly by torque wrench. A further check shall be made to ensure that the armature can be easily rotated.

The insulation resistances of the coils and connecting leads within the machine shall be checked against earth by a suitable megger. Insulation resistance if found less, the machine shall be dried to achieve the desired value.
Space heaters of main drive motor required to be installed in motor foundation pits shall be suitably and firmly mounted.

For handling the machine with the crane, the slings, lifting cables etc. shall not be

secured around the shaft. However, the armature of disassembled machines may be lifted or supported by the shaft.

The system components delivered in separate packages like tank, gear pumps, filters, pressure switches, thermometer, flow regulators, centrifuge etc. shall be assembled at site and installed as per supplier's drawings. The supply and return pipelines along with their supporting structures from the lubrication system to the motor bearing shall be laid/erected by the contractor as per the relevant pipeline routing drawings. Meters and gauges shall be fixed and wired.

05.04.03 Sheet metal enclosed panels, open control panels, control desks and boxes

The base frames of all panels, desks, posts etc., shall be welded to structures or to the civil inserts provided on the floor/walls. Fabrication of supports/frames, wherever required, shall be done by the contractor.

The shipping section shall be placed in position before removing the protective covering to eliminate scratch/damage during movement. The shipping section shall be moved by using rollers under the shipping skids wherever lifting cranes are not available. The contractor shall do the assembly at site as per manufacturer's general arrangement drawings and installation instruction. While assembling a complete board comprising several unit type cubicles, the board as a whole shall be aligned. The panels shall be properly leveled prior to grouting the holding down bolts or welding the panels to the inserts. All interconnection of busbars and wiring between the panels shall be done as per manufacturer's instructions and drawings. Welding work on the panels shall only be carried out after consultation with the purchaser/ consultant. Damage to the paint due to welding/ transport shall be rectified by the contractor.

After mechanical installation of the board is completed, loose instruments shall be installed, wherever required, and wires shall be connected to the instrument. The wiring of intermediate terminal strips between two panels, wherever disconnected for transport, shall also be connected.

Each post shall be mounted at the place of installation in such a way that the operator has both the plant and the post before him.

The installation of control posts/boxes on mechanical equipment must be approved by the purchaser/ consultant.
In cases where the control posts/boxes are separately mounted near the equipment, the contractor shall fabricate and install a structural support for the same before mounting the control posts/ Control box etc.

05.04.04 Static Converters& Inverters

The installation shall be carried out as per manufacturers' instructions &approved equipment layout drawings.

The preservative grease from the metallic parts shall be removed by petrol and with clean markin cloth. Grease from copper parts shall be removed with ethanol and wiped with clean dry markin cloth.

The base frame of panels shall be welded to the civil inserts.

The panels supplied in separate shipping units shall be assembled at site as per manufacturer's drawings/instructions. The unit installation shall be started with the main converter. All the cabinets shall be aligned in a perfectly straight row and each of them exactly leveled. All inter-connections shall be done as per manufacturer's drawings/instructions.

05.04.05 Transformers and reactors

The transformer and its accessories and mountings like radiators, conservator, thermometers, silicagel breathers, marshalling box, rollers etc., delivered at site in separate packages, shall be assembled at site after cleaning by the contractor in proper sequence as per manufacturer's drawings& instructions.

Jacks shall never be placed under valves or cooling tubes.

After proper alignment of the transformer, suitable stopper shall be provided both in front as well as rear of transformer to keep the transformer stationary in its position. For the front wheels such stoppers shall be screwed on the rails.

The oil conservator and the pipes shall be erected as shown in the manufacturer's drawings. All radiator tubes shall be cleaned before installation.

Before the transformer is filled/topped with oil, oil samples shall be checked by the contractor from each container. The oil shall possess the dielectric strength as per relevant IS/IEC. Oil shall be filled upto the mark shown.

The contractor shall also test the oil from each transformer to determine its suitability for use. If required, the contractor shall carry out drying and filtering operations as per IS code of practice or manufacturer’s recommendations to ensure that moisture is removed and the oil is free from impurities. This may be carried out by using oil filtering equipment to be provided by the contractor having vacuum as well as heating arrangement. Only after the dielectric strength of oil and other parameters are checked and approved, the external connections shall be made to the transformers.

The dial thermometers shall be screwed to the thermometer pockets after removal of the blind plugs.

Any modifications to HT and LT terminal box to accommodate the number of cables to be terminated shall be carried out by the contractor.

Naked light and flame shall never be used near the transformer.

05.04.06 Battery installation

All batteries shall be installed at appropriate location as per the approved drawing. Battery for UPS (SMF type) shall be panel mounted and located by the side of UPS.

Rooms having battery installation (Except VRLA or SMF type) shall have acid resistant floors and walls shall have acid resistant tiles upto 1.5m height. The battery room shall have a water tap and adequate ventilation facilities for acid/ alkali fume extraction as applicable.

Battery shall be installed such that all around approach is available for attending the terminals of the batteries. The clearances shall be as per the recommendations of the manufacturer.

All the terminals of the batteries shall be cleaned and applied with No-Ox greaseor any other grease recommended by the manufacturer before and after interconnecting link installations

05.04.07 Busbar installation in sheet metal enclosed panels/ Bus trunking system

Busbar installation shall be commenced from the middle section and the buses shall be fastened without tightening the bolts. The buses shall lie freely on the insulators without warping and if necessary, suitable packing shall be provided at the insulators.

Final tightening of the bolts shall be done after the complete laying of buses. Approved means shall be used for tightening of the bolts with recommended tightening pressure as per the manufacturer recommendations.

Bimetallic strips/ washers shall be used wherever aluminiumbusbars or aluminium cables are terminated on copper busbars.

05.04.08 Crane Trolley Lines

While sectionalizing, one middle safety section shall be arranged slightly in excess of the crane braking distance so that it can act as a buffer and prevent the danger of crane collector bridging the isolator gap and leading to accidents on other section under repair or maintenance.

Boarding or access platform shall be arranged within the limits of each repair section for approach to the crane.

In the middle of the run between two expansion joints and at sectionalizing gaps, the rails

shall be rigidly fastened/supported.

05.04.09 Resistance boxes

The resistance boxes shall be installed on frames to be welded to civil inserts already provided.

05.04.10 Cables Installations

Interplant cabling shall be done in Overhead cable galleryor Cable tunnel or Concrete cable trench as specified in TS.

Cables of small in numbers and cables for drives/field switches inside shop units shall be laid along the structures and columns of the shop / buildings. Cables may run partly in walkable cable tunnels or underground trenches and/or surface ducts in the shops and partly along the structures and columns of the buildings considering site conditions.

Where the number of cables to be laid calls for walkable tunnels and cable shafts, same shall be provided. Underground walkable cable tunnels shall have hydro sealing to prevent water seepage.

05.04.11 Cable Installation in excavated trench

Laying of cables directly in underground or in excavated trenches shall be avoided. However, it may be allowed in special case with permission from site in charge. In such case, cable shall be laid in one layer only, more than one layer is not permissible.

Cables in excavatedcabletrenches shall be laid on 8 cm of riddled sand and covered with 8 cm of riddled sand. RCC slabs shall be provided over the upper layer of riddled sand for protection against accidental damage during excavation.. The maximum trench depth shall normally be 1.5 m and thickness of RCC cover of 75 mm.

For crossing the road / rail track, surface drains and water, oil, gas or other pipe lines, cables shall be laid in concrete cable ducts, heavy duty GI pipes/RCC Hume pipes encased in concrete blocks. 25% spare conduits / pipes / duct openings shall be provided. The top of pipe blocks shall be minimum 1500mm from rail sleeper/road or as per approved drawing.

Installation of cables directly buried in ground shall generally conform to the requirements given in IS: 1255 –1983.

Entry of cables from underground to the buildings or trenches shall be through metallic conduit upto a height of 2 mtrs. After laying of cables, the conduit shall be sealed with

bitumen or epoxy compound with sand matting and cement plaster to make them fully water tight.

In areas having considerable rainy season, cable entry from outside to inside of any building shall be done at elevated levels or at least above FFL so that cable entry points never become water leakage points inside building.

Cable markers shall be provided on either side of road crossing at each turning and at 30 m intervals at straight runs for underground cables.

05.04.12 Cable Installation in Overhead cable gallery/ tunnels/surface ducts/on structures

All the cable trays shall be in horizontal laying configurationalong the horizontal run of the cable.Cable racks for cable trays shall be fixed at a maximum interval of 1.5 m.

Cables shall be laid in separate racks according to the voltage / application classification. Fireproof partitions such as asbestos sheets shall be provided between trays carrying LT & HT power cables. The cables shall be laid from Bottom to Top in order of HT on Bottom rack followed by LT cables and other cables on upper racks. Signal/instrumentation cables shall be laid on top rack.

Cables shall be suitably protected against heat, and mechanical damages.

Cables at fire partition wall crossings shall be painted with flame retardentpaint 2 m on either side of wall.

05.04.13 Cable Trays &Structural support for cable laying

In general pre-fabricated GI cable tray only shall be used unless other type i.e. MS or FRP is specified in TS.

Power cables shall be laid on ladder type cable trays& control/signal cables shall be laid on perforated trays. Communication cables, FO cables shall be laid inside separate GI Conduits.

Ladder type cable trays shall be selected from sizes 300 mm, 450 mm & 600 mm. Standard length of trays shall be 2.5/3.0mtr. Perforated cable trys can also be below 300mm width as per the requirement.

GI ladder type trays shall be pre-fabricated from 2 mm thick sheet steel hot dip galvanized.GI perforated type trays shall be pre-fabricated from sheet steel of min. 3 mm thick with Hot dip galvanizing. For GI trays, method of hot dip galvanizing shall conform to IS 2629:1985. Mass & thickness of zinc coating shall conform to IS 4759:1996. However, minimum thickness of GI coating shall be 75-86micron. In case of ladder type trays, C channel shall be used for longitudinal member & cross member with holes for cable binding shall be provided at interval of max 250mm throughout the length

of tray. Generally pre-fabricated bends, joints, junction connectors shall be used. However, site fabricated bends, joints, junction connectors may be used at places, where it is not possible to use pre fabricated in consultation/approval from site engineer.

MS trays (if applicable) shall be fabricated from 50x50x6 mm MS angles for longitudinal members and 25x5 mm flats for cross members placed at an interval of 250 mm along the length of cable tray. The MS cable tray shall be painted with twocoats of red oxide primer (Zinc cromate) and a top coat of finishing enamel paint as approved. Paint shall be removed at appropriate location before installation of earthig strip and repainted after installation of earthing strip. Minimum thickness of painting shall be 120 microns.

Supporting vertical racks and horizontal hooks shall be of 50x50x6 mm MS angles except in cable cellar/ basement. Cable racks and hooks shall be of welded construction.

Inside cable cellar/basement, min. ISMC-100 shall be used for supporting cable trays. The ISMC-100 shall be supported from roof beam and fixed with floor so that load transfer takes place to ground. In case, numbers of trays are less (2 or 3), same can be supported from roof only with min. ISMC- 75.

To avoid damage during cable laying, cable structures shall have no scales, abrasive or rough surfaces or cutting edges.

Wherever Cable Trays are installed in parallel formations, they shall have minimum distance (or gap) of 250 mm or higher as per requirement.

05.04.14 General requirement of cable installations

All cables shall be tested for proper insulation before start of laying work.

Cables shall be laid in conduits, racks/trays, cable tunnels/trenches, along with structures or buildings, as per cable routing drawing and cable list. Suitable adjustment shall be made in cable routes, if required at site, with a view to avoid any interference with any part of building, structures, equipment, utilities and services with the approval of the purchaser/ consultant.

In the cable basement/ Cellar/ cable galleries/ tunnel, cable structures shall be properly arranged giving sufficient clearance for movement of personnel from one part of the basement/ Cellar/ cable galleries/ tunnel to the other. It shall also be possible to escape easily in case of fire.

Cables shall be clamped rigidly at an interval of not more than 1000 mm in horizontal, and 500 mm in vertical & inclined run and at bends.Cable shall be fixed to racks or trays or cleats as required for proper support, accessibility and neatness of installation. Hanging of cables racks over panels shall not be permitted rather no cable shall be

laid/pass over any electrical equipment e.g. transformer, switchboards etc.

Cable passing through water/scale pit/acid fume etc. shall be laid in PVC pipe with PVC junction boxes and pull boxes etc. Where cable racks or trays cannot be erected or the number of cables on the route does not justify their use, cables shall be cleated direct to walls or structural steel work in consultation/approval from site engineer.

Not more than one cable (for power cable) shall be drawn into one conduit unless otherwise agreed. After the cable has been drawn in, the conduit shall be sealed by an approved means.
Fire protection barrier as approved by purchaser shall be provided between HT cables racks and LT power cables racks.

While laying cables, care shall be taken that kinks, twists or mechanical damage do not occur to the cable.

All bends in cables shall be made with due consideration to the minimum permissible bending radius of the cables.

Loops shall not be allowed to be formed during the laying of the cables. When being pulled, the cable shall not be allowed to drag drawing along the ground or over a second cable already laid. Special care shall be taken while pulling through an opening where other cables have already been laid. Only approved cable pulling devices shall be used.

No joints shall normally be made at any intermediate point in through run of cables unless the length of the run is more than the standard drum length. In such cases where jointing is unavoidable, the same shall be made inside proper bases having plastic moulds and shall have moulded epoxy resin construction. Provision shall be made for earthing continuity at the joint. Cable splicing and jointing shall be done in accordance with the relevant IS, code of practice and manufacturer's instructions. Insulation resistance of cables shall be checked before cable jointing.

Adequate length of cables shall be pulled inside the switch boards, control panels, control desks, etc. so as to permit neat termination.

All cables shall be neatly dressed without interlocking or cross overs. While laying the cable vertically, these shall be clamped at suitable intervals. Horizontal runs shall be rigidly secured to trays on racks/hangers in all the places where the direction of the route changes as well as at cable terminations or joints. The clamps shall not be done up so tight that the insulation is damaged or deformed.

All cable entry openings in the equipment shall be sealed and made vermin proof. All

cable openings in walls and floors shall be sealed after laying of cables by a weak mixture of asbestos and cement mortar.

All cables shall be provided with identification tags indicating the cable number in accordance with cable lists. Tags shall be fixed at both ends of the cable and at 30 m spacing for straight runs as well as on both sides wherever cables are crossing walls/floors.The tags shall be of aluminium/PVC with numbers engraved on them and securely attached to the cables by non-corrosive wires. The shape of tags shall be round, triangular and rectangular for control, medium voltage and high voltage cables respectively.The cable tags shall be marked with cable number, size and voltage grade. Start tag shall be indicated with destination. The end tag shall be with second terminal point.

Suitable numbered printed ferrulorcoloured letter interlocking type ferrules shall be provided for end termination of power and control cables.

Control cable entering switch boards, control panels, control desks etc. shall be neatly bunched and strapped with PVC perforated straps and suitably supported to keep it in position at the terminal blocks. All spare cores of each cable shall be segregated, marked spare, neatly dressed and suitably tapped at both ends.

When the cores of two or more multicore cables take a common route in side equipment, cores of each cable shall be separately bound and the separate bundles neatly bound together.

The contractor shall be responsible for correct phasing of motor power connections and shall interchange connections at the motor terminals box, if necessary, during each motor is test run.

05.04.15 Cable Joint/termination accessories

a) For HT Cable

The cable accessories shall include end termination kits, straight through joints and also any special tool and tackles and accessories required for making the joints/terminations.

The straight through joint/termination arrangement shall be complete with all fittings and consumables. The joint/ termination shall have electrical and mechanical withstand capability, same as that of the associated cable. For all cables, a minimum extra length of 2 metresshall be left before jointing.

The termination/ jointing kit shall be of heat shrinkable type, unless specified otherwise in TS.

The termination kits/straight through joints shall have the following features:

- Electrical stress control to be provided at the cable insulation shield terminus.
- An external leakage insulation to be provided between the cable conductors and ground.
- Adequate protection to be provided at the end of the cables against the entrance of the moisture and, provision to maintain the constant pressure in the cable.

* **Cold Shrink Cable Joints shall be used in Hazardous Area.**

b) For LT Power and control cable

The cables shall be terminated in accordance with relevant connection diagram. Termination and clamping shall be carried out in such a manner as to avoid strain on the terminals.

Glanding shall be done for direct entry of both power and control cables into the panels/ enclosures by the contractor. Double Compression type brass cable glands shall be used. Crimping type tinned copper lugs only shall be used for all cable termination

All power& control cable terminations shall be by means of crimping type cable lugs. For flexible conductors, soldered termination shall be adopted. In case of aluminium power cables termination on copper bus bars, suitable aluminium copper bimetallic washers shall be used. Corrosion inhibiting grease shall be used for aluminium cable terminations.

Cold Compound Cable Joints shall be used for LT Power & Control Cablein Hazardous Area.

c) Exposed & Concealed conduits

Exposed conduits shall be laid along walls, floors, ceilings, on steel supports etc. as per working drawings/site requirements in consultation with the supervisory personnel. The conduits shall be neatly run and evenly spaced.

Fixing of conduits to the supports on wall, column, structure shall not be done by welding. Exposed conduits shall be adequately supported by racks, clamps, straps etc.

Jointing of conduits shall be done only in straight portion and not in bend portion.

The contractor shall have arrangements at site for bending facilities for conduits as well as dies for threading conduits of diameters and threads corresponding to the standards.

The threaded ends of conduits shall be painted with anticorrosive paint. The outer ends shall be smoothened free of burrs and sharp edges. Bushings shall be fitted at both ends of conduits.

Flexible metallic conduits shall be used for termination of connections to motors and other electrical equipment like pressure switches etc. which need to be disconnected at periodic intervals.

All conduits shall be effectively connected to the earth terminal of the equipment where it terminates.

Both ends of conduits shall be suitably earthed. Earthing continuity to be maintained by means of flexible wire wherever two conduits are joined with sockets.

Approved conduit bending machines to be arranged by the contractor shall be used for bending conduits at site. The radius of any conduit bend shall be as per standards for cabling. Bends shall be free from cracks, crimps or other damage to the pipe or its coating.

Annular space of used & un-used conduits should be sealed at both ends.

05.05 FACTORY TESTING

Test on all equipment shall be conducted as per latest edition of Standards IS/ IPSS/ IEC/VDE/DIN/BS as applicable as per the respective equipment specification.

All external components and fittings that are likely to affect the performance of the equipment shall be put in place during the factory test and the test shall be carried out at the manufacturer's works, unless otherwise agreed between the purchase and the manufacturer.

The contractor shall arrange to conduct Routine test/ Acceptance test as applicable on all equipment at manufacturer works as per latest applicable standard as referred in technical specification. At least following routine tests, as listed below, shall be conducted by the supplier for each supply. Any additional test as per the standard procedure of the manufacturer shall also be conducted. Also purchaser may ask for conducting other tests as per the relevant standard in case the same is applicable.

All routine test/ acceptance tests as applicable shall be carried out at manufacturer's works in the presence of the contractor and purchaser or purchaser's representative.

Type test certificates shall be submitted for tests conducted earlier on equipment having same/ similar rating & design that of being supplied. The rating and design of equipment being supplied may be stringent that the type tested design and the same shall be vetted by purchaser or its representative during the inspection of the panel. In case valid type test certificate is not available with the supplier, the same shall be conducted in the presence of Purchaser or Purchaser's representative, if purchaser so desires, without any

financial implications to the purchaser. The type test certificate shall be provided for the same manufacturing unit from where supply is being made. All type test reports shall be from NABL accredited government or semi government or independent third party laboratory / equivalent foreign laboratory.

At least type test certificates for the following tests listed shall be submitted by the supplier for each supply. However purchaser may ask for other type test certificates as per the relevant applicable standard.
The Contractor shall be responsible for satisfactory working of eachequipment and complete system in an integrated manner and its guaranteed performance.

A) HT Switchboards

a) Routine tests

1) Physical, dimensional and fitment & alignment checks including:
   i) Checking with respect to general arrangement like feeder disposition, appearance, terminations, wiring etc.
   ii) Checking of mechanical work like fitment and alignment, surface finish, movement and proper engagement of withdrawable breakers, fixing of doors, etc.
   iii) Verification of BOQ.
   iv) Interchangeability of drawout breakers of the same rating.
2) Operational, functional & interlock Checks with respect to single line diagram and control circuits.
3) Operation test for circuit breakers etc. with normal control voltage and closing at 85-110% and trip at 70-110% of normal control voltage.
4) Tests to check polarity of CTs and primary injection test
5) Insulation test and Dielectric test of the switchboard.
6) Checking of protective earthing circuits
7) Measurement of total contact resistance for feeders.
8) Breaker closing/ opening time & contact resistance for 20% of the breakers.

b) Type tests

1) Short circuit breaking, making & withstand capacity of all CB ratings used.
2) Mechanical and electrical endurance test of all CB ratings used.
3) Short circuit withstand capacity of switchboard.(For same rating &same design of switchboard)

4) Internal arc withstand test for switchboard as per IEC 62271-200. (For same design of switchboard & enclosure)
5) Temperature rise test as per IEC 62271-200. (For same rating & same design of switchboard)
6) Impulse withstand test as per IEC 62271-200. (For same voltage rating & same design of switchboard)
7) Double earthfault test (for switchboard used in unearthed system)

B) Power Transformer (Oil Type)

a) Routine Tests

1) Physical, dimensional and fitment & alignment checks
2) Operation and function checks
3) Measurement of winding resistance
4) Measurement of voltage Ratio and voltage vector relationship
5) Measurement of Impedance Voltage/Short-circuit impedance (Principal Tapping) and Load Loss at 50% and 100% load
6) Measurement of No-load Loss and No-load Current
7) Measurement of insulation resistance
8) Induced overvoltage withstand test.
9) Separate source voltage withstand test
10) Pressure test
11) Oil Leakage test
12) Painting checks
13) Measurement of Acoustic Noise level (As per cl 5.10.3.6 of IEEE C57.12-01)

b) Type Tests

1) Lightning impulse test (for same voltage rating and similar design)
2) Temperature Rise test (for same rating & same design, conductor sizes and enclosure type & size to match)
3) Short Circuit Test (for similar rating & design confirming to requirement as per IEC 60076 (Part5, AnnexB))
4) Measurement of commutating reactance and determination of inductive voltage drops (for thyristor converter transformer only).
5) Ingress protection test report for Marshalling Box

C) Distribution Transformer (Dry Type)

a) Routine Tests

1) Physical, dimensional and fitment & alignment checks
2) Operation and function checks
3) Measurement of winding resistance
4) Measurement of voltage Ratio and voltage vector relationship
5) Measurement of Impedance Voltage/Short-circuit impedance (Principal Tapping) and Load Loss
6) Measurement of No-load Loss and No-load Current
7) Separate source voltage withstand test
8) Induced overvoltage withstand test.
9) Partial discharge measurement test (As per cl 22 of IEC60076-11)
10) Measurement of Acoustic Noise level (As per cl 5.10.3.6 of IEEE C57.12-01)

b) Type Tests

1) Lightning impulse test (for same voltage rating and similar design)
2) Temperature Rise test (for same rating & same design, conductor sizes and enclosure type & size to match)
3) Short Circuit Test (for similar rating & design confirming to requirement as per IEC 60076 (Part5, AnnexB)
4) Ingress protection test report for Marshalling Box
5) E2 / C2 / F1 Test certificate according to IEC 60076-11

D) Power Control Centre and LT Switchboard

a) Routine Tests

1) Physical, dimensional and fitment & alignment checks including:
   i) Checking with respect to general arrangement like feeder disposition, appearance, terminations, wiring etc.
   ii) Checking of mechanical work like fitment and alignment, surface finish, movement and proper engagement of withdrawable breakers, fixing of doors, etc.
   iii) Verification of BOQ.
   iv) Interchangeability of drawout breakers of the same rating.

2) Operational, functional & interlock Checks with respect to single line diagram and control circuits.
3) Operation test for circuit breakers etc. with normal control voltage and closing at 85-110% and trip at 70-110% of normal control voltage.
4) Tests to check polarity of CTs and primary injection test
5) Insulation test and Dielectric test of the switchboard.
6) Checking of protective earthing circuits
7) Measurement of total contact resistance for feeders.

b) Type Tests

1) Short circuit withstand capacity of switchboard. (For same rating &same design of switchboard)
2) Temperature rise test. (For same rating & same design of switchboard)
3) Impulse withstand test. (For same voltage rating & same design of switchboard)
4) Internal arc withstand test for switchboard as per IEC 61641. (For same design of switchboard & enclosure)
5) Ingress protection test (for same design and similar construction)

E) Battery Charger

a) Routine Tests

1) Physical, dimensional and fitment & alignment checks including:
   i) Checking with respect to general arrangement like feeder disposition, appearance, terminations, wiring etc.
   ii) Checking of mechanical work like fitment and alignment, surface finish, fixing of doors, etc.
   iii) Verification of BOQ.
2) Operational, functional & interlock Checks with respect to single line diagram and control circuits.
3) Dielectric test.
4) Ripple Content
5) Load test

b) Type Tests

1) Ingress protection test

2) Other type test reports as per the applicable standars to be finalized during DE along with the manufacturer.

F) MCC/PDB/MLDB/CONTROL PANELS/SOFT STARTERS/MCPs/VFDs

1) Checking of GA, size, shipping length, enclosure class, sheet steel thickness, colour shade and other constructional features as per approved drawings/documents/data sheet.
2) Checking of door opening, cable alley, cable termination facility, cable gland plate size etc.
3) Checking of alignment of draw out modules, proper movement & positioning.
4) Checking of component lay out inside module, component layout on door front, wiring, termination etc.
5) Checking of BOQ, rating, make, model numbers etc. as per approved drawings/documents/data sheet.
6) Powering/charging of incomers, bus couplers and all feeder modules and checking all components, meters, indication lamps etc.
7) Functional/Operational test of incomer, bus coupler & all out going feeders as per approved drawings/control scheme.
8) Communication checking of all communicable relays/meters if possible & checking of completion of wiring etc.
9) Safety interlock checking, checking of working of Em. Stop PB, PCS/BSS/ZSS/Limit switch working in circuit etc.
10) Checking of interlocking between incomers/ bus couplers and other feeders
11) Test of prove interchangeability of similar parts.
12) Checking of earthing connection for neutral-earth bus, cable armour, location of E/F CT etc. as per the scheme.
13) Checking of tests, service and drawout position of all the feeders as applicable.
14) Checking the functioning of various electrical schemes like auto change over, signaling etc.
15) IR test
16) HV test with 2.5 kV megger
17) Checking of all Test reports, test certificates, calibration certificates of all meters, relays, etc.

G) Automation System (FAT Hardware & Software)

1) Checking of GA, size, shipping length, enclosure class, sheet steel thickness, colour shade and other constructional features as per approved drawings/documents/data sheet.
2) Checking of door opening, cable alley/marshalling box, cable termination facility, cable gland plate size etc.
3) Checking of component lay out inside module, component layout on door front, wiring, termination etc.

4) Checking of BOQ, rating, make, model numbers etc. as per approved drawings/documents/data sheet.
5) Powering/charging of panel, checking of power supply distribution and checking all wiring of IO cards, components, meters, indication lamps etc.
6) Network checking,
7) Checking of power supply & distribution.
8) Checking of provision of electronic & panel earthing & earthing of all panels/electronics equipment as per manuals/manufacturer's recommendation.
9) Checking of redundancy of network, CPU, Servers and other hardware as per configuration drawing.
10) Checking of Software under simulation, checking & modification of Graphics, Reports and correction/revision as required by process/site requirement etc.
11) Checking of safety & process interlocks and correction as required by process/site requirement, Checking of local & remote manual, auto mode of operation, release of outputs, calibration etc.
12) PID loop setting, calibration
13) Communication checking with all networking equipment as per configuration drawing and establishment of communication with third party equipment.
14) Bidder shall submit FAT procedure segregating Hardware FAT & Software FAT indicating above tests for approval of purchaser/consultants during engineering. Hardware FAT shall be carried out on each and every automation equipment, whereas software FAT shall be carried out retaining few minimum equipment to be finalized with FAT procedure. Hardware FAT & Software FAT can be carried out together or in stages as per approved FAT procedure.

H) Final Test of Materials of Grounding and lightning system

i) Visual check

ii) Dimensional check

iii) Accessories fitting check

iv) Mechanical and electrical test (where applicable)

I) CABLES

a) Routine test

1) The cables shall be subject to shop tests in accordance with relevant specified standards to prove the design and general qualities of the cables
2) Routine test as per the applicable standard indicated in the technical specification shall be carried out on each drum of cables.

b) Acceptance test

1) Acceptance tests as per the applicable standard indicated in the technical specification shall be carried out on the drum chosen randomly as per the sampling plant for acceptance of the lot.

c) Type Test

1) Type tests certificates for each type of cable, as per the applicable standard shall be furnished by the contractor

J) Motors

a) Routine Tests

1 Measurement of resistance.

2 Insulation resistance test.

3 Motors are tested at 1/3 times the rated voltage for checking the ability of the motor to run upto full speed , when switched in either direction.

4 No load test.

5 High voltage test.

b) Type Tests

1 Measurement of rotor resistance.

2 No load test

3 Locked rotor test .

4 Full load reading of voltage, current , power input and slip.

5 Temperature rise test.

6 Momentary overload test .

7 Insulation resistance test .

8 High voltage test .

9 Polarisation index test (for HT motors)

- Note: Hazardous Area Equipment, Electrical system relevant Site Tests shall be done as per norms and procedure of OIL & GAS installation.
  any specific test mentioned

5.06 SITE TESTS AND CHECKS

5.06.01 General

All the equipment shall be tested at site to know their condition and to prove suitability for required performance after installation and before commissioning.

The test indicated in following pages shall be conducted after installation. All manpower, tools, accessories and required instruments shall have to be arranged by the contractor. Any other tests/ checks considered necessary by the OEM/ Contractor / commissioning manual of the equipment has to be conducted at site.

In addition to tests on individual equipment some tests/checks are to be conducted/observed from overall system point of view. Such minimum tests/ checks are highlighted under miscellaneous tests. However these shall not be limited to as indicated and shall be finalisedin consultation with client and consultant before charging of the system.

Based on the test results clear observation shall be indicated by testing engineer regarding suitability for charging of the equipment or reasons for not charging.

All checks and tests shall be conducted in the presence of Client or its representative and witnessed test results shall be submitted in six copies to Client and one copy to Electrical Inspector. Test results shall be filled in appropriateproforma cleared by the client or its representative.

Taking necessary clearance from electrical inspector is the responsibility of the contractor. After clearance from Electrical Inspector, system / equipment shall be charged in step by step method.

The Contractor shall be responsible for satisfactory working of complete integrated system and guaranteed performance.

5.06.02 Trial Run Test

After the successful test of each equipment as per standard test procedure, the entire system shall be put on trial run test on actual site conditions and operation.

5.06.03Acceptance Test

The acceptance test on the system shall be carried out by the contractor as per mutually agreed test procedures to establish satisfactorily functioning of the system as a whole and each equipment as part of the system.

5.06.04 Site Tests

The tests to be carried out on the equipment at pre-commissioning stage shall include but not limited to the following minimum tests:

A) HT SWITCHBOARD

1) Complete wiring check for proper functioning for each feeder and feeder wise field markup drawing to be prepared, signed by testing agency and the contractor and one set to be handed over to client.
2) Checking of all mechanical and electrical interlocks in each feeder.
3) Auto changeover and momentary paralleling scheme checking (if applicable)
4) Functional test of all circuit components for each panel/ feeder.
5) Test to prove correct operation of breakers at minimum and maximum specified control voltages
6) Checking of PTs for polarity, ration & connection
7) Testing of CT polarities and CT ratio by primary injection test.
8) Measurement of knee point voltage and secondary resistance for CTs used for differential protection.(If applicable)
9) Secondary injetion tests on Relays and meters.
10) Testing of relays as per supplier's commissioning manual
11) Contact resistance/ millivolt drop test for each feeder and breaker.
12) IR test before & after HV test.
13) HV test.
14) Overall Integrated Testing of Switchboard.

B) POWER TRANSFORMER (OIL TYPE)

1) IR test on each winding to ground and between winding and check for polarization index.
2) Turns ratio test on each tap.
3) Polarity and vector group test.
4) Conducting magnetic balance test.
5) Measurement of magnetizing current and no load loss.
6) Measurement of winding resistance by Kelvin bridge.
7) Checking of earthing w.r.t. transformer tank (flexible from top cover to tank) other parts, neutral.
8) Testing of Buchholz relay for alarm and trip conditions.
9) For bushing CTs, tests applicable shall be as per manufacturer.
10) Check insulators for cracks - Physical.
11) Checking for oil leakage -Physical.
12) Checking of operation of all valves.
13) Checking of silica gel breather - Physical.
14) Filtration of oil by using line filter and heater set.
15) BDV test on Oil samples from top & bottom after filteration.
16) Checking of Oil for acidity, water content and tan delta as per IS 335.
17) IR, wiring and operational tests on marshalling box componenets, oil level indicator winding and oil temp. indicatorsetc.
18) Calibration and setting of oil/winding temperature indicators, level gauge.

19) Checking of other points given in manufacturer's commissioning manuals.

C) DISTRIBUTION (DRY TYPE)

1) IR test on each winding to ground and between winding and check for polarization index.
2) Turns ratio test on each tap.
3) Polarity and vector group test.
4) Conducting magnetic balance test.
5) Measurement of magnetizing current and no load loss.
6) Measurement of winding resistance by Kelvin bridge.
7) Checking of earthing w.r.t. transformer enclosure, neutral etc.
8) For bushing CTs, tests applicable shall be as per manufacturer.
9) IR, wiring and operational tests on marshalling box componenetsetc.
10) Checking of other points given in manufacturer's commissioning manuals.

D) POWER CONTROL CENTRE AND LT SWITCHBOARD

1) Complete wiring check for proper functioning for each feeder and feeder wise field markup drawing to be prepared, signed by testing agency and the contractor and one set to be handed over to client.
2) Checking of all mechanical and electrical interlocks in each feeder.
3) Auto changeover and momentary paralleling scheme checking (if applicable)
4) Functional test of all circuit components for each panel/ feeder.
5) Test to prove correct operation of breakers at minimum and maximum specified control voltages
6) Checking of PTs for polarity, ration & connection
7) Testing of CT polarities and CT ratio by primary injection test.
8) Secondary injetion tests on meters.
9) Testing of releases as per supplier's commissioning manual
10) Contact resistance/ millivolt drop test for each feeder and breaker.
11) IR test before & after HV test.
12) HV test.
13) Overall Integrated Testing of Switchboard

E) BATTERY

1. Checking of layout as per approved drawing.
2. Visual inspection test for level and leakages.
3. Checking for availability of safety devices, water and first aid box.
4. Checking of adequacy of charger output/ requirement w.r.t current required for battery charging as per the manual.

5. Checking the polarity of connections between battery and charger.
6. Checking of tightness of connectors on each cell.
7. Checking of voltage per cell and total voltage between positive negative and earth to positive/ negative.
8. Checking of capacity test and hourly measurement of specific gravity and voltage for each cell.

F) BATTERY CHARGER

1. IR test before and after HV test
2. HV test
3. Checking the voltage ratio of boost and float mode transformers
4. Checking for charging mode of batteries, constant current and constant voltage mode.
5. Load test on chargers by liquid resistance system.
6. Checking of tightness of earthing connections.
7. Checking for all alarm conditions.
8. Checking and calibration of all indicating meters.
9. Check for functional operation of charger, auto/ manual change over from float to boost and boost to float etc.
10. Checking and setting of all relays.
11. Checking for polarity of cables connected to battery.

G) MCC/PDB/MLDB/CONTROL PANELS/SOFT STARTERS/MCPs

1. IR test.
2. HV test with 2.5 kV megger.
3. Functional test for all feeders.
4. Testing and calibration of all meters.
5. Checking and calibration of overload relays and protective relays by primary injection method.
6. Check operation of contactors from local and remote/PLC modes from control room.
7. IO checking.
8. Communication checking.
9. Safety interlock checking, checking of working of Em. Stop PB, PCS/BSS/ZSS/Limit switch working in circuit etc.
10. Checking of interlocking between incomers/ bus couplers and other feeders.
11. Test of prove interchangeability of similar parts.
12. Checking of earthing connection for neutral-earth bus, cable armour, location of E/F CT etc. as per the scheme.
13. Checking of tests, service and drawout position of all the feeders as applicable.

14. Checking the functioning of various electrical schemes like auto change over, signaling etc.

H) VFD

1. IR test.
2. Checking of earthing connection earthing as per scheme.
3. Safety interlock checking, checking of working of Em. Stop PB.
4. Functional/Circuit wise test, Check operation of contactors from local and remote/PLC modes from control room.
5. IO checking.
6. Setting of all parameters/parameterization.
7. Idle running of VFD and motor for tuning/parameterization.
8. Testing and calibration of all meters.
9. Communication checking with plant automation.

I) AUTOMATION SYSTEM

1. Network checking.
2. Checking of power supply & distribution.
3. Checking of electronic earthing system and proper earthing of all panels/ electronics equipment as per manuals/manufacturer's recommendation.
4. Checking of redundancy of network, CPU, Servers and other hardware as per configuration drawing.
5. Checking of Software under simulation, checking & modification of Graphics, Reports and correction/revision as required by process/site requirement etc.
6. IO checking and rectification.
7. Checking of safety & process interlocks and correction as required by process/ site requirement, Checking of local & remote manual, auto mode of operation, release of outputs, calibration etc.
8. PID loop setting, calibration.
9. Communication checking with all networking equipment as per configuration drawing and establishment of communication with third party equipment.
10. Check operation of contactors from local and remote/PLC modes from control room HMI.
11. Safety interlock checking, checking of working of Em. Stop PB.

J) MOTORS

1. Insulation resistance (IR) test.
2. Continuity Test.
3. Checks for leveling, & fitment, Bolt tightness & other matching with mechanical equipment.
4. Check for earthing (Body earthing, cable 4^{th} core earthing inside motor TB).
5. Checks for Cable termination, continuity, phase sequence.

6. Checks for cable termination for space heater, RTD/BTD if any.
7. Direction of rotation under de-coupled condition.
8. Check for noise, vibration etc.
9. Check motor no load current under idle condition & FLC under loaded condition.

K) CABLES

1. Visual check for proper laying and dressing of cables.
2. Checking of continuity and IR values for all the cables before and after HV test.
3. HV test and measurement of leakage current.
4. HV test and measurement of leakage current after termination of cable termination kits (for HT cables only).
5. Checking of earth continuity for armour and fourth core (as applicable).
6. Check for mechanical protection of cables - Visual.
7. Check for proper dressing of cables, mechanical protection of cables, placement of cable markers, placement of cable identification tags etc.
8. Check earthing of cable support structures and trays.
9. Check safe head room in tunnel and basement area.
10. Check clearance from ventilation duct and light fittings for cable structures.
11. Check proper fixing of cable support structures and trays.
12. Check tightness of all connections.

L) EARTHING

1. Check tightness of all earth connections.
2. Check earthing of all metallic equipment, cable trays, busbar supporting. structures, building column (if steel) all elect equipment, pipe lines etc. as per the drawing/specification.
3. Measurement of earth resistance for each electrode.
4. Measurement of total earth resistance.
5. Measurement of earth loop resistance for E/F path of biggest LT drive.

M) MISCELLANEOUS

1. Checking of continuity of the system.
2. Checking of phase sequence from overhead line consumer end.
3. Checking safe accessibility of all operating points.
4. Check availability of emergency lighting.
5. Check availability of control aux. supply.
6. Ensure availability of all safety items egfirst aid box, firefighting equipment, earth discharge rods, rubber mats, rubber glove etc.
7. Check oil drainage system for transformer oil.
8. Check filling of gravels in transformer pits.

9. Check for safe movement of operators control room / switchgear etc., w.r.t. proper illumination, escape light, uncovered openings, provision of hand railings in stairs etc.
10. Check proper covering of cable channels.
11. Placement of shock treatment chart, danger boards provision of boards indicating 'Man on work' Do not switch ON' 'Do not switch OFF'. 'EARTHED' etc.
12. Provision of route map at gallery entry points for indication of escape.
13. Check proper dressing of cables, mechanical protection of cables, placement of cable markers.
14. Check sealing of all cable openings including conduits opening with fire resistance material.
15. Check sealing of all openings at bottom of electrical panels.
16. Check for proper drainage and removal of water

TABLE –1A

SELECTION OF POWER COMPONENTS, WIRING & CABLE SIZES FOR CONTINUOUS DUTY CAGE MOTOR DRIVES

Rating of MCCB / MPCB / Contactors shall be selected based on type-2 co-ordination chart.However, Contactor rating can not be less than as specified below.

Contactor rating mentioned below are also applicable for input/bypass/output contactor in VFD panels.

Motor rating at S1 duty (kW)	Minimum rating of Power contactor Amps (AC3)	Minimum size of Cu wire / flat in sq. mm for internal power connection	Minimum size of XLPE insulated Power cable in sq.mm. (if not specified then consider Aluminium cable)
Up to 3.7	25	4	4x2.5 Copper Cable.
5.5	25	4	4X6 Aluminium cable
7.5	25	4	4X6
11	45	6	4X10
15	45	10	4X16
18.5	70	16	3.5X25
22	70	16	3.5X25
30	110	35	3.5X50
37	110	35	3.5X50
45	170	50	3.5X70
55	170	70	3.5X95

75	250	95	3.5X120
90	250	30X5 Flat	3.5X185
110	400	30x5 Flat	3.5X185
125/132	400	30x5 Flat	2(3.5x120)
160	630	40x5	2(3.5x120)
180/200	630	30x10	3(3.5x185)

06.00 CONTROL & INSTRUMENTATION (C&I)

06.01 INTRODUCTION

This specification is intended to define the requirements for Control & Instrumentation (C&I) of

- **4nos (3W+1S) Reciprocating type Natural Gas Compressor and their auxiliaries for Compressor Station for Indradhanus Gas Grid limited (IGGL) setup near Guwahati, Assam**

The basic philosophy of C&I system shall be based on **dedicated microprocessor based SIL-3 redundant TMR Programmable logic Control (PLC) System** for the each Natural Gas Compressor Package with 4-20 mA unified current signal system along with **1:1 hot redundant common PLC** for respective plant automation. The C&I system shall ensure safe, efficient and smooth operation of the plant and equipment with minimum intervention of the operating personnel during normal working of the Compressors, load fluctuation / shut down of the Compressors.

General requirements

a) The Tenderer shall furnish the complete Control and Instrumentation system including dedicated SIL-3 redundant TMR Programmable Logic Control System for Natural Gas compressors and Common 1:1 Hot redundant PLC for complete plant operation & control, Primary, Secondary Instruments, Panels, Modular control Desks, mosaic grid mounting Alarm Annunciation System, Maintenance and Calibration Equipment, Control Valves and Actuators, Instrumentation Cables and Process Connection and impulse Piping and Electrical Actuators/MOV etc. as identified in the specification.

b) The Tenderer shall provide all material, equipment and services so as to make a totally integrated Instrumentation and Control System together with all accessories, auxiliaries and associated equipments ensuring operability, maintainability and reliability. This work shall be consistent with New **Natural Gas Compressors** plant practices and shall be in compliance with all **applicable codes, standards, guides, statutory regulations and safety requirements in force.**

c) Further, Tenderer shall also include in his proposal and shall furnish all equipment, devices and services, which may not be specifically stated in the specification but are needed for completeness of the equipment/systems furnished by the Tenderer for meeting the intent and requirements of the specification.

d) It shall be noted that where equipment or system for the generating units are described, it shall be understood that the quantities described refer to only one system, similar system shall be considered for each system by the Tenderer, unless specifically indicated otherwise. Where equipment or systems for plant common facilities are described, it will be understood that the quantities described are the total quantities required.

e) Tenderer shall include in his bid a detailed Bill of Material (BOM) for each of the systems i.e. PLC, Measuring instruments, Power Supply System, Cables, field instruments, Erection hardware etc. Tenderer shall include Compressor skid mounted instruments as per OEM standards.

f) Standardization and Uniformity of Hardware to ensure smooth and optimal maintenance easy interchangeability and efficient spare parts management of various C&I instruments / equipment like vibration monitoring systems, all 4-20mA electronic transmitters/ transducers, control hardware, control valves, actuators and other instruments/ local devices etc. being furnished by the Tenderer for Natural Gas Compressors and other station auxiliaries for similar applications, the Tenderer shall ensure that they are of the same make, series and family of hardware.

g) The equipment shall employ state-of-the-art technology to guard against obsolescence. In any case, Tenderer shall be required to ensure supply of spare parts for at least 10 years from the date of supply. In case, it is felt by the Tenderer that equipment / component is likely to become obsolete, Tenderer shall consider alternate make/ & model no. to avoid future spare inventory problem.

h) This specification shall be read, together with the Electrical, General Conditions of Contract (GCC) and other commercial terms & conditions attached separately with the tender specification, shall form the Tender document, against which selected vendors (here-in-after called Tenderer) shall submit their complete & most competitive techno-commercial offers.

i) Wherever PLC, micro-PLC, SCADA based automation systems are to be used for any application like as nitrogen plant, metering unit, DG set, Air compressor, etc. these shall be interfaced through OPC/Modbus protocol or hardwired as applicable with the common PLC network under Level-1 automation for centralized, smooth and integrated operation of the plant.

j) Signals from Other Systems

The control, monitoring and operation of the other common system facilities will be carried out from the local control panel/ operator work station. Tenderer's shall provide all hardware and software at his end for establishing a two-way link for exchange of signals for information purpose across country via V-SAT or any other

proven mode of communication system and also through a station wide LAN/WAN for signals related to information purpose.

In case certain signals are required from Employers supplied systems for Monitoring of process & equipment in Tenderer's scope, the referred signals will be made available at Employer's panel/system only and all necessary interconnection (cabling, routing, termination, related Software & hardware) shall be under Tenderer's scope.

06.02 SCOPE OF SUPPLY & WORKS

06.02.01 The scope of supply & work shall include design, engineering, procurement, manufacture, assembly, inspection, supply, packing, transportation to site, storage, calibration, erection, testing and commissioning of the complete control & instrumentation (C&I) system with all types of cables, pipes and erection hardware necessary for completion of C&I work for the Natural Gas Compressors, and their auxiliary units on a **turnkey basis.**

06.02.02 Measurement and control equipment offered shall be complete in all respect and any equipment / accessories not explicitly indicated in this specification, but considered essential for proper functioning of equipment and process shall be included in the Tenderer's scope of supply and work. Measurement and control equipment as per list covered under clause number 06.03 as minimum.

06.02.03 The PLC based automation system as per the details included in this TS and in compliance to PLC system configuration diagram **DRG.NO: MEC/05/28/23UU/NGCS/TD/023, Sheet 1 of 1, Rev. 0.**

Following minimum peripherals units shall be provided of Human – Machine interface system. Beside these, the Tenderer shall recommended additional equipment necessary for the smooth and reliable operation of the power plant.

SIX number (6 nos.) Operator Workstations (OWS) with 24" TFT monitor, R-W DVD drive, Multimedia keyboards, optical mouse, Core 2 Duo, 2GB DDR2 RAM, 4 USB (2 nos. front & 2 nos. Rear side) ports, 2 serial ports, 1 parallel port, 1TB HDD, DVD Drive R/W, 10/100 MBPS Ethernet card ,Windows 10/OEM standard professional with latest service pack with media CD, Anti-virus software with minimum 3 years up gradation license.

- Two nos. of color laser printers A3 cum A4 size
- Two no. of monochrome laser printer A4 Size and

For control & monitoring of Natural Gas Compressors, electrical system other auxiliaries and BOP system.

- **One (01) no**. Operator Work Station with 24"TFT monitor for In-charge,
- one no. of colour Laser printer – A4 size

TWO (2nos.) Engineers Workstations (EWS) cum Operator Workstations (OWS) with 24" TFT monitor, R-W DVD drive, Multimedia keyboards, optical mouse, Core 2 Duo, 2GB DDR2 RAM, 4 USB (2 in front side) ports, 2 serial ports, 1 parallel port, 1TB HDD, DVD Drive R/W, 10/100 MBPS Ethernet card, Windows 10 professional/As per latest system support, latest service pack with media CD, Anti-virus software with minimum 3 years up gradation license.

- One number of color laser printer - A4
- One number monochrome laser printer - A4

Large Video Screen in the Common Control (refer clause **06.07.04.03)** .

06.02.04 The scope of supply and work shall include but not limited to the following:

01. The instrumentation equipment for Natural Gas Compressors, the auxiliary units like lube oil system as covered in this specification and also as felt necessary by the successful Tenderer for the completeness of the job.

02. Tenderer shall confirm to supply all instrumentation & automation equipment from the recommended Vendor list included in this TS. No deviation from this list is acceptable. For items for which vendor list is not included or successful contractor proposes alternate Vendor, other than those included in the recommended Vendor list, they shall propose the vendors name(s) together with all the pre-qualification documents for approval, prior to placement of order. In such case MECON/ IGGL approval is final.

03. Contractor shall ensure that all Design and Safety requirements for Natural Gas Compressors Plant are as per **OISD-116** other relevant OISD standards, API 650 and recommendations of M B Lal Committee as applicable. Operation and Shutdown of the Plant facilities shall be implemented in the common PLC systems.

04. Safety logics, process upset trips and other digital logic functions shall be carried out in a separate dual redundant SIL3 TMR PLC as per IEC 61508 for Natural Gas compressors.

    TMR's architecture and diagnostic cover combine to create a system with 99.999% availability and reliability. The TMR can be applied as a component of protection and safety systems to allow the overall system to meet IEC61508 SIL-3 compliance standards.

- Controls with triple redundant to simplex configuration
- Hot replacement modular I/O, CPU and power supplies design
- Deterministic update as fast as 5 ms
- SNTP compliant for time synchronization
- Time stamping of events to 1 ms
- Expandable with real time network (RTN)

All the components used in the identified Safety Instrumentation Functions (SIFs) for required SIL capabilities shall be certified by the reputed certification agencies accredited by a member of the IAF (International Accreditation Forum) complying to IEC: 61508:2010 Chapter 1~7.

The valid SIL-certification must be accompanied by the supporting assessment report and the failure rate analysis report

The Functional Specifications of the PLC, Field Instruments etc. are given elsewhere in the bid document.

05. 1 (One) set of parallel redundant 240V AC, 50Hz Uninterruptible Power supply (UPS) along with ACDB containing adequate nos. of feeder for C&I system. UPS shall be based on a separate Specification enclosed with electrical Specification chapter 05

06. 24V DC Battery Backup to be provided for PLC and others critical system.

07. All 24V DC power supply feeders going outside the building for feeding various equipments in the field with a respective cable length or above shall be provided with SPDs suitable for voltage protection level of 1.5 KV and a Surge current of 5 kA (8/20 micro Seconds wave shape).

08. Lightning zone shall be calculated as per IEC:62305 Type-2 SPD shall be provided in Zone-2 equipment. All PLC, RIO panel, SCADA panel, UPSDB, Battery charger shall be provided with Type-2 surge protection device (SPD).

09. Fully wired panels, cabinets, desks, consoles, racks, transmitter cabinets and junction boxes.

10. ALL Panel dimensions, colour shall be uniform throughout the control room & Control Equipment Room (size of PLC cabinets preferably 2000mmx1200mmx800mm & Front & Rear colour RAL9002-Grey white, end panel side RAL5012-Light Blue and inside brilliant white) with 100mm black Base channel and 15mm anti-vibration pad with standard protection class. Panel

thickness shall be: Side & Top minimum-1.5mm, front and rear door shall be minimum 2mm, bottom plate 2mm and removable type gland plate 3mm.

11. All types of power, control, signal, instrument, compensating and system cables required for instrumentation work. All the cables shall be FRLS type and as per clause no. 06.07.11. All Control & signal Instrument Cable shall be 1.0 mm2 screened overall as well as individual pair Shielding twisted pair type. Paired compensating cable shall be used for thermocouples and Triad cable for RTDs. All power supply cabling from ACDB / Instrument Power Distribution Board to all consoles, cabinets and panels, enclosures those covered under all areas shall be 2.5 mm2. All Electronic/system Earthing cable shall be 25 sqmm for length $\leq$ 250m single core copper (cu) insulated cables. Resistance <0.5 Ohms.

    Tenderer scope shall include supply, storage at site, laying & terminate all type of cables required i.e. the control, instrumentation, interfacing (coaxial, fiber optic) cables, Ethernet / network cables, etc.

    The tenderer's scope of supply for C&I cables shall be as described below, but not limited to the following. Tenderer to note that no price adjustment shall be permitted on the account of shortage of cables / excess cables supplied during detailed engineering. Tenderer shall supply all the cables within quoted price.

    i. All Instrumentation, control, Power and Special cables (i.e Pair, Core, Triad, Compensating, Extension, Fiber Optic, Co-axial, Twisted pair, Power cables, any special cables, etc.) including both end terminals are in tenderer scope.

    ii) Preparation of Complete cable schedule, Interconnection diagram & JB schedules for the above shall be in tenderer scope.

    iii) The quantity of the above types of cables shall be estimated by the Tenderer based on his experience.

    iv) Tenderer shall supply the specified type of cable on as required basis for different cabling and interconnection work, provided the same meet the requirements of Tenderer's I&C application.

    v) It is not the intent to completely specify all details of design and construction herein. Nevertheless, the cables shall confirm to high standard of engineering design and workmanship in all aspects and shall be capable of performing continuous operation in a manner acceptable to the purchaser.

    vi) All cable including special cables, internal wiring and electrical field construction material shall conform to this specification. Purchaser approved

detail engineering drawing & documents and the latest edition of the relevant standards & guidelines shall be followed for laying & termination purpose. The Tenderer shall furnish all material and services required for the completeness of the work identified in his scope as per this specification.

12. All impulse pipes, fittings, valves shall be of SS 316/ 304. The specification of first root valve shall be as per technological specification.

13. The design and installation of instruments shall be generally in accordance with ISA/ API recommended practices and other applicable standards like ASI, IBR and OSID etc.

14. Machine Monitoring system shall be as per API 670 system.

15. Suitable terminal blocks shall be provided for Cable Termination Cable Glands and for Cable from Transmitter/ Converter to the Totalizer (Control Room). Cable glands (explosion proof certified to NEMA 7) and cable shrouds shall be in Contractor's scope of Supply.

16. All Junction boxes to be installed in hazardous area shall be DGMS certified.

17. DGMS/ CCOE approval of the field Instruments is a statutory requirement and is required irrespective of ATEX/ FM/ UL/ CSA/ CENELEC/ BASEEFA/ PTB certifications.

18. Material for all junction boxes shall be SS 316 or die-cast aluminum or FRP as per industry/manufacturing standards for Oil and Gas applications.

19. The scope of work shall also include all civil work like chipping, digging, concreting, including filling material etc., and associated erection of instrumentation equipment.

20. Necessary wide perforated and ladder type high-grade thick wall galvanized cable trays with, conduit pipes & flexible conduits shall be provided. Lockable or unlockable type cable straps (at the interval of 1mtrs.), cable marker (interval & location will be finalized during engineering), explosion proof type double compression type cable glands, numbering ferrules, supports, angles and bracings, terminations lugs/ferrules (to be used at both ends for cable), needed for laying & termination of above cables in a decent and logical manner shall be provided. Cable to be laid in single layer.

21. 12" (Digit size) Digital running LED display with countdown for discharge gas pressure, flow & temperature along with date, hour, sec. shall be displayed at

outside control room. Interfacing with automation system via RS232/RS485/Ethernet TCP/IP, wifi, Bluetooth, GPRS shall also be provided.

22. All isolation & bypass valves for control valves (i.e upstream and downstream of control valves and by pass) shall be SOV operated tight shutoff valve.

23. All networking outside control room building shall be through optical links only.

24. Temperature monitoring of control room & each panel room along with humidity and noise level measurement of outside and inside Control Room shall be provided.

25. HMI table shall be Aluminum Composite Panel (ACP) type, such that CPU, Keyboard, Power Points with surge arrester and all connecting cables shall house inside ACP cabinets. Each HMI shall be provided with two nos. cushioned revolving operator chair of Godrej make and with printer table also.

26. Erection material as required including all necessary materials required for Earthing of entire C&I system including PLC.

27. All unused cable entry ports shall be shielded with rubber grommets for non-hazardous area and ex-proof SS/Ni-plated brass plug for hazardous area. JB housing shall conform to IP-65. JB covers should be hinged and preferably with handles.

28. Submission of drawings and documents as per TS clause no.06.13.00

29. Arranging inspection at the manufacturer’s premises.

30. Material being procured by Contractor shall be inspected by the representative of IGGL / Consultant / Third party as per the approved QAP / ITP at the Vendors/manufacturer's workshop.

31. Company at its own cost shall arrange a Third Party Inspection Agency (TPIA) for inspection of equipment / material at Vendors works for bought out items.

32. Contractor shall prepare QAP / ITP for materials, bought outs, and submit to IGGL/Consultant for approval.

33. All arrangements for shop testing and calibration of all instruments shall be carried out by the Contractor. TPI and/ or authorized representative of IGGL may witness any or all items during manufacture or at final stage before shipment as per approved QAP.

34. **FAT:** Factory Acceptance Test shall be carried out for the Control Systems I/O panels, cards etc, F&G System, TMR PLC Mounted Control Panels for Compressors package and other such Control and Monitoring Specific panels prior to shipment from the factory/ shop floor/ manufacturing facility.

35. FAT clause shall also applicable for Vibration Monitoring System or Machine Monitoring System for Compressors.

36. Erection, calibration, testing and commissioning of the total equipment included in this specification. All tools and tackles, special testing equipment and consumables required for erection and commissioning activities shall be arranged by the successful Tenderer.

37. The installation of all package control system shall be done under the supervision of Contractor's personnel. It is the responsibility of Contractor to co-ordinate and to make available the specialist's services from Contractors at the time of installation, testing and commissioning.

38. Maintenance platforms and access ladders for instrumentation equipment installed at inaccessible heights. Suitable access ladders shall also be provided for first root valve of instrument impulse line tapping.

39. Selection of a particular make and model of instruments shall be such to permit maximum interchangeability, easy maintenance and repair and to maintain minimum inventory.

40. The client reserves the right of selecting the manufacturer / model of control & instrumentation items in the interest of standardization wherever necessary and the Tenderer shall agree to supply equipment of particular make if so desired by the client without any cost implication.

41. Providing instrument quality air for all pneumatic type actuators of regulating control valve and SOV (Solenoid operated valve). Necessary redundant Air compressor with air drier and receiver of suitable size shall be provided for the same.

42. Supply of Mandatory spares for Control & Instrumentation as per Clause no. 06.14.00

43. Supply of Laboratory Instruments as per clause 06.15.00.

44. Any C&I equipment required during any stages for the efficient / safe / reliable operation of the plant either during detail engineering / commissioning shall be

supplied, installed and commissioned by the successful Tenderer without any additional cost.

06.03 List of Controls, Measurement Refer respective P&IDs

A minimum list of measurement and control functions envisaged for the Natural Gas Compressors (NGC) & their auxiliaries is furnished in P&IDs. Tendered will furnish the Broad requirements of the C&I facilities in P&ID. The Tenderer shall offer C & I facilities taking care of these requirements and also supplement the same by inclusion of other instrumentation equipment, as may be required for the safe, efficient & reliable operation of the total System & equipment. Unless otherwise stated, all the measurement, control, alarm and interlocking functions shall be carried out from the PLC based control room automation system.

The measurement and control for each NGC and their auxiliaries shall include but not limited to following. Tenderer shall offer following measurements, controls, alarms, interlocks as a minimum for Natural gas compressor and also other measurements, controls and protections required for all other auxiliary equipment/system shall be considered as necessary. All measurements, controls, alarms & interlocks shall be available in HMI of PLC at control room unless otherwise stated.

Lubrication System

- Frame Oil Sump/Reservoir Level
- Sump/Reservoir Temp.
- Main/Stand by L/O Pump Disch. Pr.
- Lub Oil Filter Diff. Pr.
- Supply Header Pressure
- Supply Header Temp.
- Oil cooler Oil Inlet Temp.
- Stand by Pump Start
- Compressor Main bearing metal Temp.

Cylinder & Packing Oil

- Lubricator Oil Level
- Lubricator Oil Flow
- Lubricator Failure

Aux. Oil

- Lub. Oil Supply Pr. to Electric Motor Driver
- Lub. Oil Supply Pr. to Electric Motor Driver

- Lub. Oil return from Electric Motor Driver
- Elec. motor bearing metal temp.

Process Gas System

- Each stage inlet Pressure
- Each stage inlet temp
- Each stage Outlet Pressure
- Each stage Outlet temp.
- After Cooler Gas Outlet temp.
- Suc. Pulsation Device Each Stage Level
- Cylinder Packing Vent Pressure
- Separator each stage level
- Piston Rod Drop Indicator, (if applicable)
- Distance piece purging gas pressure
- Common machine parameters
- Common process parameters

Tentative list of measurements

Sl.no	Description	Remarks
1.	Pressure at LP Scrubber Vessel	
2.	Pressure at LP Scrubber Vessel to Common Suction Vessel line	
3.	Pressure at Common Suction Vessel to Common inlet header line	
4.	Pressure at Inlet of Common suction Vessel	
5.	Pressure at Common Suction Vessel to Compressor Package	
6.	Pressure at Common Suction Vessel to Compressor Package	
7.	Pressure at Common Suction Vessel to Compressor Package	
8.	Pressure at Compressor Discharge Vessel to Valve	
9.	Pressure at Catch pot vessel	
10.	Level at LP Scrubber Vessel	
11.	Level at Common Suction Vessel	
12.	Level at Compressor Discharge	
13.	Level at Catch pot vessel	
14.	Level at Closed blow-down drum	
15.	Level at Diesel storage tank	
16.	Flow at LP Scrubber vessel to Common Suction vessel	

Sl.no	Description	Remarks
17.	Flow at Inlet of Common suction vessel	
18.	Flow at Common Suction vessel to Compressor Package	
19.	Flow at Common Discharge vessel to valve	
20.	Flow at Flare gas to flare	
21.	Flow gas at Catch pot vessel to Flare package	
22.	Pressure control at LP Scrubber vessel to Common Suction vessel	
23.	Pressure control HP Gas to Inlet of Common suction vessel	
24.	Pressure control at Flare sub Heater from vessel	
25.	Pressure control at Common Suction vessel to Compressor Package	
26.	Level control at LP Scrubber vessel	
27.	Level control at Common suction vessel	
28.	Pressure control at Common Suction vessel to RIL B/L	
29.	Pressure control at Common Suction vessel to Flush sub header	
30.	Level control at Common Suction vessel	
31.	Pressure control at High pressure gas to vessel	
32.	Pressure control of fire water to network	
33.	Level Alarm of Common suction vessel	
34.	Temperature at LP Scrubber vessel to Common suction vessel line	
35.	Temperature at HP gas to Common suction vessel	
36.	Temperature at Compressor Discharge Vessel outlet line	
37.	Pressure at LP Scrubber Vessel	
38.	Pressure at Suction Vessel	
39.	Pressure at HP gas inlet to Common suction vessel	
40.	Pressure at Common suction vessel	
41.	Pressure at Catch pot vessel	
42.	Pressure at Liquid transfer pump discharge	
43.	Pressure at Liquid transfer pump discharge	
44.	Differential Pressure across filter Liquid transfer	
45.	Differential Pressure across filter Liquid transfer	
46.	Pressure at Closed blow-down drum	
47.	Pressure at pump discharge common header	
48.	Pressure at Discharge to common header	
49.	Temperature at LP Scrubber vessel	

Sl.no	Description	Remarks
50.	Temperature at Suction vessel	
51.	Temperature at Compressor Discharge Vessel	
52.	Temperature at Compressor Discharge Vessel inlet	
53.	Temperature at LI & Flare vessel	
54.	Temperature at Closed Blow-Down drum	
55.	Level Indication of LP Scrubber vessel	
56.	Level Indication of diesel tank	

06.04 DESIGN PHILOSOPHY

06.04.01 Control & Instrumentation (C&I), system shall be provided to enable the Compressor operation to be carried out in a safe, effective and reliable manner, without invoking plant or system operational limits and to provide the quality of control to support the overall performance guarantees detailed in other sections.

The main objective of centralized control room operation for the Natural Gas Compressor is for the following actions.

a. All routine unit operations (including all normal, emergency, start-up, shut down operations on load).

b. Any non-routine operation for which there is not ample time for plant attendant to accomplish.

06.04.02 The design of control system and related equipment shall adhere to the principle of “fail-safe” operation at all system levels (i.e.) the loss of signal, loss of power or failure of any component should not cause a hazardous conditions and at the same time prevent occurrence of false trips and provide reliable and efficient operation of the plant under dynamic conditions and attainment of maximum availability.

06.04.03 The entire unit operation and monitoring under all regimes of operation i.e. start-up, normal operation, shut down, etc shall be possible through Colour TFTs / Keyboards / Mouse or equivalent cursor control devices mounted on Unit Control Desk (UCD) in the unit control room. A minimum quantity of back-up push button station may be provided.

For all electrical systems within the plant, all electrical breakers control shall be performed from TFT / Keyboard mounted on UCD with back-up from miniaturized hard wired switches and push buttons mounted on electrical control panel provided with mimics.

06.04.04 TFT alarm displays, sequence of event monitoring etc. shall be provided for rapid diagnosis and logging of events following a unit trip.

06.04.05 Vibration monitoring devices, bearing temperature- monitoring devices etc for major auxiliaries shall be provided to give alarms for proper healthiness of the equipment.

06.04.06 Extensive self-monitoring and diagnostic features shall be employed to enable location of faulty components / system in the minimum possible time.

06.04.07 PLC shall work on 24 V DC. The 24 V DC supply shall be generated from the UPS 240 V AC. A suitable dedicated battery bank of 24 V DC is to be considered separately as a input source for PLC backup, Alarm annunciation ,emergency system etc.

06.04.08 All actuators of regulating control valve and 24v DC operated SOV (Solenoid operated valve) shall be of pneumatic type for that suitable redundant Air compressor with air drier and receiver to be provided.

06.05 DESIGN CRITERIA

06.05.01 The equipment and system shall be designed and constructed to meet all specification requirements, and perform accurately and safely under the environmental and operating conditions without undue heating, vibration, wear, corrosion or other operating troubles. It shall be the responsibility of the Tenderer to fully acquaint himself with the functional requirements and operating conditions, for equipment, system and accessories offered for the project. Additional features shall be provided where required to meet the service conditions, functional or descriptive requirements stated in individual specification for these equipment system.

Unit Control Room (UCR) for Gas compressors will house the HUMAN MACHINE INTERFACE system necessary for the operation and monitoring of the unit. The Control Equipment Room (CER) adjacent to Common Control Room (CCR) will house all PLC control cabinets and the necessary marshalling racks. Local control rooms or local control panels shall be provided for the normal operation of auxiliary plants, at locations where local operations shall be performed.

All requirements of auxiliary equipment for instruments and control devices including thermocouples and wells, resistance elements and wells, transmitters, special wiring and piping accessories, separation chambers, condensation pots and all other special devices required for installation in instruments piping and wiring system shall be furnished in complete as required for each individual elements, instrument or system unless specifically stated otherwise in this specification.

Redundancy of components and system shall be governed by availability criteria to ensure the system availability target as well as safety considerations in critical applications.

Separate sensors shall be provided for Control / protection and Monitoring and alarm

If a transmitter's signal is used for control, there shall be another transmitter furnished for measurement with facility for transfer of signal to use the measurement transmitter for control, in the event of loss of control transmitter. The transfer operations shall be notified in HMI by alarm.

Any single failure of instruments or control equipment shall not affect the performance of the unit in anyway.

For very critical application like protection of Gas Compressor and its auxiliaries, Governor Control system, 2 out of 3 redundant sensor / transmitters shall be used. 2 out of 3 system modules shall also be provided for this application.

For balance protection rest of the closed loop controls, sequential logic and related measurement dual redundant hardware shall be used.

For balance measurement non-redundant hardware may be used.

The common plant PLC shall have 1:1 hot bump less redundancy in following levels:

- Main processor, (CPU)
- Communication module,
- I/O modules (for critical I/Os),
- Network interface module,
- Communication cable and
- Power supply other than those which are to be achieved through 2 out of 3 configuration.

For all measurements, independent transmitters shall be connected to separate tapping points.

Operation & Maintenance

The design of the system and related equipment shall adhere to the principal of "fail Safe" operation wherever safety of personnel / plant equipment is involved. "Fail Safe" operation wherever signifies that the loss of signal, loss of excitation or failure of any component shall not cause a hazardous condition. However, it shall also be ensured that occurrence of false trips are avoided / minimized.

The types of failure which shall be taken into account for ensuring operability of the plant shall include but not limited to

- Failure of sensor or transmitters.
- Failure of controller / other modules during automatic operation
- Loss of motive power to final control element
- Loss of control power
- Loss of instrument air.

The choice of hardware shall also take into account sound maintainability principles and techniques. The same shall include but shall not be limited to the following:

- Standardization of parts.
- Minimum use of special tools.
- Grouping of functions.
- Interchangeability.
- Malfunction identification facility / self surveillance facility
- Easy modular replacement
- Fool-proof design providing proper identification and other features to produce proper monitoring and installation
- Appropriate derating of electronic components and parts.

Equipment / devices which require maintenance shall be suitably located to ensure easy accessibility.

The tenderer shall supply all necessary furniture including ergonomically designed chairs & desks for use at the control room and various programming stations. All the equipment like PC's, Programmers Stations, various peripherals & similar devices shall be complete with desks, stands and other mounting accessories.

06.05.02 Codes & Standards

All design, manufacturing, testing and installation shall conform to any acts, laws, rules and regulations of the jurisdiction within the project is located and the current editions of the following or equivalent standards or codes, so far as they apply

American Gas Association (AGA)

AGA Report No. 3 Orifice Metering of Natural Gas
AGA Report No. 7 Measurement of Gas by Compressor Meters.
AGA Report No. 8 Compressibility and Super-compressibility for Natural Gas and other Hydrocarbons.
AGA Report No. 9 Measurement of Gas by Multi-path Ultrasonic Meters

American National Standards Institute (ANSI)/ Fluid Control Institute (FCI)

B.1.20.1	Pipe Threads
B 16.5	Steel Pipe Flanges, Flanged Valves and Fittings
B 16.10	Face to Face and End to End Dimensions of Ferrous Valves
B 16.34	Hydrostatic body and leak testing of isolation valves.
B 16.37	Hydrostatic Testing of Control Valves
B 16.104	Control Valve Leakage
FCI 70.2	Leak Testing of Control Valves
ANSI C 96.1	Temperature Measurement Thermocouples
ANSI B 1.20.1	Pipe Threads, General Purpose
MC 96.1	Temperature Measurement Thermocouples

American Petroleum Institute (API) / Manual of Petroleum Measurement Standards (MPMS)

API 6D	Specification for pipeline valves
API 6FA	Fire Test for Valves
RP 500	Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Division 1 and Division 2
RP 520	Sizing, Selection and Installation of Pressure Relieving Devices in Refineries, Part I and Part II
RP 521	Guide for Pressure Relief and Depressing Systems
RP 526	Flanged Steel Safety Relief Valves
RP 527	Commercial Seat Tightness of Safety Relief valves with Metal to MetalSeats
RP 551	Process Measurement Instrumentation
RP 552	Transmission Systems
RP 554	Process Instruments and Control
RP 555	Process Analyzers
RP 598	Valve Inspection and Testing
S 1101	Measurement of Petroleum Liquid Hydrocarbons by Positive Displacement Meter
S 2000	Venting Atmospheric and Low Pressure Storage Tanks: Non- refrigerated and Refrigerated.
S 2534	Measurement of Liquid Hydrocarbons by Compressor Meter Systems
CH. 5.6	API Manual of Petroleum Measurement Standards (MPMS) Measurement of Liquid Hydrocarbons by Coriolis Meters

American society of Mechanical Engineers (ASME)

ASME PTC 19.3	Performance Test Code Temperature Measurement
ASME Section VIII	Sizing and Selection of Pressure Relief Valves

American Society for Testing and Materials (ASTM)

ASTM A269	Stainless Steel Tube
ASTM A276.316L	Stainless Steel Fittings
ASTM 370	Standard Test methods and definitions for Mechanical Testing of steel products
ASTM 450	General Requirements for Carbon, Ferritic Alloy, and Austenitic Alloy Steel Tubes

British Standards

BS 1904	Specification for industrial platinum resistance thermometer sensors
BS 4937	International Thermocouple Reference Tables
BS 5501	Electrical Apparatus for Potentially Explosive Atmospheres

International Electro-technical Commission (IEC)

IEC 60801	Electromagnetic compatibility for Industrial Process measurement and Control equipment
IEC 60092-373	Shipboard flexible coaxial cables
IEC 60092-359	Specification for insulation and sheath of electric cables
IEC 60227	Polyvinyl chloride insulated cables of rated voltages up to and Including 440/750 V
IEC 60331	Fire resisting characteristics of electric cables
IEC 60332-1	Tests on electric cables under fire conditions Part I: Tests on single vertical insulated wire or cable

International Organization for Standardization (ISO)

ISO 5167	Measurement of Fluid Flow by means of Orifice Plates

National Association of Corrosion Engineers (NACE)

NACE MR 0175	Sulphide Stress Cracking resistant metallic materials for oilfield equipment

06.05.03 Metering Bases of Units

The following system of units shall be followed throughout the specification unless otherwise mentioned.

Pressure	:	Kg/sq.cm
Differential pressure	:	mm of H_2O column or Kg/sq.cm
Draught	:	mm of H2O column
Vacuum	:	mm of Hg/H2O Column
Temperature	:	Degree Celsius
Flow (Steam / feed water)	:	Tones / hr or Kg/hr
Flow (Air / Gas)	:	N.Cu. M / hr
Flow (oil)	:	Kg/hr
Density	:	gm/c.c.
Level	:	mm
Conductivity	:	Micro-mho/cm
Gas Analysis	:	Percentage by Volume or as specified in respective cases.

06.05.04 **Process Connection Size**

The following connection sizes shall be adopted for the instrumentation tapping points for measurement, control and test:

i. Pressure measurement (above 40.0 bar pressure and / or 45^0 C temperature and fuel oil): 25 NB socket Weld (SW)

ii. Pressure measurement) low pressure / temperature): 15 NB SW

iii. Temperature measurement (high pressure / temperature): M33 * 2 (screwed) full coupling with seal welding.

iv. Temperature measurement (low pressure / temperature): M33 * 2 (screwed) full coupling.

v. Flow, level and differential pressure measurement: Same as (i) & (ii)

vi. Level switches: 25NB (SW)
vii. Gauge glasses: 1" NPT (Screwed)
viii. Sampling connections (water/steam): 25 NB (SW)

06.06 GENERAL TECHNICAL STANDARDS

I.1 PRESSURE & DIFFERENTIAL PRESSURE GAUGES (PG & DPG)

Applicable standard	:	IS:3602-1966, IS/3624, ASME B 40.1
Type/Construction	:	
- (-) 760 mm Hg to 1.0 Kg/cm2		Bellows / Diaphragm
-Above1.0 Kg/cm2		Bourdon Tube
Suction Side of pumps	:	Compound gauge
Materials	:	
- Bourdon tube		316 SS
- Bellows		316 SS
- Movement		316 SS
- Case		SS 304
- Protective Diaphragm		Teflon
Dial	:	150mm size with toughened shatter proof glass. For special application eg. skid mounted equipment, 50mm/ 100 mm dial size may be used
Scale Details	:	Graduations in black lines on White dial, 270 Deg. pointer deflection scales provided with glass cover. Smallest scale division shall be one (1) percent of full scale value or smaller. Pointers stop for all gauges.
Accuracy	:	± One (1) percent of Span or better
Process Connection	:	1/2 inch NPT Male Bottom
Enclosure Class	:	IP-65 or better
Zero adjustment	:	For all gauges External Micrometer screw for zero adjustment. Internal micrometer screw for range adjustment.
Safety device	:	
- Ranges 5 to 20 Kg/cm2		Rubber blow out disc with open front construction
- Ranges above 20 Kg/cm2		Neoprene safety diaphragm at the back with solid front construction
- Over range protection		One thirty (130) percent of full scale
Accessories	:	
- 3 way gauge Cock		For all gauges

- Snubber / Pulsation dampners		
Application		For Pump and compressor suction & discharge lines and for pulsating fluid applications
Type		Self Cleaning type
Material of Construction		SS 316
- Syphon / Pigtail		For all Steam Lines
- Protective Diaphragm Seal		
Application		For oil, corrosive, viscous, solid bearing or slurry type medium SS 316 Flange and Diaphragm, PTFE coated / block, Silicon Oil filling fluid
Type		Flush Type
Process Connection		NPT / Flanged SS316 Class 150

I.2 Pressure / Differential Pressure Switch

1. The pressure switches shall have sensing elements made of copper alloy or stainless steel sealed diaphragm and piston actuated for high pressure service and bellows for low pressure / vacuum service.
2. Low differential pressure switches for low static pressure ranges shall be diaphragm type with snap action switch elements.
3. Low differential pressure switches for high static pressure shall be elbows and torque tube and snap – action switch elements and metric scale dial indicators.
4. Each pressure switch shall be selected for the proper range, over pressure capability and dead band as required by the specific application.
5. For corrosive, viscous process fluids diaphragm sealed with completely filled inert liquid, shall be provided. Material of diaphragm and wetted parts shall be selected considering the nature of process fluid.
6. The sensing elements shall be properly aged and factory tested to remove al residual stress. They shall be able to withstand at least 150 % the full-scale pressure without any damage or permanent deformation.
7. Actuation set point, dead band shall be externally adjustable through out the range with tamper proof facilities.
8. All switches shall have an accuracy of ±2.0 percent _ or better of the full-scale range. All switches shall be repeatable within ± 0.5 percent of the scale range.